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AfricaInteract: Enabling research-to-policy dialogue for adaptation to climate change in Africa

Review of Research and Policy for Climate Change Adaptation in the Health Sector in East Africa

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Acronyms and abbreviations

ACT	Artemisinin-based combination therapy
ACPC	African Climate Policy Centre
CDC	Centers for Disease Control and Prevention
DFID	Department for International Development
EAC	East African Community
HPP	Health Policy Project
icipe	International Centre of Insect Physiology and Ecology
ILRI	International Livestock Research Institute
IPCC	Intergovernmental Panel on Climate Change
KEMRI	Kenya Medical Research Institute
NAPA	National Adaptation Plan of Action
NGO	Non-governmental organisation
UNDP	United Nations Development Programme
UNFCCC	United Nation Framework Convention on Climate Change
USAID	United States Agency for International Development
WHO	World Health Organization

Executive Summary

This review examines the state of research on adaptation to climate change in the health sector in the East African region and identifies key research and policy gaps. The review is based on peer reviewed publications and reports available on the internet from governments, non-governmental organisations, international agencies and newspapers. The information on East Africa and elsewhere was found in searches of databases using keywords. Consultations were also made with individuals involved in the policymaking process to confirm information available on websites. To the extent possible, the most recent research papers have been referred to, but older publications have also been used to provide a historical perspective.

The review indicated that it is now generally accepted that some diseases are sensitive to climate change and variability, particularly malaria and Rift Valley fever. However, the health sector has been slow in linking climate change and variability to other diseases, perhaps because of less clear cause-effect relationships. The review finds that the health sector has not embraced the concept of adaptation in its approach to responding to climate change, a concept that includes adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, and which moderates harm or exploits beneficial opportunities. The health sector in the region faces many challenges that include high prevalence of endemic diseases, low socioeconomic development, inadequate health services and dependence on external funding. Climate change will increase the disease burden on the overstretched health services.

The government led health sector is still operating in the disaster management mode instead of the disaster prevention mode. There is little evidence that climate information is being used to mitigate against weather related disasters. Similarly, there is no evidence that efforts are being made to predict the likelihood of geographic range expansion of climate sensitive diseases. There is little local support for the development of epidemic prediction models, tools that are critical for early warning of disease outbreaks and epidemics.

There has been little climate and health related research in the region, and much of what has been done has been shrouded by controversies over the issue of attribution of health outcomes to climate change and variability. The review suggests that the health sector has very little capacity to assimilate research findings because no formal training has been available for the health experts on bio-meteorology and other climate change related sciences. Due to lack of guidelines and policies on the use of climate information in the health sector there are few opportunities for the application and use of climate products and research in the sector.

This review has identified the following major gaps in research on adaptation in the region:

a. Detecting changes in disease geographic distribution

b. Detecting changes in disease seasonality

c. Attribution of these changes to climate change and variability

d. Development of locally applicable affordable and sustainable disease prevention and control strategies

e. Development of early warning systems for detection of disease outbreaks and geographic spread

f. Development of rapid response systems for disease prevention and control

g. Identification of epidemic and disease hot-spots

h. Tracking emerging and re-emerging infections

There is an urgent need for capacity to use climate information and to apply tools such as predictive and spatial models. Interaction between researchers, practitioners and policymakers should be encouraged. There is also an urgent need to increase research funding to support development of predictive tools, monitoring of climate risks and disease surveillance. The health sector needs to realise that adaptation is consistent with primary health care where disease prevention is the major goal of the strategy.

Stakeholders' involvement with research and policy is fragmented and lacks coherence. This may have arisen from the historical development of disaster management and disaster prevention frameworks. The disaster management framework has an emphasis on rapid response to natural disasters while the disaster prevention framework has an emphasis on early warning and prevention of disasters. The sector is not pro-active with regard to climate sensitive diseases and health conditions. Adaptation policies in most countries in the region are based on the disaster management framework. It is now accepted that climate hazards are to a large extent predictable with reasonable skills and significant time leads. For example, the El Niño events that cause many epidemics can be predicted with a lead time of 6 months. Disaster prevention is a multi-stakeholder and multi-sector engagement. While policy guidelines may exist at country level, detailed sector engagement plans have not been well developed. For example, research institutions dealing with health and climate change have no formal engagement with the departments of meteorology and they depend on informal contacts for data sharing. A greater involvement of stakeholders in the formulation and development of adaptation policy to climate change may contribute to accelerating adaptation.

The absence of some key stakeholders such as the World Health Organization (WHO) in addressing climate change concerns in Africa has delayed the process of

adaptation in the sector. This is expected to change with the new WHO initiative on climate change in Africa. Mainstreaming adaptation in the health sector has not taken place. However, the sector continues to address emerging health threats as they occur. There is need for a more proactive approach.

Conclusions and recommendations

It is recommended that a solid body of knowledge indicating the relationship between disease epidemiology, climate change and variability should be developed. This will be achieved through the integration of the biology of transmission and mathematics with regards to the biophysical and socioeconomic situation in the region. It is critical that models are developed on how meteorological parameters modulate the rate of vector, water, food and air borne disease transmission. This will greatly help in defining, in precise terms, the impacts of climate change and variability risk on disease epidemiology. Evidence of these relationships will also be used to determine the future trends in the risk of disease transmission and thus the actions that need to be taken to prevent the potential impacts of a disease. Similar models will be required to indicate the potential geographic spread and changes in density of the diseases.

The weather may become more unpredictable and thus there will be need to anticipate climate risks as required by the precautionary principle. Biologists and other health scientists as well as meteorologists will need a great deal of collaboration, data and knowledge sharing in developing predictive tools. Capacity building must be increased in order to develop a sustainable critical mass of experts on climate and health related issues.

There has also been the problem of treating adaptation as a separate programme from other national development agendas. It has been proposed that adaptation should be embedded in the health sector policies and strategies. There is need to increase the policy space and increase capacities in evaluating the risks posed by climate change, propose interventions, and allocate resources for implementation. Policies in adaptation to climate change in all sectors need to be treated with urgency as the rate of climate change could accelerate or shift into a non-linear mode. Such a scenario would reverse years of national development and would result in increased poverty and negative economic development. Bottlenecks to implementation of adaptation policies are associated with unavailability of resources, both human and capital.

Introduction

Background

The health profile of human populations in the East African region includes infectious and non-infectious diseases. Many of these health conditions are rooted in the environment and poverty, with climate variability and change playing a major role in the increased risk of exposure and transmission of diseases (Yanda et al. 2005; Morse 1995). There is an urgent need to formulate policies to address adaptation to climate change and variability through evidence based research. A matter of concern is whether such research is informing adaptation policies in the health sector in the East African region.

As a preamble, the links between climate change and variability and health impacts are briefly examined prior to exploring the research and policy issues. Some of the countries in the region have carried out more research than others and lessons will be drawn from these.

Water development projects such as irrigation have increased breeding habitats for some vector borne diseases and subsequently their transmission (O'Meara et al. 2010; Githeko et al. 1993). Some of the diseases are particularly sensitive to meteorological parameters such as temperature, rainfall and humidity. Malaria is probably the most climate sensitive vector-borne disease. In Kenya 30 percent of outpatient consultations and 15 percent of inpatient admissions are due to malaria (USAID 2014).

Estimates indicate that 24 percent of the Kenyan population lives in the highlands, which are prone to malaria epidemics, and these figures are similar to those reported in Tanzania. In Uganda the population at risk is about 12 percent (Githeko, unpublished data). Similar conditions are expected in Rwanda, Burundi and Ethiopia. Lack of disease control programmes and insecticides (Sachs 2002; Najera 2001) along with drug resistance (Wongsrichanalai et al. 2002) can lead to high disease prevalence. The wide-scale use of insecticide treated bed nets and effective artemisinin-based combination therapies has recently markedly reduced morbidity and mortality in the East African region.

More than 40 percent of diarrhoeal fatalities occur in Africa in children under 5 years of age (Swierczewski et al. 2012). Diarrhoeal diseases have many causes and different modes of transmission, with many of them associated with poor sanitation as well as contaminated food and water. Extreme climate events such as floods and droughts can increase the risk of diarrhoeal diseases. Large scale cholera epidemics are closely associated with extreme climate events such as the 1982 and 1997/98 El Niño events (Patz et al. 2005). The 1997/98 El Niño significantly affected the whole of the East African region (Alajo et al. 2006). Cholera epidemics have in recent times occurred in human populations living close to the shores of the Great Lakes of East Africa (Nkoko et al. 2011; Bompangue et al. 2008; Birmingham et al. 1997). Epidemics have also occurred in coastal East Africa. In Kenya, Uganda and Tanzania, these were particularly associated with the El Niño events (Kovats et al. 2003), a major component of climate variability.

The appearance of multi-drug resistant diarrhoeal pathogens is presenting a challenge to their control (Bii et al. 2005). In one study in Kenya two commonly used antibiotics, ampicillin and gentamicin, faced resistance levels of 84.2 percent and 68.4 percent respectively (Silas et al. 2006). This means that many individuals treated with these common drugs would not be cured.

Rift Valley Fever is a zoonotic disease affecting both livestock and humans. The virus is transmitted by mosquitoes that breed in flooded areas after exceptionally heavy rainfall (Davies et al. 1985). Contact with animal fluids and drinking raw milk is a major risk factor in the transmission of the disease (Woods et al. 2002). Much of the flooding in the Rift Valley Fever-prone areas is caused by El Niño and the Indian Ocean Dipole events (Cai 2014). The risk is highest when the two events are in a positive mode – i.e., when the Western Indian and equatorial Pacific Ocean surface temperatures are positively anomalous (Anyamba et al. 2009; Indeje et al. 2006). The concurrent warming of the two oceans in addition to easterly winds bring heavy rains to the East African region.

Animal trade can cause Rift Valley Fever to spread to new areas and enlarge the geographic range of this and other infectious diseases (Jupp et al. 2002). The disease causes severe economic challenges to pastoralist communities in Tanzania, Somalia and Kenya following loss of livestock business (Rich and Wanyoike 2010).

Dengue and chikungunya fevers are two vector-borne viral diseases that are climate sensitive. Dengue epidemics have been linked to climate variability in Southeast and South Asia (Kovats 2000). Although dengue and chikungunya viruses are not widespread in East Africa, they have been isolated in Kenya, Tanzania and Uganda (Sang and Dunster 2004; McGill 1995). Recently, dengue and chikungunya virus infections have been detected among infants and HIV-infected individuals in northern Tanzania (Hertz et al. 2012). There have been reports of dengue fever outbreaks in northeast Kenya during the dry season (Holzwarth 2010). Epidemics have also occurred along the Kenyan coast (Johnson et al. 1990). A large dengue epidemic was reported in the City of Djibouti in the Republic of Djibouti in 1991/92 (Rodier et al. 1996). Chikungunya fever has been reported along the Kenyan coast during a period preceding a severe drought. This epidemic may have been caused by *Aedes* mosquitoes breeding in domestic water stored in containers (Gieseker 2004).

O'nyong'nyong virus epidemics, though uncommon, have occurred in Uganda and spread rapidly to Tanzania. The epidemics affected 60-80 percent of the human populations in the affected areas (Lanciotti et al. 1998; Rwaguma et al. 1997). *Anopheles funestus* and *Anopheles gambiae* are the major vectors of this virus (Vanlandingham et al. 2006; Williams et al. 1965). The

link between climate variability and O'nyong'nyong virus transmission is unknown. The epidemics have occurred in close proximity to lakes and swamps.

Plague is endemic in northern Uganda and occurs in two forms, bubonic and pneumonic. The bacterium is transmitted by fleas that infect rodents such as the common rat. The disease is associated with flooding, which forces the rodents to seek shelter and food in human dwellings (Ogen-Odoi et al. 2009). The risk of plague transmission has been positively associated with rainfall in the West Nile region of Uganda (MacMillan et al. 2012). Plague is common in the Usamabara region of Tanzania (Laudisoit et al. 2007) and also occurs in Madagascar. There have been no records of plague in Kenya for the last three decades.

The development and management of water resources is an important risk factor for schistosomiasis transmission (Steinmann et al. 2006). Climate change is expected to lead to more irrigation for food production and this has the potential to increase schistosomiasis transmission in irrigated areas. In the Mwea rice irrigation scheme in Central Kenya the prevalence of intestinal schistosomiasis was 47.4 percent in individuals 4-18 years old (Steinmann et al. 2006). Early records of intestinal schistosomiasis in an irrigated sugarcane area in Tanzania indicate a prevalence of 59 percent (Fenwick and Jorgensen 1972). The disease is most prevalent in the southeast and northwest regions of Tanzania (Kabatereine et al. 2006). In Ethiopia, the prevalence of intestinal schistosomiasis in irrigated areas was 27 percent compared to 1.8 percent in non-irrigated areas (Dejenie and Petros 2009).

HIV leads to immuno-compromised status (AIDS) and increases vulnerability to opportunistic viral, bacterial, fungal and parasitic infections. HIV infections predispose infected people to AIDS and later to opportunistic infections. HIV/AIDS has no direct link to climate change or variability but it can predispose AIDS victims to climate driven infections. Studies in the Democratic Republic of Congo (then Zaire) indicated that HIV infected children had an 11-fold increased risk of dying from diarrhoea (Thea et al. 1993). *Cryptosporidium* is a protozoan parasite whose risk of transmission increases during floods. Studies in Uganda indicated that 47 percent of HIV infected patients were also infected with *Cryptosporidium* (Sewankambo et al. 1987). In Kenya, 47 percent of children with diarrhoea were HIV positive while only 26.8 percent of HIV negative children had diarrhoea (van Eijk et al. 2010).

Droughts are a major cause of malnutrition and under-nutrition, common features in drylands regions. Droughts affect both humans and livestock and have long-term effects on human populations due to both physical and mental stunting. Droughts in East Africa are associated with the La Niña phenomenon, which is part of climate variability. During the 1999-2001 La Niña event, 25 percent of the pastoralist population in Wijir, Kenya suffered malnutrition (Aklilu and Wekesa 2002).

In 2005/06 drought conditions ravaged the northern frontier and North Eastern Province of Kenya, affecting a total population of 4m people with an estimated loss of 50-60 percent of livestock (goats, camels and cattle) (Kenya Red Cross 2011). This was the most severe drought in the East African region, and was also experienced in Uganda and Tanzania.

On the other hand, the El Niño phenomenon causes flooding and landslides in East Africa. Such events are associated with injury and death in affected populations.

Methodology used for review

This report is based on peer reviewed and grey literature from research carried out in the region. As much as possible the latest research findings were reported. Evidence of the link between some health conditions and climate is referred to from other regions where evidence in the East African region is not available. Unpublished reports from credible sources are included and the sources identified. Government and other agency reports containing relevant data and policies are sourced from their websites.

The relevant literature was identified using keyword searches on the Google Scholar and National Library of Medicine websites. The references were managed using EndNote software. Grey literature was identified using Google search engine. As much as possible the review referred to scientific and reports published in the last 10-15 years. Priority was given to papers published in the last five years whenever possible. The grey literature covered official published government and non-governmental organisation (NGO) reports. Experts involved in the policymaking process in the region were consulted where clarification was required.

Climate change may modify many health parameters and even recent reports may become out of date after a short while. Likewise, ongoing health interventions may modify the current disease trends. As countries strive to meet the Millennium Development Goals, health statistics in the region will change.

Scope of the review

The main thrust of this report is synthesising research-generated knowledge related to climate change adaptation in the health sector in East Africa. In particular the paper will focus on:

- Climate change adaptation research and policy pertaining to the health sector, including the relationship with water resources and gender

- Gaps in climate change adaptation research and policy in the health sector, and the way research informs policymaking

- Key stakeholders and opportunities for improving the climate change adaptation research-policy nexus in the health sector

Figure 1: Linkages between the various stressors of the health sector, vulnerability research and adaptation
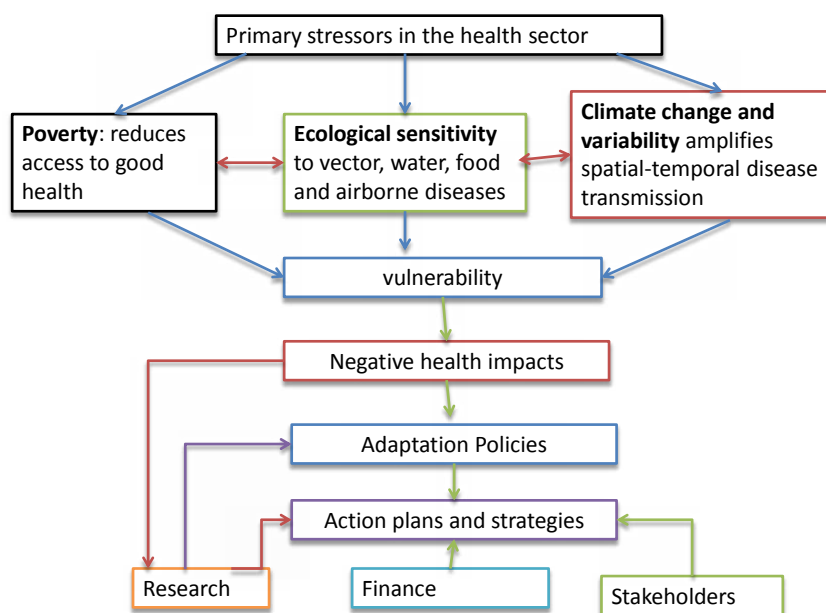
Defining adaptation to climate change

The following definition, based on Smit et al. (2000), has been adopted for this report:

> Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation.

The purpose of adaptation is to reduce vulnerability by increasing adaptive capacity and resilience.

$$Vulnerability = \frac{Harzards \; XExposure}{Adaptive capacity}$$

Hazards include climate change and variability. Extreme events such as floods and droughts represent some of the greatest climate hazards. The exposure domain includes human populations, resources, services and ecosystems. Adaptive capacity is the ability of the exposure domain to resist damage and maintain its integrity. This can be done by increasing its coping capacity and resilience. Adaptation must reduce the extent of exposure and increase the adaptive capacity. It must also be able to anticipate the climate hazards in order to reduce exposure.

Current state of knowledge on adaptation to climate change in the health sector in the region

It is now well established that epidemics of malaria, cholera, Rift Valley Fever and famine are associated with the El Niño Southern Oscillation (ENSO) phenomenon. It has been shown that malaria epidemics in the East African highlands are driven by unusually warm weather followed by heavy rainfall (Githeko and Ndegwa 2001). Likewise, it is also known that regional scale cholera epidemics are linked to strong El Niño events (Olago et al. 2007). Rift Valley fever has been linked to heavy rainfall (Anyamba et al. 2009). It is now well established that droughts and famine occur during La Niña events (Anyamba et al. 2002).

The 1997/98 El Niño event was characterised by severe flooding, providing evidence even to common people of how weather changes can affect health. The increased use of insecticide treated bed nets, vaccination of livestock and use of safe drinking water technology have decreased the incidence of climate driven epidemics in the region. However, it must be noted that the health sector has to a large extent focused on controlling endemic diseases, some of which can occur in epidemic forms.

Current state of knowledge on whether and how research findings are integrated in health sector policies in the region

The key pillars of adaptation to climate change in the health sector include identification of risk factors, vulnerability mapping, early warning systems and rapid responses. The health sector has programmes that carry

out normal disease control and others that deal with disease outbreaks and epidemics. Epidemic responses require a rapid intervention to prevent a disease outbreak. In the case of malaria early epidemic prediction models have been developed and validated. Although these models are in use in Kenya by the Ministry of Health and the Department of Meteorology they are not yet part of the malaria epidemic control policy. Similarly, while an early Rift Valley Fever epidemic prediction model has been developed, it is still in the research domain. No models have been developed for cholera in East Africa.

The major gaps in research on adaptation to climate change in the health sector

A major gap in developing early warning systems has been the lack of reliable health and meteorological data. There is need to collect historical malaria data covering the decade of 1990-2000, when several epidemics occurred. Longer data sets will be required for cholera because there have been few large-scale epidemics. Meteorological data collected close to the health data sources is required for the development of early warning systems. Many of the early attempts to develop early warning systems failed because important parameters such as immunity and ecosystem characteristics were not included in the models. Likewise, the behaviour of an ecosystem can change over time. For example, the number of mosquitoes in an ecosystem only partially correlates with rainfall. There is need to develop a multidisciplinary approach to modelling.

Ensuring that research findings are better integrated into health sector policies

Many of the health policies in the region are in line with those of WHO. For example, the strategy for managing malaria epidemics is spelled out in the Abuja Declaration and was guided by the Roll Back Malaria programme of WHO (Eldis 2014). For new strategies to be accepted by the Ministries of Health in the regions they also need the approval of WHO. Extensive testing and validation of the new research findings and products is required and this calls for multiple stakeholder involvement. It is not sufficient to develop new products and stop at publication. If research findings have direct application there is need to share the knowledge with major stakeholders such as technocrats and policymakers as well as WHO and funding and development agencies. In addition, mass media can help in the mobilisation of public opinion and gather support for the product.

Current state of knowledge on the stakeholders involved with research and policy on adaptation to climate change in the health sector in the region, and how stakeholder involvement could be improved

The health sector has a number of stakeholders, which include:

- The public
- Technicians
- Civil servants
- Local policy advisors
- International policy advisors
- Politicians
- Policymakers
- Development partners
- Donor agencies
- NGOs

The public are both the consumers and the financiers of health services; funding of health care partly comes from taxpayers and health insurance. The public can put pressure on governments to address certain health conditions such as malaria and HIV/AIDS. Technical staff include researchers and health providers that deal directly with the patients and matters of disease prevention and control. This group of stakeholders is also involved in collecting health statistics and prioritising subsectors that need special financing and support. Civil servants deal with health financing and general administration. Local policy advisors are health experts who identify areas of concern and advise on potential interventions, while international policy advisors and foreign experts provide scientific and technical advice to the Ministries of Health and governments. These experts may be provided, for example, by WHO or the US Centers for Disease Control and Prevention (CDC). Policymakers comprise the top health technocrats, other senior government actors and politicians. Development partners normally provide financial support to specific health programmes and actions supported by the health policy; some of these are the World Bank, Japan International Cooperation Agency (JICA), African Development Bank (AfDB), United States Agency for International Development (USAID) and UK Department for International Development (DFID). Donors may be corporate entities or individuals that support health programmes, for example the Bill and Melinda Gates Foundation (BMGF). NGOs complement government health services.

Key crosscutting considerations

Social differentiation and gender implications

Vulnerability, risk exposure and access to health are highly differentiated within the health sector. For example, children are at high risk of childhood diseases and need special services such as immunisation programmes. They are also at particularly high risk from malaria and diarrhoeal diseases. Poverty and climate extremes expose children to malnutrition and mental and physical stunting. Poverty can also be a barrier to health care. Pastoralists are exposed to a high risk of Rift Valley Fever following floods. In addition, climate driven conflicts are becoming more frequent due to resource scarcity in the semi-arid areas. Whereas there are many drivers of conflict within pastoral communities, environmental variability in factors such as foliage and water fuels these conflicts (Meier et al. 2007). These issues remain controversial, however, due to lack of empirical evidence. Men are often killed during such conflicts and women are left as widows. Moreover, men are more likely to suffer from depression and suicide following the loss of their livestock. Women suffer physical fatigue during drought as they collect water from great distances. Pregnant women are at high risk of malaria and this risk increases during epidemics that are to a great extent climate driven.

Implications for water resources

Water affects most socioeconomic sectors and natural ecosystems. In particular, too much or too little water will affect food production, health, transport and energy production. Extreme rain increases the risk of Rift Valley Fever and cholera epidemics, while contamination of public water supplies increases the risk of diarrhoeal diseases. Climate change will have a direct impact on the quality and quantity of water. Moreover, extreme events in the hydrological cycle such as floods will increase in intensity and frequency.

In Kenya, 68 percent of urban and 49 percent of rural populations have piped water supply but less than 50 percent have sanitation facilities (WHO 2006). Thus a significant proportion of Kenyans are exposed to lack of water and sanitation and this increases their vulnerability to water-borne diseases. In Uganda in 2008, rural water coverage stood at 64 percent and urban at 91 percent, while sanitation stood at 49 percent (AMCOW 2011). About 50 percent of Tanzania receives less than 800mm of rainfall annually, and this can be classified as an arid region. In this country, 70 percent of the urban and 42 percent of the rural population had access to piped water by 2007 (AMCOW 2011).

In terms of public health it is important to provide everyone with safe drinking water and sanitation, particularly in urban areas, because small pockets of population without safe water and sanitation can act as reservoirs of disease that can be transmitted to the rest of the population. The East African region will need to protect and develop its water resources in its quest for adaptation to climate change.

Up to 80 percent of Kenya is classified are arid and semi-arid (Flintan 2011). These regions are economically important because over 70 percent of the country's livestock and 75 percent of the wildlife are found there. About 98 percent of food production is by rain-fed agriculture and this makes the country highly vulnerable to food security. A 1998-2000 drought is estimated to have cost Kenya US$2.8bn (Catherine Fitzgibbon 2012). The country plans to increase the area under irrigation as an adaptation to climate change.

Cross-scale interactions (national, sub-national, local)

Climate change has been shown to be a regional rather a local event. For example, the 1997/98 cholera epidemic impacted all populations living around the shores of Lake Victoria. The epidemic not only affected human health but also international trade. Fish from Lake Victoria was banned from the European Union markets, thus affecting the livelihoods of the fishermen and their families in the Lake Victoria basin. Similarly, export of livestock from Kenya was banned in the Middle East following the Rift Valley Fever epidemics in 1998.

Droughts have caused large scale migration of pastoralists in northern Kenya and eastern Uganda, and quite often these results in conflicts and large populations of refugees. Such populations are exposed to disease and famine. Cross-border migration occurs between Uganda and Kenya, Somalia and Kenya, and Ethiopia and Kenya. Many of the immigrants are refugees while others are pastoralists looking for pasture and water. These migrations are often associated with resource conflicts.

Water as a resource frequently involves trans-boundary issues. For example, countries in the East African region would like to use Nile River water for irrigation. However, this has resulted in disagreements with other water users such as Egypt.

Focus on the informal health subsector

The informal health subsector is practiced by individuals who are not registered as health practitioners by governments. This sector is not regulated but it is important to populations where government health services are unavailable and private services are too expensive or remote. The informal sector may include village shops where one can buy anti-malaria drugs or painkillers; traditional birth attendants who provide services at home; and traditional healers who provide psychiatric interventions to rural and even urban populations. In some populations in East Africa, entire communities depend on traditional herbal medicines.

Relation between adaptation, resilience and coping

Human populations may be able to maintain their integrity despite exposure to hazards. This would imply that they can withstand external shocks, exhibiting a high level of resilience. Human populations and ecosystems may be able to cope with moderate perturbations in the climate system. However, this may not be the case in extreme climate events. Coping strategies include sharing resources, particularly after disaster. Adaptive capacity will include building resilience and coping capacity to resist damage caused by climate change. For example, a high coverage and use of insecticide treated bed nets can reduce and prevent the evolution of a malaria epidemic.

Defining the health sector: Focus on food, water and vector borne diseases and HIV/AIDS

Most water borne diseases are also food borne. However, some of these diseases have a direct link to meteorological parameters. In Zanzibar a 1°C increase in temperature at four months' lag resulted in a twofold increase in cholera cases, and an increase of 200mm in rainfall at two months' lag resulted in a 1.6-fold increase in cholera cases (Reyburn et al. 2011a; 2011b). In the Africa Great Lakes region of Kenya, Tanzania, Uganda, Burundi, Rwanda and DRC, cholera epidemics have been associated with El Niño events since 1982 (Nkoko et al. 2011). Cholera occurs in both endemic and epidemic forms in East Africa. Typhoid is endemic in the region, and so are shigellosis, cryptosporidiosis, *Escherichia coli* infection, amoebiasis, giardiasis, leptospirosis and hepatitis A.

Food borne pathogens include viruses, bacteria, protozoa and helminths. Among the viruses are hepatitis A and E. Bacterial infections are commonly caused by *Shigella, Streptococcus, Vibrio cholerae, Staphylococcus* and E. *coli,* while parasites include *Amoeba, Giardia, Trichinella spiralis, Fasciola hepatica* and *Ascaris lumbricoides.*

Vector borne diseases are among the biggest challenge to public health in the region. The leading vector borne disease is malaria, followed by schistosomiasis, filariasis, Rift Valley fever, dengue, chikungunya, West Nile fever, leishmaniasis and trypanosomiasis.

Food and water borne diseases lead to diarrhoea. In coastal Kenya, bacterial and viral diarrhoea had a prevalence of 27.7 percent and 18.1 percent respectively in children under five years of age. The prevalence of the infections correlated positively with rainfall (Saidi et al. 1997). In Uganda the prevalence of diarrhoea in children under two years was 40.3 percent (Mbonye 2003). Little data is available from Tanzania.

The prevalence of vector borne diseases varies in space and in time. Following the provision of free insecticide treated bed nets in the East African region malaria

mortality has declined by about 50 percent (O'Meara et al. 2010). In coastal Kenya, hospital admissions for malaria decreased from 18.43 per 1,000 children in 2003 to 3.42 in 2007 (O'Meara et al. 2008). Similar findings have been reported in Tanzania, Rwanda and Burundi (O'Meara et al. 2010).

Vector borne diseases and HIV/AIDS

HIV increases the susceptibility of an individual to malaria. Furthermore, malaria infected individuals have a higher HIV viral load than uninfected people (Abu-Raddad et al. 2006). High malaria parasite densities in the blood increased the risk of mother-to-child HIV transmission in mothers co-infected with both diseases in western Kenya (Githeko et al. 2006). Similar observations have been reported from Uganda (Brahmbhatt et al. 2003). Co-infection of malaria and HIV has increased the prevalence of malaria by 28 percent and mortality by 11.4 percent in a group of Southern African countries where malaria is unstable (Otten et al. 2009). It has been shown in Zimbabwe that women with urinary schistosomiasis had a threefold higher risk of becoming HIV infected (Kjetland et al. 2006). HIV increased the susceptibility of an individual to co-infection with *Schistosoma mansoni* in western Kenya (Karanja et al. 2002). Individuals with HIV have a much higher risk of co-infection with visceral leishmaniasis (Molina et al. 2003). The fatality rate of individuals infected with leishmaniasis and HIV was 4.5 times higher than that of individuals without HIV in Ethiopia (Lyons et al. 2003). Leishmaniasis is endemic in Kenya, Uganda, Somalia and Ethiopia but not in Tanzania (Brooker et al. 2004).

Overview of the health situation in the region

Key health indicators in the East African region

The governments of Kenya, Tanzania and Uganda carry out demographic health surveys every five years to assess the health of their populations and collect data for planning in the health sector. Certain essential parameters that are outcomes of improved health are used as indictors of population health. A list of these key indictors for the three countries are provided in Tables 1-3 along with national data from recent surveys. All three countries have similar health indicators, but the national statistics are different. In general, infant mortality rates have significantly declined since 1999 while life expectancy at birth has increased. Across the three countries these indicators reveal a general improvement in health.

Policy context for health and climate change adaptation

Currently climate change adaptation in East Africa has been driven by the National Adaptation Programmes

Table 1 Basic health indicators in Kenya		
Indicator	**1999**	**2009**
Crude birth rate	41.3	34.8
Crude death rate	11.7	Unknown
Inter-censal growth rate	2.9	2.8
Total fertility rate	5.0	4.6
Infant mortality rate (per 1,000 births)	77.3	52.0
Life expectancy at birth	56.6	58.9

Table 2 Basic health indicators in Tanzania		
Indicator	**2002**	**2010**
Crude birth rate	43	38.1
Crude death rate	14	10.5
Inter-censal growth rate		
Total fertility rate	6.3	5.4
Infant mortality rate (per 1,000 births)	95	51
Life expectancy at birth	51	57

Table 3 Basic health indicators in Uganda		
Indicator	**2002**	**2010**
Crude birth rate	47.8	45.2
Crude death rate	15.6	12.3
Inter-censal growth rate	3.2	
Total fertility rate	6.9	6.2
Infant mortality rate (per 1,000 births)	88.4	61.2
Life expectancy at birth	48.1	50.4

of Action (NAPA) and the disaster preparedness and management framework. The NAPAs are a requirement of the United Nations Framework Convention on Climate Change (UNFCCC) for the Least Developed Countries (LDCs) that could benefit from adaptation funds. Kenya however is not one of the LDCs. Disaster management policies respond more to events that have already occurred. Adaptations should focus on the prevention of disasters by anticipating and putting into place mechanisms for prevention, or for reduction in exposure to and impacts of climate hazards.

The Ministries of Health in the region are yet to formally use climate information to prevent well known climate sensitive diseases. Nevertheless, ad hoc climate and health committees have been set up by the Intergovernmental Authority on Development's Climate Prediction and Applications Centre (ICPAC). These committees are issued with rainfall forecasts during the seasonal climate outlook forum and the health sector determines the impacts of the forecast on health. Generally the Ministries of Health have not made use of meteorological data for disease epidemic control. Instead they have used epidemiological data to detect outbreaks and epidemics: an example of a disaster management strategy.

Table 4 shows the variation in the basic health indicators for the three East African countries in the last demographic and health survey. Compared to the survey carried out ten years earlier, there has been an overall improvement in health in the region. There is a difference in the indicators among the countries, with Kenya having the slightly better population health and Uganda having lower levels of indicators. Tanzania has values close to those of Kenya.

The role of climate change challenges

Climate change projections for different parts of the region

Results from the North Carolina State University enhanced version of the RegCM3 regional model (NCSU ReGCM3) (Anyah et al. 2006) which were run for both a control and a climate change (A2 scenario) simulation, have been analysed for Kenya (WeADAPT 2011).

Climate analysis using the Regional GCM model indicates that Kenya is likely to experience the following climate changes between the late 2020s and 2100:

Table 4 Variations in key indicators within the region			
	2009	**2010**	**2010**
Indicator	**Kenya**	**Tanzania**	**Uganda**
Crude birth rate	34.8	38.1	45.2
Crude death rate	Unknown	10.5	12.3
Inter-censal growth rate	2.8		
Total fertility rate	4.6	5.4	6.2
Infant mortality rate (per 1000 births)	52.0	51	61.2
Life expectancy at birth	58.9	57	50.4

a.   Average annual temperature will rise by between 1°C and 5C, typically 1°C by 2020s and 4°C by 2100.

b.   Climate is likely to become wetter in both rainy seasons, but particularly in the Short Rain (October to December). Global Climate Models predict increases in northern Kenya (rainfall increases by 40 percent by the end of the century), whilst a regional model suggests that there may be greater rainfall in the West.

c.   The rainfall seasonality i.e. Short and Long Rains are likely to remain the same.

d.   Rainfall events during the wet seasons will become more extreme by 2100. Consequently flood events are likely to increase in frequency and severity.

e.   Droughts are likely to occur with similar frequency as at present, but to increase in severity. This is linked to the increase in temperature.

f.   The Intergovernmental Panel on Climate Change (IPCC) predict an 18 to 59 cm rise in sea- level globally by 2100. One study suggests that 17 percent of Mombasa's area could be submerged by a sea-level rise of 30 cm (WeADAPT 2011).

In Tanzania by the end of the century, average temperatures are projected to increase between 1.9°C and 3.6°C, while sea level is projected to rise between 65cm and 1m. Rainfall is expected to decrease in the dry season and to increase during the rainy season, leading to a growing risk of floods, water shortage and related conflicts. Climate change is also expected to increase the severity, duration and frequency of weather related extreme events such as drought and floods, threatening water availability and food security for millions of poor people. Climate change is viewed as one of the gravest threats of the present and future of humanity in Tanzania (CAN undated).

In Uganda, there is evidence that average temperatures have increased by as much as 1.4°C since the 1960s. Looking further ahead, up to 4.3°C change in average temperatures is possible by the 2080s (Corner 2011). The rainfall projections are the same as for the rest of East Africa.

Overview of the range of possible impacts of climate change in the health sector in the region

Increasing temperatures are associated with increased altitudinal range of malaria and schistosomiasis, particularly in the highlands of East Africa. Malaria epidemics have occurred in the highlands of Kenya, Tanzania, Uganda, Rwanda, Burundi and Ethiopia. During one epidemic in Rwanda the disease prevalence increased by more than 500 percent (Loevinsohn 1994). A wetter short rainy season (during September, October, November and December) will increase the risk of malaria transmission because these months are a warm period and increased wetness will increase malaria transmission. Flooding will increase the risk of Rift Valley fever epidemics in all flood prone areas. Endemic and epidemic cholera are likely to increase in the region as the transmission thresholds are exceeded due to climate change. Diarrhoeal diseases are likely to increase due to contamination of public water supplies due to flooding. The meningitis belt may expand eastwards into Uganda and Kenya as the region becomes dry. Drought driven famine is likely to increase in north-eastern Kenya and parts of Tanzania.

Extreme events such as severe droughts and flooding are likely to increase and will be associated with landslides and drowning. Floods and drought may damage food cops resulting in food shortages and famine. Increased humidity will increase the risk of mycotoxins such as aflatoxins which will reduce stored food safety. Higher temperature may affect food and livestock production and even fish production from lakes in the region, all affecting food security.

Overview of the key causes of vulnerability in the health sector in the region (immediate, underlying)

The major sources of vulnerability include:

a.   Ecosystem vulnerability
b.   Socioeconomic vulnerability
c.   Institutional vulnerability

Ecosystems present different vulnerabilities in their support for pathogens. For example, human populations

living around the lakeshores are at risk of cholera and diarrhoeal disease (Cooper et al. 2008) while those living in the highlands are at a higher risk of epidemic malaria (Lindsay and Martens 1998). Pastoralists living in semi-arid flood prone areas are at a higher risk of Rift Valley fever (Pope et al. 1992) while urban populations in the same areas are more likely to be affected by dengue fever (Gubler 2004).

Socioeconomic attributes such as income levels represent different levels of exposure to climate hazards in terms of settlements. Poor people tend to live in marginal areas such as slopes that are prone to landslides. Other populations with low incomes have settled in flood prone areas that are also habitats for disease vectors.

Weak institutions, for example medical services, are not able to deliver adequate and timely services in times of need. They may be unable to respond to medical emergencies such as epidemics. In addition, they may be unable to anticipate climate hazards and undertake early responses to prevent and minimise the negative impacts of exposure.

Implications of climate change for other key challenges (and opportunities) for the health sector in the region: Population growth and urbanisation

In 2008 Kenya's population was 38m people and the annual growth rate was three percent. In 2009 Uganda had a population of 31m with an annual growth rate of 3.2 percent while Tanzania had a total population of 40.2m and an annual growth rate of two percent. By 2011 the annual growth rate in Kenya was four percent, in Uganda 4.4 percent and in Tanzania 4.6 percent (UN DESA 2011).

High population growth creates a high demand for resources and generates a high volume of waste. It also means that the development of basic services such as health education, provision of safe drinking water and food cannot keep pace. High population growth is likely to lead to settlements in marginal areas such as slopes, wetlands and slums. It has been associated with poverty, high morbidity and mortality (Kibirige 1997).

High population growth leads to shortage of agricultural land, low productivity and migration to urban areas (Murton 1999). Deforestation has been associated with demand for agricultural land and settlements and this leads to environmental damage and in some cases increases in disease transmission (Afrane et al. 2008; Afrane et al. 2005).

Water resources supply and demand

Water resources are directly affected by temperature: The warmer it is the faster the water evaporates. According to IPCC (2007), 75-250 million people will be under water stress by 2020. At the same time, yield from rain-fed agriculture in some African countries could fall by 50 percent, and towards the end of the century up to 80 percent of land could be classified as arid or semi-arid.

Equally at that time sea level rise will be a major threat to coastal cities like Mombasa and Dar el Salaam. Towards the middle of the century rainfall is expected to increase in East Africa. However, extreme flooding and droughts are expected before that time (AMCEN 2007). Many sectors such as agriculture, transport, tourism, energy and health are water dependent. Water shortages will negatively affect all of these sectors.

Gender and health

Malnutrition is rife in the Lake Victoria basin and its cause is controversial. It has been argued that men control earnings from the fishing business, leaving women with little income for household food security, and this leads to malnutrition (Geheb et al. 2008). In sub-Saharan Africa, male children under five years of age are more likely to become stunted than females as indicated by studies carried out in countries including Tanzania, Uganda and Kenya (Wamani et al. 2007). It has been observed that during the 1998 malaria epidemic in Rwanda, pregnant women were two to five times more likely to be admitted to the hospital for malaria than other adults (Kiszewski and Teklehaimanot 2004; Hammerich et al. 2002).

Traditional health vs. formal health systems

Traditional healers and traditional birth attendants are ubiquitous throughout Africa, where they represent the first line of health care for 70 percent of the population (Farmer et al. 2001). Thus they play an important role in health. Traditional healers have played an important role in Kenya, Uganda and Tanzania (UNAIDS 2002). Access to formal health care and education can lead to a shift from traditional health care. In the old days poor health was attributed to evil spirits that could only be treated by a traditional healer.

In East Africa the use of ethno-botanicals to treat fevers such as malaria and diarrhoeal diseases is quite common (Nuwaha 2002; Nyamongo 2002; Gessler et al. 1995). Poverty also plays an important role in the choice of health services (Woods et al. 2002).

Research related to climate change in the health sector

Status of scientific evidence for implications of climate change for food and water borne diseases

Many of the food crops in East Africa have been developed for specific agro-ecological zones. For example, there are different maize varieties developed for different altitudes that correspond to different rainfall

regimes and temperatures. Likewise, coffee and tea grow in highlands that have adequate rainfall and cool temperatures.

As the climate of these agro-ecological zones changes, food and cash crops will be affected. It has been projected that by 2055 the mean temperature of 32°C could cause a reduction of ten percent in the yield of maize. Likewise, it could cause a five percent reduction in the yield of wheat and rice (Bayoh et al. 2011). In Tanzania it has been predicted that a 33 percent reduction in maize yield will occur (Government of Tanzania 2003). The demand for food is likely to triple by the middle of this century given the current population growth (Jones and Thornton 2009).

Climate change may be responsible for new maize diseases such as the Maize Lethal Necrosis which spread from Kenya to Tanzania and Uganda in 2011. This disease destroyed 30-100 percent of the crop in Kenya. Excessive rainfall has been associated with poor drying of the harvested maize crop and its contamination with aflatoxins. According to the UN Food and Agriculture Organization (FAO), mycotoxins contaminate up to 25 percent of agricultural crops, and aflatoxicosis can be a lethal disease. (Lewis et al. 2005). Scientists in the region are developing new maize strains that are disease resistant and that can adapt to climate change.

Cholera

The major food and water borne disease is cholera. The disease occurs in endemic and epidemic forms. Cholera is caused by *Vibrio cholerae,* a bacteria that normally lives in water. The pathogen can be found in seas, lakes and rivers as a free living organism. Transmission of the pathogen occurs through drinking contaminated water or eating food that is contaminated by human faeces. The disease causes diarrhoea, severe dehydration, and if not treated death.

Cholera cases exhibit seasonality, as observed in Peru and the Bay of Bengal, and this corresponds to temperature and algal blooms. (Colwell 2004). Temperature, salinity, rainfall and plankton have proven to be important factors in the ecology of *V. cholerae,* influencing the transmission of the disease (De Magny et al. 2008). Cholera has been closely linked to the sea surface temperature increase observed during El Niño events (Pascual et al. 2000).

Two major cholera epidemics have occurred in East Africa, these being the 1983 and the 1997 events that were associated with strong and very strong El Niño events (Nkoko et al. 2011; Emch et al. 2008; Yanda et al. 2006). Recent studies in the Great Lakes region have reported an association with temperature and rainfall. In Zambia a 1°C rise in temperature six weeks before the onset of the outbreak explained 5.2 percent of the increase in the number of cholera cases from 2003 to 2006. In addition,

a 50mm increase in rainfall three weeks before explained an increase of 2.5 percent (Luque Fernández et al. 2009).

The transmission of cholera involves climatic and environmental variables that interact in a complex pathway. Modelling of the disease transmission has proven difficult. However, it is likely that there exit ecological and climatic thresholds that need to be exceeded for large epidemics to occur.

Diarrhoeal diseases

Climate change will include extreme events such as floods. In the East African region public health sanitation is poor, particularly in rural areas and in poorly developed urban areas. Drinking water is usually obtained from rivers, lakes, ponds and shallow wells. It has been shown that unprotected wells contain high levels of faecal material from surface runoff (Sabwa and Githeko 1985). Drought can also reduce the availability of safe drinking water, particularly in the arid and semi-arid areas. Water resources are often shared with livestock, thus contaminating it. Shrinking water bodies can also increase the pathogen dose making water more infectious.

In northern Kenya during a flood event, for example, over 6,000 shallow wells were contaminated. These had previously served 350,000 people in Wajir Central. Following the collapse of 350 latrines in Mandera, the Kenya Red Cross Society begun construction of 20 pit latrines, strategically placed in four different sites in the flood-affected villages (IFRC 2008). El Niño events that are now occurring every three years in the East African region are associated with flooding and outbreaks of diarrhoea. This is compounded by other diseases such as malaria, Rift Valley fever and cholera.

Little formal research has been carried out on the exact nature of the pathogens involved; much remains to be done in this area. While cholera is perhaps the most common and most climate sensitive waterborne disease, there are other pathogens such as *Salmonella enterica enterica Typhi, Escherichia coli, Cryptosporidium, Giardia, Amoeba, Shigella, Staphylococcus aureus* and *Campylobacter enteritis.*

While many of these pathogens are transmitted through faecally contaminated food and water, the pathogens by themselves are not very temperature sensitive. However there are pathogens that are temperature sensitive and they multiply rapidly in warm temperatures. This is the reason why foods are kept in refrigerators to stop these pathogens from multiplying.

It has been shown in Europe that salmonellosis has a linear relationship with temperature above a threshold of 6°C (Kovats et al. 2004). Similar observations have been reported in England and Wales (Bentham and Langford 1995). In many of the cities in East Africa such as Nairobi

cooked and raw food is sold in the streets and this food is kept at ambient temperature (Muinde and Kuria 2005).

Cryptosporidiosis

Cryptosporidiosis is an infection caused by protozoa of the genus *Cryptosporidium* that infect humans through the faecal-oral route. There are several species of the parasite and some of them infect domestic animals. The most common route of infection is through drinking contaminated water. In the United States *Cryptosporidium* outbreaks follow floods (Ebi et al. 2006). In East Africa, the infection is commonly found in people who are HIV positive. In Tanzania the prevalence of *Cryptosporidium* in cattle was 54.5 percent, indicating a large reservoir of the parasite in livestock (Swai and Schoonman 2010). *Cryptosporidium* species were found in 8.9 percent of chimpanzees in Tanzania. It was found that the prevalence of the parasites was three times greater during the rainy season compared to in the dry season. Furthermore, the prevalence of the parasites declined at temperatures above 28°C (Gonzalez-Moreno et al. 2013). In Kenya it was confirmed that the peak of the *Cryptosporidium* species in surface water occurred at the end of the rainy season coinciding with infections in human populations (Muchiri et al. 2009). *Cryptosporidium* cysts are resistant to water chlorination and thus even populations with piped water may be exposed to the infections. Filtration of water is required to remove the cysts from drinking water. HIV is a risk factor for infection with the parasite, and so is malnutrition.

Causes of vulnerability to food and water borne diseases (structural, individual)

The major causes of vulnerability to food and water borne diseases are low socioeconomic development, poor sanitation and hygiene and lack of access to safe drinking water (Yanda et al. 2006; Lule et al. 2005). Equally, certain cultural practices increase this vulnerability. For example, some communities do not use latrines, leaving cysts of parasitic pathogens in the environment from where they end up in water used for drinking. Lack of fuel to boil water contributes to the risk of infections (McLennan 2000) as does eating uncooked foods and foods stored at ambient temperatures. Washing of hands is well known to prevent most of the food borne infections. Hand washing has been found to reduce the incidence of diarrhoea by 32-39 percent (Ejemot-Nwadiaro et al. 2008). Some cultural practices require sharing of food from the same source and this increases the risk of infections from one person to the other.

Certain environments have been referred to as pathogenic, as they tend to maintain the pathogenic organisms. Living near Lake Victoria is a risk for diarrhoeal diseases such as cholera (Cooper et al. 2008). People living in slums and poorly developed urban areas may not have access to clean water and sanitation.

Options for strengthening adaptive capacity of individuals, households and communities to food and water borne diseases

Access to safe drinking water and functional sanitation reduces the vulnerability of urban and rural populations to food and water borne infections. Changing certain cultural habits, for example introducing the use of latrines and toilets, could reduce the incidence of diarrhoea.

In Uganda around 26,000 children die every year from diarrhoea caused by unsafe water and poor sanitation (WHO 2005). The country has set targets for improvement of access to improved sanitation and safe drinking water by 2015. It is expected that 70 percent and 72 percent of the population will have access to improved sanitation and safe drinking water respectively. This will be achieved through the combined efforts of the government and NGOs towards meeting the Millennium Development Goals MDGs. In Kenya the targets for use of improved sanitation and safe drinking water are 63 percent and 72 percent respectively, while in Tanzania they are 62 percent and 78 percent (WSSCC 2013).

Some of the activities for safe water include:

a. Construction of micro dams
b. Harvesting roof collected water
c. Piping treated water
d. Construction of protected boreholes
e. Construction of wells
f. Treatment and filtration of drinking water
g. UV sterilisation of drinking water
h. Washing hands after visiting the toilets and before eating a meal

Improvement of sanitation includes construction of ventilated improved pit latrines and changes in behaviour. Several NGO are involved throughout East Africa in carrying out the above activities in local communities.

Adaptation to food and water borne diseases in the region (including strategies based on local indigenous knowledge)

Many local communities are aware that diarrhoeal disease is associated with unsafe water and food. However they may be unable to link climate change events with health. Most people associate extreme events with seasonal weather changes and they assume that this is quite normal. While traditional knowledge has ways of treating diseases, it has few strategies for preventing them because their etiology is unknown. Herbal medicine has been used for a long time to treat diarrhoeal disease but children still die in large numbers, an indication of low effectiveness of such treatment.

Lessons from adaptation projects and interventions to combat food and water borne diseases in the region

While there have been many programmatic projects in the region to reduce the incidence of diarrhoea, little has been done in the area of adaptation to climate change. The major focus has been on vector borne diseases such as malaria and Rift Valley fever. It has been noted that though the climate community has generated knowledge on vulnerability of the East African populations to food and water borne diseases, little specific adaptation action has taken place (Olago et al. 2007). However, washing of hands in the region has been shown to reduce the incidence of diarrhoea by 40 percent (WaterAid Australia et al. 2010). In a village in western Kenya near the shore of Lake Victoria, mortality of children under five was found to be as high as 20 percent due to the unavailability of safe drinking water. A number of methods were put in place to improve water quality and quantity and this included rainwater harvesting from roofs and treatment of the water using traditional herbs. Further steps were undertaken to improve sanitation through public health education (Levicki 2005).

Key documented barriers to adaptation to food and water borne diseases

The barriers to adaptation in preventing food and water borne diseases include:

a.   Lack of safe drinking water
b.   Lack of good hygienic practices
c.   Low socioeconomic status
d.   Climate and environmental factors
e.   Education level of the head of the household

Lack of water has many variables that include quantity and quality. In some cases women and children have to travel long distances to obtain water (Olago et al. 2007; Tumwine et al. 2002). Poor hygiene and sanitation includes the lack of proper disposal of solid and liquid waste from humans and households (Garrett et al. 2008). Only 23 percent of the rural population of sub-Saharan Africa had access to proper sanitation (unicef 2010) in 2010. A large proportion of people in East Africa still lack improved latrines or toilets (O'Reilly et al. 2008; Konde-Lule et al. 1992) and this could be due to poverty, poor education, cultural practices or environmental conditions such as sandy and clay soils. In other cases the water table is very high and latrines flood easily. This is quite common in the Lake Victoria basin. All these factors can lead to poor sanitation and exposure to disease.

Socioeconomic status underlies three major determinants of health: health care, environmental exposure and health behaviour (Adler and Newman 2002). High mortality and morbidity rates have been found in populations with a low socioeconomic status in western Kenya (Adazu et al. 2005). In Uganda children living in a poor area and who used unprotected wells during the dry season had high mortality rates (Vella et al. 1992). Multi-variable data analysis has indicated that variables such as household income, number of children, gender, age and voting preference were strong predictors of an individual's risk perceptions with regard to health and food safety (Dosman et al. 2002). In general poor nations tend to have poor health outcomes and this is also the case with poor people. Low socioeconomic status is associated with lack of access to good health and knowledge that is useful for disease prevention and cure (Wagstaff 2002).

Climate is an important determinant of food security and safety. Likewise it has a major influence on the availability of water. In Kenya for example 80 percent of the country is classified as drylands (Kahi et al. 2006) characterised by high temperatures, water stress and low crop yield. Likewise, 80 percent of Tanzania is semi-arid with inadequate rainfall (Dercon 1996). Poverty, malnutrition and poor access to clean water and medicines are some of the major problems facing the communities in these areas in Tanzania (Mbwambo 2004).

Populations living in proximity to Lake Victoria and who use its water are at high risk of water-borne disease such as cholera and shigella (Cooper et al. 2008). Aflatoxin is a serious problem in cereals and grains. It has been shown that areas that are wet and humid have a higher risk of contamination with aflatoxins (Mutegi et al. 2009). Heavy rains and humidity in semi-arid areas have also been associated with aflatoxins. During hot and dry weather, particularly during drought, the cop becomes infected while it is in the field. Heavy rains and humidity increase the risk of contamination of the harvested crop (Cotty and Jaime-Garcia 2007).

Education plays an important role in the wellbeing of households, in particular for the head of the household who usually makes major decisions on the allocation of household income. Households with lower education tend to have a larger number of children, thus creating a high dependency ratio in the household and indeed in the community. Such a scenario creates poverty and vulnerability to external shocks.

Vector borne diseases: status of scientific evidence for implications of climate change for vector borne diseases

Most vector borne diseases are potentially sensitive to climate change; however, some are more sensitive than others. In some cases non-climate factors have played a significant role in the spread and increase of vector borne diseases. For example the invasion of Aedes albopictus, the Asian tiger mosquito, into Africa and Europe has caused an increase in dengue and chikungunya fevers. A disease such as malaria is highly sensitive to climate as several parts of the parasite life cycle and that of the vector are affected by temperature, while the vector's aquatic life stages are affected by rainfall and adult stages by humidity.

The major vector borne diseases in the East African region include:

a. Malaria
b. Schistosomiasis
c. Filariasis
d. Leishmaniasis
e. Rift Valley fever
f. Dengue
g. Chikungunya
h. Trypanosomiasis
i. Plague
j. West Nile fever
k. O'nyong'nyong

Malaria

Malaria occurs from the coastal lowlands to the highlands at about 2,200m above sea level. The disease is caused by four *Plasmodium* parasites, these being *P. falciparum, P. ovale, P. malarie* and *P. vivax*. Over 90 percent of the malaria infections in East Africa are caused by *P. falciparum* and this causes a potentially fatal disease. The disease occurs in a range of endemicities ranging from hypo-endemic to meso-endemic, hyper-endemic and holo-endemic. Hypoendemic malaria occurs in some areas in the highlands where it causes epidemics due to low transmission levels and low immunity in the human population (Wanjala et al. 2011). Malaria epidemics in the western Kenya highlands have been associated with El Niño events that are characterised by anomalous warming and heavy rainfall (Githeko et al. 2012; Githeko and Ndegwa 2001). Similar observations have been reported in the south-western highlands of Uganda (Lindblade et al. 1999). In other sites in the East African highlands climate variability has played an important role in initiating malaria epidemics (Zhou et al. 2004; Githeko et al. 2000).

Besides these climate driven epidemics, malaria has also spread to areas where it did not exist before the 1980s. However, few studies have been undertaken to map the spread of the disease. In Kenya is has been shown that stable malaria transmission started in the early 1990s when the mean annual temperature in the central Kenyan highlands permanently rose above 18°C, the threshold temperature for malaria transmission (Githeko 2009). Furthermore it was reported that the malaria vector *Anopheles arabiensis* had established itself in the high altitude area (Chen et al. 2006). Studies are urgently required to investigate whether malaria has spread to other high altitude areas in East Africa.

Schistosomiasis

There is little evidence that the epidemiology of schistosomiasis has changed as a result of climate change. The disease only exists in endemic forms and not in epidemic forms. It has been reported that schistosomiasis may have shifted to higher altitudes in the western Uganda highlands but more research is required to confirm this observations (John et al. 2008).

Filariasis

Filariasis is a disease commonly found along the East African coast (Mwandawiro et al. 1997) but also inland in Uganda (Onapa et al. 2005) and Tanzania (White 1971). Despite the availability of the three vectors of the disease further inland in Kenya *(Anopheles gambiae, A. funestus* and *Culex quinque fasciatus)*, transmission has failed to become established inland. There are no records of an increase in the geographic range of the disease.

Leishmaniasis

Leishmaniasis is caused by protozoan parasites and the disease occurs in two forms in East Africa, mainly in Kenya and Uganda (Reithinger et al. 2007). The two forms are cutaneous and visceral leishmaniasis. The disease is transmitted by sand flies mainly found in arid and semi-arid regions. Statistical modelling of spatio-temporal distributions indicates that increasing temperatures in the rage of the IPCC future projections will expand the geographic rage of suitable niches for the leishmaniasis vectors (Ready 2008). Empirical evidence of this phenomenon has been reported in Brazil where an association between El Niño and the incidence of visceral leishmaniasis was observed. In Brazil El Niño events are characterised by severe dryness and drought. It has been shown that from 1985-1999 the incidence of visceral leishmaniasis was correlated to the El Niño events (Franke et al. 2002). Similar studies are required in the East African region where the leishmaniasis geographic range may increase with climate change.

Rift Valley fever

Rift Valley fever is mainly a zoonotic disease affecting livestock but it is also infectious to humans. The disease causes hemorrhagic fevers in humans and can cause fatalities. The major routes of infections are through bites by infected mosquitoes and by direct contact with fluids from infected animals (Hoch et al. 1985). The disease is associated with heavy rainfall and flooding which creates stable breeding sites for the vectors of the disease (Linthicum et al. 2008; Davies et al. 1985). Much of the flooding occurs during El Niño events characterised by heavy rains and floods and abnormally warm weather (Anyamba et al. 2009). The warming of the western Indian Ocean, a phenomenon known as the Indian Ocean Dipole Oscillation, during El Niño events can enhance rainfall and lead to extensive flooding (Anyamba et al. 2002). Rift Valley fever is thus associated with climate variability, and the frequency of El Niño events is expected to increase. In the last decade the event occurred every three years while in the past an El Niño event occurred every 5-7 years. There is evidence that the geographic range of Rift Valley fever has increased recently in Kenya, moving from the former North Eastern Province to Central Province (Linthicum et al. 2008). In Tanzania the disease has spread away from the Kenyan border toward Dodoma and Arusha (IRIN 2007).

According to IPCC assessment (Christensen et al. 2007) rainfall is likely to increase in the Horn of Africa and this

will increase the frequency and intensity of Rift Valley fever epidemics (Martin et al. 2008).

Dengue

Dengue, like malaria, is a climate sensitive disease caused by a group of four viruses, in this case transmitted by *Aedes aegypti* and *Ae. albopictus* mosquitoes. The disease occurs in endemic and epidemic forms. Dengue epidemics have been caused by both heavy rainfall and droughts. *Aedes* vectors breed in containers around human settlements and this includes outdoor and indoor containers. The development of the aquatic stages of the dengue vector is temperature sensitive and so is the dengue virus. Humidity increases the longevity of the adult mosquito and the temperature increases its feeding frequency.

During droughts *A. aegypti* commonly breeds in water containers in or around houses and this increases human-vector contact and dengue transmission. There have been few dengue epidemics in the East African region. Epidemic dengue fever was reported in Kenya as early as 1982 (Choudhuri et al. 2011). Very low dengue transmission was reported in 1997 on the Kenyan coast (Turell et al. 2002). Infections remain largely underestimated in the region but it appears to be on the increase (Sang 2007). Recently evidence of infections has been found inland in western Kenya (Blaylock et al. 2011). In 2011 an outbreak affecting 5,000 people occurred in Mandera, an area in then North Eastern Province next to the Somalian and Ethiopian borders. A similar outbreak was reported in the same area in 2013 (Blaylock et al. 2011).

The first report of dengue fever in Tanzania was in 2010 (TEPHINET undated). Dengue has been reported in coastal Tanzania including Dar es Salaam and Zanzibar (Crisis Consulting 2010). Dengue has been associated with droughts elsewhere (Bangs et al. 2006).

Chikungunya

Chikungunya is another viral disease transmitted by *Ae. aegypti* and *Ae. albopictus* (Lahariya and Pradhan 2006). The disease has been largely absent in East Africa since its discovery in 1952 (Pialoux et al. 2007) in Tanzania. However, there have been large chikungunya epidemics in the Indian Ocean Islands of the East African coast (Murithi et al. 2011) and coastal Kenya. Investigation in coastal Kenya indicated that the outbreak was associated with drought (Chretien et al. 2007).

It is still not clear what role *Ae. albopictus* plays in the transmission of chikungunya in East Africa. This vector was brought from Asia on ships and its presence may have increased the transmission of the disease particularly in rural areas. *Ae. aegypti* is an urban vector. While climate change may increase the risk of chikungunya transmission, other environmental changes may also play significant roles.

Trypanosomiasis

Trypanosomiasis is a disease that affects both humans and livestock. Human trypanosomiasis or sleeping sleekness is caused by the protozoan parasites *Trypanosoma brucei* subspecies *gambiense* and *rhodesiense*, and affects about 0.5 million people in sub-Saharan Africa. T. b. rhodesiense causes acute disease in Eastern and Southern Africa. The disease is transmitted by tsetse flies of the *Glossina* genus. These flies occupy different habitats in forest, savannah and riverine ecosystems. Climate change and land-use changes are likely to alter these tsetse ecosystems and impact the disease transmission.

Glossina pallidepes habitats are generally woody drylands such as Acacia woodlands. The life cycle of the tsetse fly is sensitive to temperature, rainfall and humidity. The adult stages are affected by vegetation types, as this is where they rest. It has been shown that changes in vegetation types in Masai land had a long term impact on the presence and absence of tsetse flies. It has also been shown using models that human population growth resulting in altered habitats will lead to the extinction of tsetse flies (Haque et al. 2010). There are few studies on the impacts of climate change on human trypanosomiasis in the East African region.

Historically trypanosomiasis epidemics have occurred in Africa. For example, a large epidemic occurred in Uganda from 1976-1992 transmitted by *Glossina fuscipes* fuscipes (Gibson and Gashumba 1983). The origin of the epidemic is controversial; it has been suggested that it was caused by new antigenic isolates (Mueller et al. 2005). The epidemic in south-eastern Uganda was also attributed to a breakdown in public health and disease control (Smith et al. 1998). In the endemic Lambwe Valley in Kenya an epidemic was attributed to an increase in the vector population (Gibson and Wellde 1985). According to WHO, human African trypanosomiasis is an emerging health threat (Stich et al. 2002), but it is not clear if climate change is playing a direct role in this new threat.

Plague

Plague is caused by the bacterium *Yersinia pestis*, and it is transmitted to man by adult fleas. The disease is zoonotic and has many reservoirs, with the domestic rat being very important (Neerinckx et al. 2010). The disease has foci in Uganda and Tanzania but was eradicated in Kenya. Plague epidemics occurred in East Africa between 1920 and 1940, and thereafter the incidence of the disease decreased (Traversa 2013). However, from 1982 to date plague outbreaks have been reported in Uganda, particularly in Ariua district. A similar trend in plague has been observed in Madagascar. Outbreaks of human plague have been occurring in the western Usambara Mountains in Tanzania since 1980 (Kilonzo et al. 1992). In Central Asia it has been shown that a 1°C increase in spring temperature led to a 50 percent

increase in the prevalence of plague (Stenseth et al. 2006). It is notable that in Africa, 1920-1940 and 1980 to date were abnormally warm periods compared to long term historical temperature records. In the United States warmer and wetter climate leads to increased plague activity and thus an increased number of human cases (Ari et al. 2008). Climate change might increase the risk of plague outbreaks where plague is currently endemic and new plague areas might arise (Stenseth et al. 2008). There is evidence of warming in the East African region and this may increase the risk of plague in the future. Furthermore some areas of East Africa will experience an increased frequency of flooding and this also increases the risk of plague transmission.

West Nile fever

West Nile virus was discovered in 1937 in West Nile district in Uganda (Mackenzie et al. 2004). West Nile fever is a zoonotic disease that has mammalian and avian reservoirs and is transmitted from them to man by mosquitoes. There is very little disease activity in East Africa. Much of the concern about this disease is in the United States where it has spread rapidly in the last decade.

O'nyong'nyong virus was also discovered in Uganda in 1959 during an epidemic that affected 4m people (Sim et al. 2007). The virus is transmitted by the mosquitoes *A. gambiae* and *A. funestus.* The only other epidemic occurred in 1996 in Uganda and no other activity has been reported since.

Causes of vulnerability to vector borne diseases (structural, individual)

There are many factors that determine the vulnerability of human populations to vector-borne diseases, including:

a. Climate
b. Ecology
c. Socioeconomic conditions
d. Vector and disease control
e. Conflict and migration

Vectors of disease are poikilothermic and cannot control their internal temperatures and thus their survival is critically dependent on external temperatures. The rate of parasite development in the vectors is also temperature dependent. Temperature determines the geographic range of disease transmission and also the rate of transmission.

Some vectors such as mosquitoes and snails require water for their development. The rate of transmission is dependent on the availability, suitability and productivity of the habitats and this is directly related to rainfall and temperature. Thus even though the deserts are warm the absence of water cannot allow them to sustain mosquito populations. Temperatures in mountains and high altitude areas are too low to sustain the development

of aquatic stages of the vectors and the development of the parasite in the vectors. Climate variability increases the risk of epidemics.

The availability of permanent aquatic habitats such as rivers, ponds, dams and lakes can determine the dynamics of disease transmission. For example, snails need permanent aquatic habitats to sustain schistosomiasis transmission. Epidemics of Rift Valley fever are associated with *dambos,* ponds that collect water, flood and allow prolific breeding of the vectors. Thus living in these ecosystems increases the risk of infection with vector-borne diseases. Living in arid areas and keeping domestic animals could increase the risk of leishmaniasis.

The ability to prevent disease is related to access to wealth, knowledge and the right attitude. These factors are directly linked to the socioeconomic conditions of the population. For example, lack of mosquito barriers in a house can increase the risk of malaria and other mosquito borne diseases; however, in some cases populations are provided with free insecticide treated bed nets but they do not use them for a variety of reasons that include low education.

Vector-borne disease control includes the use of insecticides, drugs and vaccines. For example yellow fever has largely been controlled using an effective vaccine. Malaria has been controlled in some areas by the use of insecticide treated bed nets and indoor residual spraying. These interventions in East Africa and elsewhere depend on external funding. The availability of these interventions is not guaranteed. Furthermore, the vectors can develop resistance to insecticides and at the same time the parasites can develop resistance to the drugs as has been observed in malaria control.

Options for strengthening adaptive capacity of individuals, households and communities to vector borne diseases

Investing in health and development is perhaps the best option for increasing adaptation of individuals, households and communities to vector borne diseases. A number of structural adjustments in the health sector have failed to achieve the goals of good health. Many of the people impacted by vector borne diseases are poor and cannot afford interventions (Guyatt et al. 2002). Following the implementation of the cost-sharing policy in the East African health sector (MSH 2001), it was assumed that people living in malaria endemic areas could afford subsidised insecticide treated bed nets. After three years of social marketing of the nets, ownership only increased from 20 percent to 30 percent.

Clearly this strategy of malaria control was not working (Kleinschmidt et al. 2001). The governments then provided free insecticide treated bed nets to the most vulnerable segments of the population, this being pregnant women and children under five. This strategy increased the impact of the nets on malaria, but the impact did not go far enough. The governments

then changed the policy again and provided a treated net for every two people in a household. Since the implementation of this policy malaria prevalence and mortality have declined significantly in the region.

Diseases transmitted by mosquitoes can be controlled by removal of water holding containers around human settlements and also by covering water stored inside houses. Free mass drug administration trials for the control of schistosomiasis are underway (Parker and Allen 2011). The control of fleas by insecticides and rats using traps can reduce the risk of plague. Removing rodent habitats around households will also reduce the risk of the disease (CDC 2013).

Documented adaptation to vector borne diseases in the region (including strategies based on local/indigenous knowledge)

Malaria is the greatest vector borne disease in the East African region and it has received the greatest attention by the health sector and the human population. In the late 1980s and in the 1990s climate driven malaria epidemics occurred in the region causing high mortality and morbidity. These triggered renewed efforts to bring the disease under control by the use of insecticides and effective treatment. Following confirmation that insecticide treated nets could significantly reduce morbidity and mortality in areas of perennial high transmission (Phillips-Howard et al. 2003) large-scale control programmes were rolled out resulting in a significant reduction of malaria in the populations (Okiro et al. 2007). In-patient malaria cases and deaths in children under five in Rwanda fell by 55 percent and 67 percent, respectively, and in Ethiopia by 73 percent and 62 percent (Otten et al. 2009). There is evidence that health education has in conjunction with insecticide treated nets contributed to the reduction in malaria (Rhee et al. 2005).

Malaria in the highlands of East Africa is particularly prone to epidemics due to climate variability. Research over the last ten years has indicated a decline in the abundance of mosquitoes, malaria transmission and prevalence in the western Kenyan highlands (Himeidan and Kweka 2012; Zhou et al. 2011). Malaria control in the highlands has reduced vector population by 90 percent and infections by 50-90 percent in humans, and in some cases transmission has been interrupted (Githeko et al. 2012).

House modification to reduce the entry of malaria transmission mosquitoes has been effective in western Kenya. Modification reduced house entry by *A. gambiae* and *A. funestus* by between 78-80 percent and 86 percent respectively compared to unmodified houses (Atieli et al. 2009). Environmental modification such as swamp restoration has been shown to reduce the breeding of malaria transmitting mosquitoes in the western Kenyan highlands. This sustainable and affordable approach reduced the breeding of the malaria mosquitoes by

about 80 percent (Wamae et al. 2010). The house and the environmental modification adaptation strategies are still in the research domain and need to be translated into development projects.

Early warning systems have been developed for epidemic prediction for malaria and Rift Valley fever. A model that can predict malaria epidemics in the East African highlands was developed (Githeko and Ndegwa 2001). The model has been validated and has been in use in the region (Githeko et al. 2012). Sea surface temperature anomalies, rainfall and normalised derived vegetation index were used to accurately predict Rift Valley fever in time and space (Anyamba et al. 2009). This tool allows decisions to be made about vaccinating livestock in the areas at risk of a Rift Valley fever epidemic.

Lessons from adaptation projects and interventions to combat vector borne diseases in the region

There have been very few adaptation projects in the health sector in the region with regard to vector borne diseases. A few previous adaptation projects were very small in scale and did not make an impact. However, the Climate Change Adaptation in Africa (CCAA) funded project on the development of climate based malaria epidemic prediction models has had impacts at various scales. In Kenya the models are being used by the Department of Meteorology and Division of Malaria Control to predict epidemics in the highlands. The WHO in its adaptation programme for Africa would like to see the model used in many more countries where there is a risk of malaria epidemics. This project can be seen as a high impact adaptation outcome. There has been much interest in the model, particularly in the United States climate and health modelling community, and that may help in using the same methodology in developing other models for vector borne disease early warning systems (Githeko 2012).

Key documented barriers to adaptation to vector borne diseases

There are a number of challenges that affect the implementation of vector borne disease control. Among them are political, policy, financial and technical issues. Many of the decisions about the control of vector borne diseases are made at the WHO level. For a long time many African countries did not have the technical and financial capacity to control vector borne diseases. Malaria control in the colonial era was associated with protecting labourers in tea, sisal and other plantations, as this made economic sense to the owners of the plantations and the colonial government (Githeko and Shiff 2005; Anderson 1930) The control of malaria in these plantations mainly involved drug treatment (Dixon 1950). Larval control was recommended for large towns such as Nairobi and Kampala (James 1929). In Tanzania attempts were made to control malaria in the rural areas using insecticides such as dieldrin and DDT but it was concluded that

the rural health system was not adequately developed to accommodate indoor residual spraying for malaria control. Chemoprophylaxis was recommended as the method for malaria control in the rural areas (Clyde 1967). Furthermore, changes in vector behaviour reduced the efficacy of the indoor residual spraying (Pringle 1967). In the 1960s chloroquine became widely available and was used for prophylaxis and treatment. It was shown to suppress malaria incidence in Tanzania despite high levels of transmission (Draper et al. 1972).

By 1978 the malaria parasite *Plasmodium falciparum* had developed resistance to chloroquine (Githeko et al. 1992; Spencer et al. 1983). Chloroquine resistance was considered a disaster in Africa as by then there was no vector control being undertaken and vaccines had not been developed. Despite all the available resistance evidence it took ten years to change the chloroquine treatment policy (Shretta et al. 2008) at a high morbidity and mortality cost in Kenya. A new drug sulfadoxine/pyrimethamine combination (Fansidar) was introduced in Kenya in 1999 even though by 1994 resistance to this drug was detected in Tanzania (Rønn et al. 1996).

New artemisinin-based combination therapies (ACTs) were then introduced and they have proven to be effective in the treatment of malaria, but they were initially too expensive for most people in sub-Saharan Africa. A private public partnership has led to the availability of affordable ACTs (Wort et al. 2004). In addition to ACTs insecticide treated bed nets have been provided at no cost to affected populations. These programmes are externally funded as the national governments cannot afford them. Recently malaria vectors are showing the development of resistance to pyrethroid insecticides used to treat the nets (Ranson et al. 2011). Some of the vector borne diseases such as dengue and chikungunya have no specific treatments. In other cases such as in schistosomiasis, even though the disease is relatively easy to treat people return to infected water where they become re-infected.

HIV/AIDS: Status of scientific evidence for implications of climate change for HIV/AIDS and for people living with HIV/AIDS; assessment of how climate change may worsen the pandemic

HIV is not affected by climate change because it resides in cells inside the human body where temperature is regulated. At no time does the virus come into contact with external temperatures. The human body has temperature regulatory mechanisms and it is homoeothermic. The virus's mode of transmission does not expose it to environmental temperatures, unlike food, water and vector borne diseases.

HIV may increase the vulnerability of an individual by compromising the immune system and making the individual more susceptible to infections. If HIV/AIDS was climate sensitive we would expect to observe seasonality in its epidemiology, with outbreaks and epidemics when

the climate favours its transmission. We would also expect to observe a climate delimited spatial distribution of the syndrome. This has not been observed.

In one study in Los Angeles, USA seasonality was found in the incidence of *Cryptosporidium* among HIV infected individuals (Sorvillo et al. 1998). No significant seasonality was reported in a similar study in New Orleans, USA (Inungu et al. 2000). The seasonality was not in HIV infections but in *Cryptosporidium* infections. In a sero-prevalence study in Maryland, USA no seasonality was found in a cohort of prisoners and the infection rates remained positive over the study period of 12 months (Vlahov et al. 1990). However, HIV infections were associated with seasonal migration of populations in search of jobs in cities such as Dakar, Segegal (Pison et al. 1993). In Malawi geographic and seasonal variations have been reported in HIV prevalence rates in malnourished children and this has been linked to differences in socioeconomic conditions, food availability and culture (Thurstans et al. 2008). It has been hypothesised that the apparent seasonality of HIV/AIDS observed in Uganda is related to the progression of the infection to clinical manifestation as a result of nutritional deficiency during the dry season (Smallman-Raynor and Cliff 1992). Immigration and seasonal food availability are strongly associated with the prevalence of AIDS in some African countries as data from Uganda shows (Decosas et al. 1995).

Health policies related to climate change

Climate change considerations in national government health sector policies and strategies

The Kenyan government acknowledges that 90 percent of all natural disaster in the world are caused by weather, and thus saw the need to develop a National Climate Change Response Strategy (NCCRS) which was published in 2010 (Government of Kenya 2010) and will guide the development of the national climate change policy.

Kenya and the other countries in East Africa have experienced severe impacts of climate change and variability in the health sector. From the late 1980s the country experienced malaria, cholera and Rift Valley fever epidemics. The 1997/98 event was a turning point as all three diseases developed into the worst epidemics the country has ever seen. Earlier malaria epidemics caused high morbidity and mortality as there was no vector control programme and the malaria parasites had developed resistance to the available drugs. In addition to epidemics, lives were lost due to flooding and landslides. Furthermore the country has been impacted by severe droughts causing malnutrition and under-nutrition. It has become clear that climate change in the health and other sectors must be addressed. Climate change will further increase the burden of the overstretched health system. Kenya has estimated that the annual

cost of climate change impacts will be in the range of US$1-3bn by the year 2030.

In response to climate change adaptation in the health sector, Kenya will 'construct a large number of nomadic clinics; recruit more (about 24,000) technical staff to strengthen public health services across the country; [implement] heightened surveillance of new outbreaks with consequent rapid responses; and [carry out] health education campaigns.'(Government of Kenya, 2010)

While the national response has been stated, it has not been translated into policy that clearly defines objectives and means of achieving the objectives. A major weakness of this response strategy is that it does not include early warning systems to anticipate and prevent negative health impacts. Instead, the health sector will only respond to disasters in progress. Much remains to be done in developing a clear policy to address the potential impacts of climate change on health.

Uganda had not developed a national climate change policy as of November 2012 (Musoke 2012). However, a Climate Change Unit has been approved by the Cabinet and it is expected to start work on the national climate change policy.

Tanzania has focused on developing its NAPA. This process has included carrying out vulnerability assessments and prioritisation of areas where there is need to address climate change impacts, and this includes the health sector. However, the plans of action have not been implemented due to lack of financing (UNEP undated). The NAPA did not appear to result in any new thinking on potential governance mechanisms that could support long-term adaptation. It has been recommended that Tanzania should be supported to develop a new National Climate Change Policy and Strategy or 'new' NAPA which includes the screening of current and future sector initiatives (Government of Tanzania 2011).

Tanzania's population is exposed to the traditional water and vector borne diseases such as malaria, Rift Valley fever and cholera, among others. These three diseases occur in epidemic forms due to climate variability and are of great concern in Tanzania (Kibona 2008).

While these three East African countries in conjunction with WHO have developed guidelines and policies for disease prevention and control, there is a need to address the new risks posed by climate change. These risks include:

a.   epidemics and outbreaks;
b.   changes in disease seasonality and intensity of transmission;
c.   changes in geographic rage of disease epidemiology; and
d.   emerging and re-emerging infections.

Climate change considerations in regional health sector policies and strategies

On 20 November 2009 the Heads of State directed the East African Community (EAC) to develop a regional climate change policy and strategies. The policy is consistent with the fundamental principles of the Treaty establishing the EAC and principles of international environmental law according to the EAC Protocol on Environment and Natural Resources, the Protocol on Sustainable Development of Lake Victoria Basin and the UNFCCC (EAC 2011).

The policy prescribes statements and actions to guide climate change adaptation and mitigation to reduce the vulnerability of the region, enhance adaptive capacity and build socioeconomic resilience of vulnerable populations and ecosystems. In view of the high vulnerability of the region to the impacts of climate change, with the emerging associated challenges especially in food security, adaptation to climate change is of priority to the EAC region. The policy aims to implement priorities identified in the National Adaptation Plans of Action. In order to implement the regional policy, each state will be required to develop national policies and strategies.

Policy statements and actions for the health sector in the East African Community

a.   Develop effective early warning systems and emergency health measures for climate change related diseases;

b.   Facilitate availability of health facilities, equipment and medicine to assist in early diagnosis and treatment in climate change related diseases;

c.   Enhance capacity of medical personnel on climate change, including traditional/indigenous knowledge;

d.   Promote awareness among populations on climate change related diseases and their prevention;

e.   Provide access to healthcare services to vulnerable groups such as pregnant women, children, older persons and others; and

f.   Promote measures for preventing the spread and mitigating impacts of HIV/AIDS on the climate vulnerable populations; i.e. those living in co-infection hotspots such as highlands and flood prone areas.

Health considerations in climate change policies and strategies

In the EAC policy statement the health sector has been given adequate attention. The sector has been identified as a key and critical sector among other sectors such as agriculture, water and energy. The policy is in line with the new WHO climate change programme for Africa, which has an emphasis on early warning systems and early response to disease outbreaks and epidemics.

Policy trade-offs and barriers to mainstreaming climate change adaptation in the health sector

The policy has recognised the commonality of climate driven health concerns in the region and thus the joint approach to adaptation. For example, early warning systems for malaria developed in Kenya could be applied across the region. This could include the sharing of the expertise available in the region (Rapuro undated).

Among the barriers to mainstreaming climate change adaptation in the health sectors have been factors such as:

a.   Controversy regarding the link between climate change variability and its linkages to health

b.   Low research capacity and lack of high quality data

c.   Lack of funds for implementation of adaptation projects

d.   Poor implementation plans

Earlier research suggested that there was no linkage between, for example, malaria epidemics and climate variability (Reiter et al. 2004; Small et al. 2003; Hay et al. 2002b). However, it has now been shown that malaria epidemics in the East African Highlands are to a large extent driven by climate variability (Zhou et al. 2004; Patz et al. 2002; Githeko and Ndegwa 2001). These controversies slowed down the development of adaptation plans in the region due to the uncertainty in decision-making.

Despite several efforts to develop models for early warning for malaria, cholera and Rift Valley fever, there has been little success until recently. The local institutions have a low capacity for undertaking multidisciplinary research that would culminate in the development of the early warning systems. Nevertheless, there have been some notable successes (Githeko et al. 2012; Githeko and Ndegwa 2001). Capacity building in the area of climate and health is still undeveloped and this needs to be addressed.

Much of the research that has been undertaken in the region on climate change has been from external sources. There is a need for the provision of research

funds for this critical area from national budgets. This will ensure sustainable programmes that are able to track the dynamics of climate change impacts on health. Such funding will also sustain the local capacity to carry out research and development of adaptation actions and strategies.

Lack of national policies for adaptation in the health sector has been a major drawback. In the absence of clear policies it is difficult to allocate budgets for specific activities.

It has been noted that even the development of a policy will not automatically lead to its implementation. There are examples of programmes with well-defined policies that failed at the implementation stage due to poor management. Such examples include the cost-sharing programmes that failed in both Uganda and Kenya (Nabyonga et al. 2005; Githeko et al. 1992).

Key arguments for policies on adaptation to climate change in the health sector

Climate change is a dynamic process that needs continuous monitoring and response. The impacts of climate change are expected to increase in severity and frequency, thus demanding special attention. The geographic range of transmission is expected to change. There is need to align the current health policies to face these new challenges. These polices must clearly articulate the implementation plans with sustainable budgets. The adaptation policies must also include support for research and capacity building. The policies should address the ability to anticipate health outcomes and to undertake preventative measures. Such an approach will be much more cost effective than any attempt to control disease epidemics.

Key policy actors and networks involved with adaptation to climate change in the health sector

The policy actors have a role in formulating policies that affect human health and adaptation to climate change, while others are service providers or resource, data and knowledge mobilisers. Policies are formulated at country, regional and global levels. Many of these actors interact in the implementation of policies through networks. Among the actors are:

a.   Ministries of Health
b.   Departments of Meteorology
c.   Ministries of Finance
d.   Development partners
e.   UNFCCC
f.   WHO
g.   NGOs
h.   Research institutions
i.   Research funding institutions

j.   Regional economic communities
k.   Regional climate policy bodies – EAC and the African Climate Policy Centre (ACPC)

State of knowledge on funding streams for policies and strategies on adaptation in the health sector at national and regional levels

Traditionally funding for policy development has come from or through the United Nations Development Programme (UNDP). The Health Policy Project (HPP) supported by USAID is an NGO that has played a major role in assisting developing countries develop and also improve their health policies (Pfitzer and Krishnaswamy 2007). However, it appears that climate change is not yet on their agenda. While several adaptation projects have been carried out in the region, there is no indication that funding has been made available for policy formulation and strategies.

Key barriers to uptake of research evidence for policy formulation and implementation

A key barrier for uptake of research into policy in the region is the fact that the researchers and the users of their products reside in separate worlds. In most cases, once a researcher has published the results in a journal, there ends his or her mission. In most cases potential users of the results may not be aware of their existence, or the results may need validation before they are absorbed into policy. Published data may need to be formulated for users and policymakers. In other cases the research findings are presented in a complex way that discourages the end user. Conflicts of interest have also been known to prevent research findings from being used for policy. A good example is the change of policy from chloroquine in Kenya to sulfadoxine/pyrimetamine. Despite clear evidence that the malaria parasite *Plasmodium falciparum* had developed resistance to chloroquine as early as 1979, it took ten years to change the drug policy and this resulted in the loss of many lives (Shretta et al. 2008; Zucker et al. 1996).

Barriers such as the requirement for cost-benefit analysis have caused the failure of policy implementation. Health benefits do not always translate into direct tangible economic or financial benefits.

Many research projects do not have a sound knowledge sharing and communication strategy nor do they engage end users and stakeholders at the inception of the project. It is critical that research that is policy-relevant should have strong elements of stakeholder and end user engagement. Projects must also have good communication strategies including the engagement of electronic and print media. High quality short videos and even blogs are highly effective advocacy tools.

Key barriers to successful policy implementation for adaptation in the health sector

At the onset the research must be policy relevant. The issue under investigation should address an existing policy gap. The entry of research findings into the policy arena is a complex process that addresses not only the health conditions but also the political and financial implications of the interventions. Policy implementation may involve the development of a new policy or a modification of an existing policy. In many cases it may mean moving into uncharted waters and that can cause much resistance. Quite often systemic changes in behaviour and practice are required in the implementation of the policy.

The Pressure-State-Response framework may indicate how the system will behave. In the health sector an emerging health condition will generate pressure on the health services that may require interventions from several quarters. The pressure forms a state that can then determine the responses. HIV/AIDS is such an example. Ultimately the response will be a function of the pressure and the state. In the climate change environment the vulnerability of human systems determines the state of health under pressure from climate-driven threats.

Unfortunately the health sector has evolved to respond to crisis, and conditions that are not in a crisis mode may receive little attention. Response to climate change only appears when serious epidemics happen and the matter is forgotten as soon as the event (pressure) is over. Thus climate change has not been able to create a state that calls for immediate and sustained interventions.

Where the health condition does not generate sufficient pressure it is necessary to advocate for policy intervention to sustain pressure on the system until a response is obtained. For this to happen there must be very good evidence that diminishes uncertainty in any decision process. Whenever possible the potential benefits of the new policy must be abundantly expressed. Much mobilisation work and advocacy is required and the media becomes very useful in marshalling support for the proposed policy intervention.

Gaps in climate change adaptation research and policy in the health sector

Areas of insufficient knowledge on adaptation to climate change in the health sector in the region

As of now there are no policy guidelines on the priority areas of research with regards to addressing impacts of and adaptation to climate change. Furthermore, little has been done on creating multidisciplinary research

teams to address the often complex pathways of disease pathogens, ecosystems and climate interactions. There is also need to develop conceptual frameworks for model development. Model development and testing requires high quality climate and health data sets and these have been in short supply. In some cases the wrong data has been used (Hay et al. 2002a) and in other cases data sets with errors have been used (Omumbo et al. 2011). Inappropriate use of data has led to wrong conclusions.

While the association between malaria epidemics and climate variability has been resolved (Paaijmans et al. 2009; Pascual et al. 2006), much work remains in determining the geographic range expansion of malaria in Uganda and Tanzania. Some evidence to this effect in Kenya has been gathered but much more need to be done (Githeko 2009). In Kenya it is now estimated that an additional 4m people are at risk of epidemic malaria in the central Kenyan highlands where the disease did not exists before the early 1990s. It is suspected that the disease has spread to higher altitudes in Tanzania but little or no evidenced has been documented. A similar situation can be expected in the Ugandan highlands. There is emerging evidence that Rift Valley fever has expanded its geographic range in Kenya and Tanzania but there is need for surveillance and documentation of these changes.

Cholera has spread throughout the Great Lakes region, suggesting that the risk of cholera epidemics may be increasing in the region. Data is required on the changing water temperatures in the lakes in the region, as this would be an indicator of the increased risk of transmission. In addition the levels of phytoplankton need to be monitored as this supports zooplanktons that are the reservoir of cholera bacteria in the water. Cholera surveillance is equally important because many people are asymptomatic carriers, maintaining the disease in the human population.

Modelling climate change dynamics in cholera still requires a lot of research before reliable early warning systems can be developed.

Dengue is a disease that has ravaged Asia and South America, and there are indications that the disease is gaining a foothold in Africa; yet not much is known about its transmission on the continent. Little work has been done on the ecology of the dengue vectors and their linkages to climate change and variability. The geographic range distribution of the Asian tiger mosquito, *Aedes albopictus*, has not been mapped in East Africa, yet this vector can transmit a number of viral diseases. It is still not clear whether droughts drive dengue fever outbreaks in the region, although there is some evidence to support this hypothesis. It would be expected that rainfall in urban areas could increase the breeding of *Ae. aegypti,* but no data is available.

The dengue virus occurs in four serotypes and infections with more than one of the serotypes can cause dengue haemorrhagic fever and dengue shock syndrome. These are serious medical conditions that can be fatal. There is need to monitor the distribution of the serotypes in the region and map out the risk of the more severe forms of the disease.

Chikungunya fever is similar to dengue and it is transmitted by the same vectors. This is a re-emerging disease and it is not clear whether it is being driven by climate change and variability or by the prevalence of the vector *Ae. albopictus* in rural areas. Research is required leading to an understanding of the key drivers of the disease. It should be noted that Chikungunya fever has also spread to Europe, possibly due to the spread of *Ae. albopictus.*

Leishmaniasis is a disease transmitted by sand flies and is associated with drylands. Climate change is likely to increase the frequency of droughts in the region and this may increase the risk of leishmaniasis transmission. There is evidence from South America that the risk of leishmaniasis increased during El Niño-driven droughts. A similar patter may be possible in the East African region. The disease has been classified as a tropical neglected disease and little research has been carried out on its epidemiology in the last decade.

Adaptation in the agricultural sector will include increased irrigation. Schistosomiasis is heavily associated with irrigation systems. Malaria is also associated with irrigation and in particular rice irrigation schemes. There is need to develop strategies for minimising the transmission of the two diseases in any new irrigation schemes. This could include improved housing and sanitation facilities.

Missing elements in national policy frameworks

Climate change adaptation policies must be based on clear evidence of impacts and vulnerability of the human populations. The attribution of climate change and variability must be equivocal. In retrospect, much controversy has been generated in trying to explain the cause of malaria in the East African highlands. The epidemics were variously attributed to drug resistance, population migration and lack of vector control. Under such circumstances it was difficult to articulate a clear policy. It is critically important that policymakers be convinced with supporting evidence that the observed dynamics of the disease are primarily due to climate change. However, low research capacity has prevented the gathering of such evidence.

For a while there was a perception that adaptation is a separate programme from the normal government development programmes. In this regard it was felt that extra financing is required to fund adaptation programmes. However, it has become clear that adaptation will have to be embedded in the normal development budgets, perhaps with some external support.

A cause of concern in adaptation is its cost. In the past the concept of disaster management has dominated the adaptation debate. However, in recent times disaster prevention has taken centre stage. The development of early warning systems can go a long way in launching interventions before the impacts of an impending disaster can occur. This approach can significantly lower the cost of reducing climate change impacts.

Identified challenges to uptake and integration of research findings in policies

There appears to be a missing link between research institutions and the end users of the research outputs in the ministries of health. Furthermore, the ministries of health depend to a large extent on external policy advisors to formulate their policies. The local researchers rarely interact with ministry personnel at the policymaking level. In many cases the policy advisors are also linked to development partners and these support the implementation of the new policies. An example is the Health Policy Project in Kenya that is linked to USAID. HPP has been instrumental in shaping health policies in the country. 'HPP work with government and health institutions to develop effective and efficient financing mechanisms that maximise the country's funding resources to deliver high-quality, equitable, and affordable healthcare services to all Kenyans.'(Futures Group, 2011).

To close the gap between policymakers and researchers there is need to establish national subsidiary bodies of technical advice (SBTA) in the region. These bodies would identify the countries' research that needs the attention of research institutions. Once the results are obtained then they would be evaluated for inclusion into policy. Currently the ministry of health professionals are too preoccupied with providing services and they have little or no time to focus on new research findings. The SBTA should periodically summarise research findings and present them as briefs to policymakers. The SBTA should comprise researchers and health professionals.

Options and possible policy spaces for improved uptake of research findings

The region must build a creditable research capacity for advising the health sector in all matters of climate change and health. There is a need to move away from the traditional practice where researchers merely publish their results in journals. Research institutions need to get into transitional research to make sure that results that can be implemented to reduce negative health impacts do not just remain in medical journals. The health sector must also reduce its reliance of foreign experts to undertake research which in many cases is of academic relevance and not development oriented.

Development partners need to interact more actively with local researchers so that there is a shared vision and mission. Local scientists need to undertake more policy relevant research as opposed to academic research that has little chance of utility in the health sector.

Analysis of stakeholders and opportunities for collaboration: Key institutional actors involved with research and policymaking on climate change adaptation in the health sector

Major research institutions

It must be pointed out that the term 'adaptation' is not used in the health sector. The term has its origins in the environmental world. The health sector makes reference to adaptation as intervention programmes that are long term in nature; this being more a matter of mitigation and elimination of a health risk. Within the epidemiological framework, climate change and variability are risk factors for disease transmission and other health disorders. Risk factors in health are managed by reducing the exposure of human populations. Examples can be found in malaria, HIV/AIDS, cancer, etc. Climate change and variability in themselves are not pathogenic, and they in most cases affect human beings by increasing pathogens in the environment. The major problem with handling climate risk is knowing how, when and where it increases health hazards. Answering these questions is a major step towards adaptation, as this would allow action to be taken to reduce exposure to the climate induced risks. The tools to reduce the health risk in most cases already exist. For example, in malaria insecticide treated bed nets and indoor residual spraying can reduce the risk of malaria infections. However, the application of these interventions in space and time has been problematic. Research in adaptation needs to address the issue of risk attribution and its spread in time and space.

Kenya and Tanzania each have a fairly well developed national medical research institute. Uganda has not developed such an institute. Many of the local universities carry out some research but much of it may have little application in the health sector. There are also many foreign universities collaborating with local universities and research institutions to carry out research in health in the region. Many of these universities are funded by the US National Institutes of Health (NIH). Much of the research by these collaborators addresses basic scientific questions and transition research does not receive much attention.

The US-based CDC carries out extensive research on major disease in East Africa, mainly in Kenya and Uganda. It addresses diseases such as malaria, HIV/AIDS, tuberculosis and diarrhoea. It also has a programme on emerging and re-emerging infections. Among the regions national medical research institutions it is only the Kenya

Medical Research Institute (KEMRI) that has a climate and human health research programme addressing epidemic malaria in Kenya. The KEMRI's climate and human health research unit has undertaken collaborative research with institutions in Tanzania and Uganda.

In Kenya there are two large international research institutions, the International Centre of Insect Physiology and Ecology *(icipe)* and the International Livestock Research Institute (ILRI). *icipe* has four major divisions:

- Human health
- Animal health
- Plant health
- Environmental health

To date *icipe* does not have an active climate change human health programme. It has however collaborated with KEMRI in the past. *icipe* has carried out research on the ecology of Rift Valley fever in areas that have been affected by recent epidemics. ILRI is also based in Kenya and has its origins in research on theileriosis, babesiosis and trypanosomiasis, all animal diseases. ILRI has carried out research on Rift Valley fever but focusing on livestock. The UK-based Wellcome Trust, like CDC, works in collaboration with KEMRI and has carried out extensive research on malaria in Kenya.

KEMRI and the Tanzanian National Institute for Medical Research (NIMR) are the major health research institutions in the region, and they also coordinate collaborative medical research. The African Medical and Research Foundation (AMREF) also has a large presence in the region and has been involved in malaria control.

Major policy stakeholders

Stakeholder mapping in climate change and health in the region has not been undertaken. This is because there are no national policies on climate change in health, or for that matter in any other sector.

In 2009, Kenya published its disaster preparedness policy (Government of Kenya 2009). The document outlines who should respond to disasters, many of which are climate driven, and how. The strategy does not adequately address disaster prevention. Health disasters such as epidemics are covered in this draft policy. The draft policy could be a precursor to a national climate change adaptation policy that has an emphasis on early warning and disaster prevention. The document identifies the major stakeholders involved in the national disaster preparedness, including all government ministries, development partners and UN and other international agencies.

In Tanzania the National Disaster Management Policy was published in 2004. The policy aims to mainstream disaster management activities as an integral part of development programmes in all sectors. Thus all sectors in Tanzania are stakeholders in disaster preparedness and response. External assistance from development partners and UN agencies would be required, and thus too would be other stakeholders. Like Kenya, Tanzania does not yet have a national climate change policy and relies on the EAC joint policy guidelines.

Uganda also has an outline of a disaster management and preparedness plan which was mainly developed to address climate related disasters. As in the other two countries, the policy includes all sectors in the government and international agencies such as the Red Cross.

Identified or inferred missing voices in research and policy debates

The region is relying on its disaster preparedness and management policies at the moment and is yet to start developing concrete climate change policies to address the health sector. WHO has produced guidelines on mainstreaming gender in climate change issues and it is expected that these will be addressed as the policy dialogue and debate intensifies (WHO 2012). Climate change impacts in marginalised communities are complex as they affect the wellbeing and livelihoods of such communities in many ways. For example, pastoralist communities face drought, famine, climate sensitive diseases, water stress and resource conflicts. Migratory lifestyles expose them to additional hazards.

There are other populations living in a climate change hot-spots where the impacts are likely to be high. The Lake Victoria basin is prone to several climate driven disasters such as outbreaks of cholera and other diarrhoeal diseases. In addition there are numerous other waterborne diseases in the region and these are exacerbated by a high prevalence of HIV/AIDS. Life expectancy at birth in the Kenyan part of the basin has been reported to be as low as 36 years for males and 38 for females due to the combination of water borne and vector borne diseases and HIV/AIDS (Adazu et al. 2005). The basin is prone to flooding and consequently it is affected by a high prevalence of vector and water borne diseases. Trypanosomiasis epidemics have also occurred in the basin.

Lake Victoria is the most dangerous fresh water lake in the world and about 5,000 people lose their lives in the lake due to bad weather conditions (Semazzi et al. 2012). Populations living in malaria prone regions in the East African highlands need a voice. Despite some successes in the control of malaria in the highlands, the meteorological risks will continue to increase due to climate change and variability.

Lessons from efforts to promote research-policy dialogues on adaptation in the health sector

Mainstreaming adaptation in the health sector has not taken place. The sector continues to address emerging health threats as they occur. The sector also faces many challenges which include capacity to provide services and carry out research and also to finance these activities. These issues have been addressed in the EAC policy guidelines, but each country must develop its own version of the policy and an implementation plan. While the new EAC policy guidelines have identified climate change as a major driver of some of the health disasters in the regions, they also recognise the great need to address capacity to handle the challenge.

At a broader scale the ACPC recognises that adaptation in all sectors must be embedded in development plans (Mainlay and Tan 2012). It is thus hoped that the member states will use this strategy to mainstream adaptation into their development plans rather than initiate a separate adaptation plan.

To promote research-policy dialogue there is a need to set up a special body to serve as a liaison between researchers, health professionals and policymakers. There is a need for a more proactive communication and knowledge sharing among these groups. Local experts must play a bigger role in advising their governments on adaptation strategies in order to minimise conflicts of interests between development partners and foreign policy advisors. Researchers must be recognised as major stakeholders in the adaptation process. Trust must be developed between the various partners in the adaptation process, as this will also promote a sense of ownership and commitment. Policymakers must promote research that advances adaptation in the sector. For example, there is evidence that simple modifications to village houses can significantly reduce the risk if malaria transmission. Such research should be fast-tracked as it has enormous benefits to local communities due to its affordability and sustainability (Atieli et al. 2009).

Conclusions and recommendations

The role of climate change challenges in the context of the multiple challenges and opportunities facing the health sector in the region

Even in the absence of climate change the health sector faces many challenges. These include economic growth that cannot match the population growth, and therefore a shortage in the provision of health services. Other challenges include emerging and re-emerging diseases such as HIV/AIDS, avian flu and tuberculosis. In addition pathogens develop resistance to drugs and

vectors to insecticides. Many countries in the region have lost health professionals to better paying countries, and this brain drain presents a major challenge to the health sector.

Climate change is an added burden to existing health challenges. For example, climate change has significantly increased the populations at risk of malaria in the East African highlands. A malaria epidemic can increase the number of malaria cases by 100-700 percent and thus outstrip the health services. Cholera outbreaks and epidemics are becoming more frequent in the region, and the geographic range of Rift Valley fever is growing. Droughts have intensified and these have both short-term and long term impacts on human health.

The current state of knowledge on adaptation to climate change in the health sector in the region

There are no guidelines to inform health related decisions under climate change conditions. For example, little or no mapping has been carried out to indicate the extent of changes in geographic range of climate sensitive diseases. Adaptation in the climate change context requires a strong emphasis on anticipation of risks and the deployment of strategies to minimise these risks. Climate change has not yet been factored as a health risk in the sector. The sector needs to develop tools to assess this risk factor and address it. Such tools include disease-climate models and early warning systems.

Apart from the cases of malaria and Rift Valley fever epidemics, no other disease outbreak or health condition has been attributed to climate change. There has been an effort to link HIV/AIDS to climate change, but this attribution is not supported by any scientific evidence. Much local research is required to determine the relationships between climate sensitive diseases and climate change and variability.

The current state of knowledge on whether and how research findings are integrated in health sector policies in the region

Currently the region is just beginning to articulate regional guidelines for national policies to deal with the impacts of climate change in the health sector. While local research may have identified potential impacts of climate change in the health sector, much remains to be done by way of practicing active adaptation. There has been some progress in using the climate based early malaria epidemic prediction models, but the capacity to use these models in the region is poorly developed. Equally there are no local experts in using the tools developed for early prediction of Rift Valley fever. In many cases the ministries of health only have a focal person for climate change matters. This state of affairs does not leave much room for assimilation of research findings

and their application in disease prediction, prevention and control.

Major gaps in research on adaptation to climate change in the health sector

This review has identified the following major gaps in research on adaptation in the East African region:

a. Detecting changes in disease geographic distribution

b. Detecting changes in disease seasonality

c. Attributing these changes to climate change and variability

d. Developing locally applicable, affordable and sustainable disease prevention and control strategies

e. Developing early warning systems for detection of disease outbreaks and geographic spread

f. Developing rapid response systems for disease prevention and control

g. Identifying epidemic and disease hot-spots

h. Tracking emerging and re-emerging infections

Ensuring that research findings are better integrated into health sector policies

There is an urgent need to develop new capacity in all the relevant fields in the health sector to handle issues of climate change and human health. Skills are required in health sciences, statistics and meteorology. This will enhance the understanding of the relationship between diseases, climate change and variability. In addition there is need to put in place technical groups that assimilate research findings and translate them into policy relevant information. This will help policymakers in making evidence-based decisions. The role of such groups would be purely advisory and they should draw from both the research and practice domains of the sector.

Current state of knowledge on the stakeholders involved with research and policy on adaptation to climate change in the health sector in the region, and potential for improved stakeholder involvement

There has been little in the way of stakeholder involvement in the sector. Many of the activities related to climate change involve local and international research organisations. Among these groups there have been many controversies, particularly in malaria and on issues of attribution. There has been support from funding agencies such as NIH, DFID, UNDP, International Development Research Centre (IDRC) and Global Environment Facility (GEF). However, major players such as WHO have not been as visible as would be expected. This is likely to change with the new initiative on climate change and adaptation driven by WHO.

Local research institutions could be more active in identifying the impacts of climate change in the health sector. However, without external support little internal funding is available.

Recommendations for research and policy

There is need for a solid body of knowledge indicating the relationship between disease epidemiology and climate change and variability. This will be achieved through the integration of the biology of transmission and mathematics. It is critical that models are developed on how meteorological parameters relate to the rate of disease transmission. This will greatly help in defining in precise terms the risk climate change and variability bring to bear on disease epidemiology. These relationships will also be used in determining future trends in the risk of disease transmission and thus the actions that need to be taken to prevent the potential impacts of diseases. Similar models will be required to indicate the potential geographic spread of climate sensitive diseases.

Biologists and meteorologists will need a great deal of collaboration, data and knowledge sharing in developing predictive tools. There is need to increase the policy space by including major stakeholders and increasing capacities in evaluating the risks posed by climate change, proposing interventions and allocating resources for implementation. Policies for adaptation to climate change need to be treated with urgency, as the rate of climate change could accelerate or shift into a non-linear mode.

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