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AN OVERVIEW OF

CLIMATE CHANGE AND HEALTH IN UGANDA

JULY 2014

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ARCC

African and Latin American
Resilience to Climate Change Project

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Tetra Tech ARD Contacts:

Patricia Caffrey
Chief of Party
African and Latin American Resilience to Climate Change (ARCC)
Burlington, Vermont
Tel.: 802.658.3890
Patricia.Caffrey@tetratech.com

Anna Farmer
Project Manager
Burlington, Vermont
Tel.: 802.658.3890
Anna.Farmer@tetratech.com

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CLIMATE CHANGE AND HEALTH IN UGANDA

AFRICAN AND LATIN AMERICAN RESILIENCE TO CLIMATE CHANGE (ARCC)

JULY 2014

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ACRONYMS AND ABBREVIATIONS

CAN-U	Climate Action Network Uganda
CDC	Centers for Disease Control and Prevention
DRC	Democratic Republic of the Congo
ECO	Ecological Christian Organization
HIV/AIDS	Human immunodeficiency virus infection / acquired immunodeficiency syndrome
IRS	indoor residual spraying
LLINs	long-lasting insecticide nets
LF	Lymphatic filariasis (elephantitis)
MUCCRI	Makerere University Centre for Climate Change Research and Innovations
NAPA	National Adaptation Programmes of Action
NMCP	National Malaria Control Program
NGOs	non-governmental organization
RVF	Rift Valley fever
STHs	Soil-transmitted helminthes
UNFPA	United Nations Population Fund
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development

1.0 INTRODUCTION

Climate change has significant direct and indirect health implications for Ugandans. It is predicted that Uganda will continue to experience rising temperatures, which will increase by more than 2 °C by 2030 (Tetra Tech ARD, 2013). Additionally, the growing variability of inter-annual rainfall is projected to continue, including increased rainfall during the dry season. This heavier rainfall is expected to increase the frequency of extreme events such as floods and landslides. This overview[1] explores how these anticipated temperature and rainfall projections, if realized, are likely to exacerbate diseases and other health-related factors. It also briefly examines the roles and relationships of other relevant health determinants, such as health care access, and includes an overview of current initiatives and recommendations for adaptation strategies to reduce the vulnerability of Ugandans to the anticipated health implications of climate change.

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2.0 CLIMATE CHANGE, SENSITIVITY, AND POTENTIAL HEALTH EFFECTS

Several diseases that are currently endemic in Uganda will likely increase in prevalence and distribution due to climate change. These diseases include mosquito-borne diseases such as malaria and lymphatic filariasis; soil-transmitted helminthes; trachoma; and waterborne diseases such as cholera and typhoid. Other diseases that Ugandans experience in a more localized or epidemic nature include plague, trypanosomiasis (sleeping sickness), and yellow fever. There is also potential for diseases that are not yet established in Uganda (in humans) to be introduced because of climate change, such as dengue fever, chikungungya, and Rift Valley fever. Finally, climate change threatens human health through its effects on food insecurity and malnutrition.

2.1 ENDEMIC INFECTIOUS DISEASES

2.1.1 Malaria

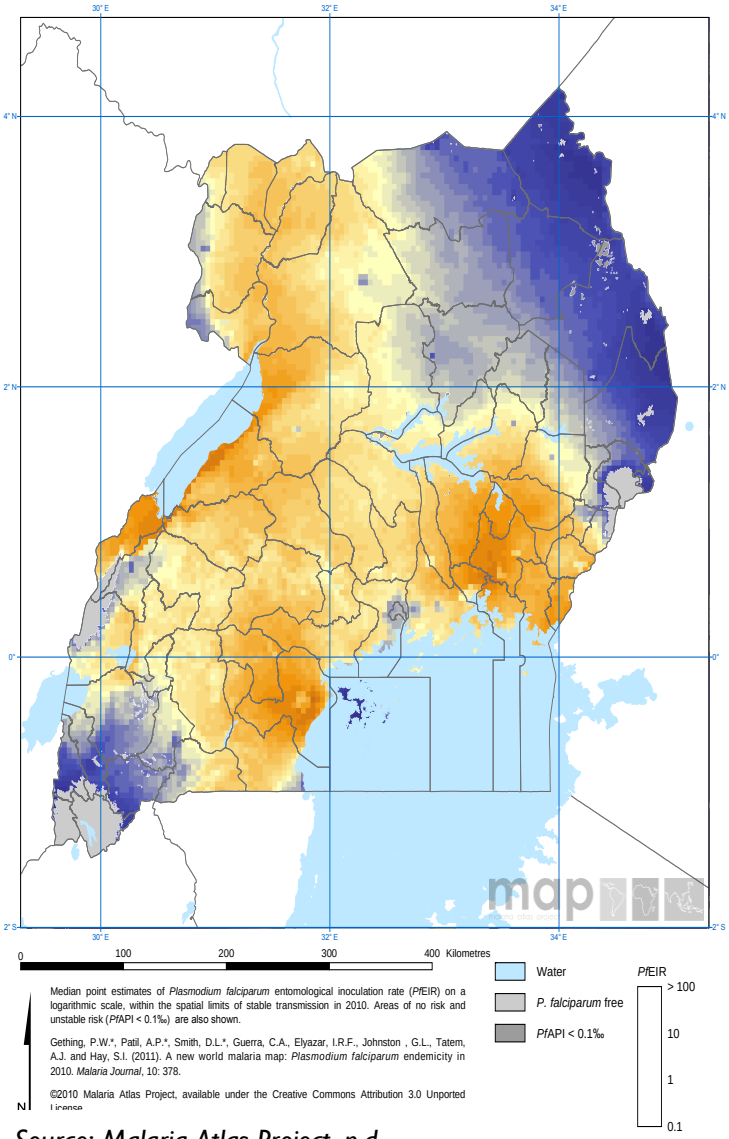
Malaria is endemic in 95 percent of Uganda (Ministry of Health, 2005) and sporadic or nonexistent in the remaining 5 percent of the country, notably in the highland areas (Malaria Atlas Project, n.d.). Temperature is a limiting factor for the malaria vector (*Anopheles)* and parasite (*Plasmodium*). Increases in temperature will allow malaria to proliferate in regions where it previously was not established or where it occurred in a sporadic nature, such as in regions with high altitude, generally thought to be above 1,500-2,000 m (Alonso, Bouma, & Pascual, 2011). Increasing temperatures will increase the speed of development of the parasite and mosquito, which, in in turn, will influence the survival of both (Lindsay & Martens, 1998). People living in high altitude regions have little to no immunity to malaria, creating highly susceptible populations. The introduction of malaria in these areas, without preventative or control measures in place, will lead to high morbidity and mortality among both children and adults.

In endemic regions, increases in temperature can result in higher transmission intensities, caused by the acceleration of mosquito and parasite development, resulting in a higher burden of malaria in these regions. It is thought that temperatures of 30-32 ˚C are optimal for the spread of malaria through parasites and mosquitos (Craig, Snow, & Le Sueur, 1999; Parham & Michael, 2009). If, however, temperatures exceed 33 ˚C, the transmission of malaria may decrease.

Increased flooding or rainfall could also increase the burden of malaria, given that there will be more breeding sites and increased humidity affecting mosquito longevity and parasite development (Protopopoff et al., 2009). Conversely, increases in severe rainfall events may wash out any mosquito larvae in these pools or aquatic environments, consequently decreasing mosquito and parasite populations (Paaijmans, Wandago, Githeko, & Takken, 2007). Based upon the climate predictions of increased temperatures and shifting to a wetter dry season, the burden of malaria is likely to increase in endemic areas given the climate suitability for increased vector and parasite development. On the other hand, the potential increases in malaria may be offset or surpassed by improvements in malaria treatment and prevention, which is briefly discussed in the Non-Climate-Related Health Determinants section (page 8).

MAP 1. ENTOMOLOGICAL INOCULATION RATE—*PLASMODIUM FALCIPARUM* IN 2010 FOR UGANDA

The spatial distribution of *Plasmodium falciparum* entomological inoculation rate in 2010 Uganda



Source: Malaria Atlas Project, n.d.

2.1.2 Lymphatic Filariasis

Lymphatic filariasis (LF), commonly known as elephantitis, is a parasitic disease transmitted to humans by mosquitoes. An estimated 13 percent of the Ugandan population is infected with the roundworm parasite that causes LF (Slater & Michael, 2013). Climate change projections indicate that an expansion of both the range and risk of LF will occur. The occurrence of LF increases as temperature rises up to approximately 32 °C, after which transmission begins to decline (Slater & Michael, 2012). Greater precipitation is also associated with increased LF transmission. Currently, LF is primarily concentrated in the low altitude (<1,150 m) northern areas of Uganda (Stensgaard et al., 2011). According to a recent study, the prevalence of LF infection in Uganda is expected to increase by approximately 17 percent between 2000 and 2050, based on projected changes in several environmental and demographic factors (e.g., mean annual temperature, precipitation, population density) (Slater & Michael, 2013). As temperatures rise, there is also a risk that LF transmission will expand into higher altitude areas in Uganda, particularly the northeastern highland areas that border currently endemic areas. If mean average temperatures increase above 32 °C in some warmer areas of Uganda, LF transmission may decline. Finally, as with other mosquito-borne diseases, the projected increase in extreme rainfall and flooding episodes may damage vector habitats, potentially leading to short-term declines in the prevalence of LF.

2.1.3 Schistosomiasis

Schistosomiasis, a waterborne parasitic disease transmitted by snails, is a major health problem in Uganda, causing approximately 40,000 deaths per year (Kabatereine et al., 2011; Schur et al., 2013). An estimated 8.5 million Ugandans were infected with the parasite in 2010. Climate change is projected to affect both the prevalence and geographical range of schistosomiasis transmission in Uganda (Schur et al., 2013). Increasing temperatures are expected to accelerate parasite transmission within the range of temperatures in which the host and parasite can live (approximately 20-30 °C) (Mangal, Paterson, & Fenton, 2008). In Uganda, rising temperatures will likely increase the incidence of schistosomiasis in most endemic areas, although declines may be seen in some areas if temperatures become too warm to sustain snail populations. In addition, climate change is expected to expand the geographical range of schistosomiasis transmission in Uganda. There is already evidence that schistosomiasis infection has expanded in recent years into areas previously not thought to facilitate transmission (e.g., high altitude crater lakes in western Uganda), which may reflect climate change factors (John, Ezekiel, Philbert, & Andrew, 2008). Temperature increases projected over the next few decades are likely to further expand transmission into high altitude areas, particularly in the northeast and southwest highland areas. In currently endemic areas, where average temperatures remain below 30 °C, rising temperatures are likely to increase the disease burden. Finally, heavy rainfall and flooding can damage snail habitats, which may temporarily reduce transmission.

2.1.4 Soil-transmitted helminthes

Soil-transmitted helminthes (STHs) are intestinal worms that infect humans and are ubiquitous in Uganda, although their prevalence is lower in the higher elevation northeastern parts of the country. Transmitted through contact with human feces, STH infections primarily affect poor communities where sanitation is inadequate and treatment is limited. STHs cause significant morbidity in Uganda, contributing to malnutrition and anemia, and adversely affecting mental and physical development of children (Brooker, Kabatereine, Tukahebwa, & Kazembe, 2004). An estimated 44 percent of Ugandan schoolchildren are infected with hookworm, one of the most common STHs (Kabatereine et al., 2011). STHs have a high tolerance to heat and occur throughout the temperature range in Uganda, with hookworms thriving at temperatures up to approximately 40 °C (Brooker et al., 2004; Weaver, Hawdon, & Hoberg, 2010). Increasing temperature is associated with faster development and survival of parasite ova and larvae, which leads to a higher prevalence of STH infections in human populations, up to a temperature of about 37 °C (Brooker et al., 2004). It is likely that rising temperatures over the next two decades will increase the burden of STHs in Uganda (Weaver et al., 2010). Greater precipitation also increases parasite development, although heavy rainfall could hamper transmission by decreasing egg hatching and larval development (Weaver et al., 2010).

2.1.5 Trachoma

Trachoma, caused by infection with *Chlamydia trachomatis*, is the common cause of infectious blindness in Uganda. Transmitted through contact with infected eye and nasal secretions by hands, infected surfaces, and eye-seeking flies, trachoma primarily affects impoverished, rural communities with poor water and sanitation access (World Health Organization, n.d.). In Uganda, trachoma is confirmed to be endemic in 22 districts, putting about 8 million people at risk (International Coalition of Trachoma Control, 2011). Current evidence on the potential role of climate on trachoma distribution is limited, although there is some evidence that temperature and rainfall play a role in the transmission of acute trachoma (Ramesh, Kovats, Haslam, Schmidt, & Gilbert, 2013). In general, trachoma seems to be most prevalent in hot, dry climates. Increasing temperatures in trachoma-endemic areas of Uganda, such as the Karamoja region, may lead to increased transmission of the bacteria. In Uganda, trachoma is less prevalent at higher

altitudes — where temperatures tend to be cooler — possibly due to decreased fly activity at lower temperatures. Current evidence is unclear on the potential effects of climate change on trachoma infection in low endemic areas.

IMAGE 1. POTABLE WATER

Source: PC Tech, Ephraim Batambuze

2.1.6 Waterborne Diseases

Flooding resulting from severe rainfall events will potentially increase the prevalence and frequency of outbreaks of waterborne diseases such as cholera and typhoid. This can occur in areas with poor sanitation infrastructure, which is the case in many parts of Uganda, when flooding causes potable water and wastewaters to mix (Haande, 2008; Muyodi, Hecky, Kitamirike, & Odong, 2009). The risk of contracting waterborne diseases may also be amplified by increased temperature, as bacteria proliferate more rapidly at higher temperatures (McMichael, Woodruff, & Hales, 2006).

Cholera is mainly an epidemic disease in Uganda, with a yearly incidence of 250 to 5,000 cases, although it is endemic in certain parts of the country, such as the Kampala slums and along the southwestern border with the Democratic Republic of the Congo (DRC) (Bwire et al., 2013). The burden of typhoid in Uganda remains unclear, although it has been associated with outbreaks and likely is endemic in certain regions as well (Neil et al., 2012). Other waterborne bacteria and viruses that could contaminate drinking water include *E. coli*, *Cryptosporidium*, hepatitis (A and E), and *Giardia* (Patz et al., 2003).

Additionally, the increased run-off of surface water due to heavy rains and rainfall occurring during the dry season will increase the mobilization of fecal materials, leading to fecal bacteria being introduced into bodies of water (e.g., Lake Victoria, Lake Albert), increasing the nutrition load and thereby causing an explosive growth of algal species such as cyanobacteria (Haande, 2008; Muyodi et al., 2009). Cyanobacteria can produce cyanotoxins, which can be a health hazard when present in drinking water supplies or waters that are used for recreational activities (Haande, 2008). Different cyanotoxins include hepatotoxins, neurotoxins, and cytotoxins, as well as skin irritants and gastrointestinal toxins.

2.2 LOCALIZED OR SPORADIC INFECTIOUS DISEASES

2.2.1 Plague

Plague is a severe bacterial infection transmitted to humans by fleas, with rodents serving as a reservoir. Plague cases in Uganda are primarily concentrated in the West Nile region bordering the DRC and are highly seasonal, with the majority of cases occurring between September and December (Moore et al., 2012a). Climate influences all three components of plague transmission: bacteria, fleas, and rodents. Increased rainfall tends to increase rodent populations, likely as a result of increased vegetation that provides food, as well as supporting the survival and reproduction of fleas (MacMillan et al., 2012). Plague outbreaks tend to occur at moderate temperatures (<27 °C), such as in the high elevation West Nile Region (Ben Ari et al., 2011). In northwestern Uganda, risk of plague transmission was negatively associated with dry season rainfall (December to February) and positively associated with rainfall prior to plague season (June to July) (Moore et al., 2012a). Given that rainfall in Uganda is projected to increase during December to February (Tetra Tech ARD, 2013), this may lead to a reduction in the risk

of plague in Uganda. Finally, it seems improbable that the geographical range of plague will expand in Uganda, as most of the country already experiences temperatures too warm to sustain plague epidemics.

2.2.2 Trypanosomiasis

African trypanosomiasis, commonly known as sleeping sickness, is a parasitic infection of the nervous system transmitted to humans by the tsetse fly. It is a serious public health problem in the northwestern and southeastern regions of Uganda (Berrang-Ford, Berke, Abdelrahman, Waltner-Toews, & McDermott, 2006). Sleeping sickness is very likely to be affected by climate change, with increasing temperatures and humidity influencing both parasite development and the distribution of suitable tsetse habitats (Moore, Shrestha, Tom, & Vuong, 2012b). Epidemic transmission of trypanosomiasis occurs at intermediate temperatures (approximately 20-26 °C) (Moore et al., 2012b). As such, in some areas previously affected by trypanosomiasis epidemics, climate change may result in temperatures too hot for parasite transmission. In contrast, higher temperatures will likely expand transmission into areas that were previously too cold. In Uganda, transmission is expected to become more favorable in the highland areas, which would pose a significant risk for human and livestock populations previously unexposed to the parasite (Moore et al, 2012b).

IMAGE 2. *AEDES AEGYPTI* MOSQUITO

Source: Wikipedia

2.2.3 Yellow Fever

A large outbreak of yellow fever was reported in northern Uganda between 2010 and 2011 (Wamala et al., 2012), with other outbreaks having been reported decades earlier (Ellis & Barrett, 2008). Yellow fever does not appear to be endemic in human populations in Uganda, although increasing temperature and rainfall during the dry season could cause outbreaks of yellow fever to occur more frequently. Yellow fever is transmitted by the *Aedes* mosquito, which exists in Uganda (Mutebi et al., 2012; Mweya, Kimera, Kija, & Mboera, 2013). Increased rainfall will likely increase the mosquito population by providing more breeding sites (e.g., tree holes, water storage containers) (Reiter, 2001). Also, the yellow fever virus develops more quickly with rising temperatures, increasing the proportion of mosquitoes that become infectious. *Aedes* mosquitoes are less responsive to temperature than *Anopheles* mosquitoes and can survive at temperatures between 6-40˚C (Martens, Jetten, & Focks, 1997). Potential transitional areas for yellow fever transmission in Uganda include regions that are bordering endemic countries, including Kenya, South Sudan, DRC, and Rwanda, and also regions where *Aedes* mosquitos and non-human primate hosts are present (Jentes et al., 2011). Risk areas include village settlements close to forested areas and neighboring communities (Mutebi et al., 2012).

2.3 INTRODUCED INFECTIOUS DISEASES

2.3.1 Chikungungya And Dengue Fever

Human transmission of chikungungya and dengue fever have been reported in Uganda, although they do not appear to be endemic nor have they been associated with epidemics (Burt, Rolph, Rulli, S, & Heise, 2012; CDC, n.d.; Kalunda, Lwanga-Ssozi, Lule, & Mukuye, 1985). Both viruses are also transmitted by the *Aedes* mosquito and therefore have similar climate sensitivities to yellow fever. The dengue virus develops more rapidly with increasing temperatures and does not survive below 12-13˚C (Martens et

al., 1997). Increasing rainfall during the dry season can increase the mosquito population and also influence the speed of virus development. Areas at-risk for chikungungya and dengue transmission are those that border areas of known transmission and also regions where the *Aedes* vector is present. Dengue transmission is currently present in Kenya, South Sudan, DRC, and Tanzania (Brady et al., 2012) although it is uncertain where chikungungya transmission is currently occurring in East Africa.

2.3.2 Rift Valley Fever

Large human outbreaks of Rift Valley fever (RVF) have been reported in neighboring countries to Uganda (Centers for Disease Control and Prevention, 1998), and the virus has been isolated in animals in Uganda (Anyamba et al., 2009; Magona, Galiwango, Walubengo, & Mukiibi, 2013). RVF is transmitted by *Aedes* and *Culex* mosquitos, both of which are present in Uganda (Mutebi et al., 2012; Mweya et al., 2013). Increasing rainfall during the dry season can increase the mosquito population and also influence the speed of virus development (Chretien et al., 2008). Areas at-risk for RVF transmission include areas bordering South Sudan, Kenya, and Tanzania, areas in Uganda where the virus has been isolated (e.g., Sembabule, Mpigi, Masaka and Mubende Districts), and regions where *Aedes* and *Culex* mosquitos reside.

2.4 OTHER HEALTH ISSUES

Malnutrition and HIV/AIDS both have important consequences on peoples' resilience to climate change and particularly to extreme events such as heavy rainfall and flooding that adversely affect agriculture.

People suffering from malnutrition and/or living with HIV are particularly vulnerable to the adverse effects of climate change on food crops, access to markets, and the increased prevalence of infectious disease. It has been well-documented that projected climate changes will adversely impact agricultural production and various staples of the Ugandan diet, potentially leading to food security issues and consequently malnutrition (Berrang-Ford et al., 2012; Tetra Tech ARD, 2013; Thompson, Berrang-Ford, & Ford, 2010). Five diet staples have been identified as having medium to high sensitivity to climate change: beans, matooke, maize, rice, and sorghum. All are vulnerable to extremes of temperature and precipitation during various stages of crop development (Tetra Tech ARD, 2013). Additionally, certain diseases and pests will thrive in moisture and increased temperatures, which will also adversely affect the yield and survival of the crops. Finally, increases in extreme weather events will damage crops and disrupt farming (Costello et al., 2009). All of these factors will contribute to food insecurity, which will be particularly significant for vulnerable populations including children, pregnant women, and the elderly. Malnutrition will increase the susceptibility of these vulnerable groups to a variety of diseases, including diarrheal diseases, tuberculosis, malaria, and cardiac disease, because their immune systems will be weakened (Balbus & Malina, 2009).

HIV has also been associated with a worsening of nutritional status, particularly among children (Nalwoga et al, 2010), a compounding challenge in the face of climate-induced food insecurity. HIV/AIDS decreases the body's capability to fight diseases like malaria and cholera, making people who are HIV-positive more sensitive to other health factors. The prevalence of HIV/AIDS is relatively high in Uganda, currently at 6.7 percent (Ministry of Health, 2011).

3.0 NON-CLIMATE-RELATED HEALTH DETERMINANTS

3.1 CLINICAL AND PUBLIC HEALTH SERVICES

Many factors other than climate change impact the health of the Ugandan population. Several climate-related diseases (e.g., malaria, lymphatic filariasis, cholera) have effective treatments that, if widely available, could mitigate the projected increases in prevalence due to climate change. However, effective and timely treatment is often not available to those in need for a variety of reasons. Uganda faces many challenges in providing good quality health services to the population including a severe shortage of skilled health workers, under-financed and under-resourced health systems, common drug shortages, and inadequate distribution of facilities in rural areas (Kiwanuka et al., 2008). In the case of malaria, drug resistance and the wide availability and use of counterfeit drugs also threaten the ability to successfully treat infections and interrupt transmission (Björkman-Nyqvist, Svensson, & Yanagizawa-Drott, 2013).

IMAGE 3. RED CROSS ASSISTING FLOOD VICTIMS

Source: Soroptimist Club

In addition to effective treatment of existing disease cases, comprehensive prevention strategies (e.g., indoor residual spraying for malaria and mass treatment of livestock for trypanosomiasis) can greatly reduce the burden of climate change-related diseases. Climate change, however, can also be expected to exacerbate current challenges to health services. For example, the potential for climate change to intensify flood patterns could lead to more frequent road closures, limiting access to health services, and making disease and vector control efforts and delivery of medications to health facilities more difficult.

3.2 SOCIOECONOMIC CONDITIONS

While socioeconomic conditions have generally improved over the past several decades in Uganda, a quarter of the population still lives on under $1.25 USD per day. Further, it is estimated that between 30 percent (Uganda Bureau of Statistics, 2012) and 50 percent (Muyodi, 2013) of households have no access to protected sources of drinking water. All of the diseases identified above are exacerbated by poverty and poor socioeconomic conditions (e.g., low education, poor housing conditions, inadequate water and sanitation, and poor access to preventive and curative health services). Many of these same factors, including low education and limited financial and social capital, also increase the vulnerability of households to climate change (Tetra Tech ARD, 2013).

Extreme events (e.g., floods, droughts) can lead to migration and displaced populations, which can contribute to conflicts over territory (McMichael, Woodruff, & Hales, 2006). In Uganda, households in areas affected by long-term conflict (e.g., Gulu district) are poorer, have lower education levels, and are more likely to be female-headed, all of which increase vulnerability to climate change (Tetra Tech ARD, 2013). It is well established that conflict and/or displaced populations also contribute to poor health outcomes; for example, conflict was linked to sleeping sickness outbreaks and disease resurgence in Uganda (Berrang-Ford, 2007).

Population growth is another major factor that will contribute to Uganda's vulnerability to climate change over the coming decades. Uganda has one of the highest annual population growth rates in the world, at 3.2 percent (Kisamba-Mugerwa, 2011). Rapid population growth increases the strain on health, food, and education systems, and worsens problems of local environmental degradation and resource depletion (UNFPA, 2009).

Climate change has the potential to substantially affect socioeconomic development in Uganda, as increasing temperatures and precipitation changes are expected to lead to a loss of economic livelihoods resulting from reduced crop yields and increases in pest infestations and crop diseases (Tetra Tech ARD, 2013). Additionally, flooding can damage buildings (e.g., health facilities, schools), roads, bridges, sanitation facilities, and water sources, which will exacerbate socioeconomic conditions directly and indirectly (e.g., through the reduced access to services). Less vulnerable households are inherently better prepared to cope with the effects of climate change, as they have larger land holdings and more livestock, greater adoption of new technology, higher levels of education, and a greater participation in income-generating activities outside farming (Tetra Tech ARD, 2013). More advantaged households will also be better able to cope with the health effects of climate change, through greater access to disease prevention and treatment, lower risk of malnutrition, and better household and environmental conditions.

4.0 CURRENT ADAPTATION PROGRAMS AND RECOMMENDATIONS FOR THE FUTURE

There are many initiatives in Uganda that strive to address many health concerns that are affected by climate change, (e.g., the distribution of insecticide treated bed-nets), but there is a recognized gap, as identified by various key informants, in policies and programs focused specifically on addressing health issues that are likely to worsen with climate change in Uganda.

4.1 POLICIES AND STRATEGIES

The Ministry of Health, environmental health division, provides leadership in mapping out and implementation of water and sanitation strategies. The Ministry is collaborating with UNICEF to develop new policy guidelines for water and sanitation including strategies to improve household sanitation through home visits and community led campaigns, technical and village health team capacity building, water quality assessment, solid, liquid, and gas waste management, and food safety and hygiene.

The Ugandan National Climate Change Policy includes health initiatives among its policy priorities. One goal of the policy is to "strengthen adaptive mechanisms and enhance early-warning systems and adequate preparedness for climate change-related diseases" (Ministry of Water and Environment, 2012). Specific health strategies include (but are not limited to) enhancing early-warning systems and preparedness for climate change-related diseases; increasing surveillance of disease outbreaks; and responding rapidly to epidemics by providing potable water and sanitation facilities to limit outbreaks of waterborne diseases. Other strategies involve strengthening public and clinical health systems, and increasing the health workforce's awareness of the relationship between climate change and human health.

Uganda also has a National Adaptation Programmes of Action (NAPA), with three of the projects related to climate change and health (Namanya, 2009):

- Community Water and Sanitation Project
- Vectors, Pests, and Disease Control Project
- Climate Change and Development Planning Project

Despite the strategic goals of national policy and NAPA, the establishment of the Climate Change Unit, and other national recommendations, Uganda has failed to successfully implement these health programs because resources are lacking, according to key informants.

Climate Action Network Uganda (CAN-U) is a network of over 200 local and international NGOs and other organizations working to respond to climate change and health-related issues in Uganda (Kabiswa, 2014). CAN-U is making efforts to solicit and build interest among CAN-U members regarding these issues (Kabongo, 2014). It also plans to urge the government toward increased commitment with respect to climate change and health, as this is the most feasible way to establish sustainable funding and resources.

4.2 PROGRAMS

There are many existing health programs that aim to prevent and treat most of the diseases that are described in this brief, but there are few programs that seek to improve the management of environmental conditions and modify behaviour to prevent and mitigate the effects of climate change. Examples of innovative programs that aim to do this are:

- Water for People, which is a consortium of donors, NGOs, local leaders, and artists who are using market-based approaches to improve access to potable water and better sanitation, especially through human waste management. Under the Cholera prevention campaign, the Ministry of Health and its partners are implementing activities that reduce introduction of fecal matter into surface and groundwater and improve monitoring and education at periods of high risk such as during major rain events. Programs include education on boiling all drinking water; the benefits of latrine use; hand washing with soap and water before preparing, serving, or eating food, and after using a latrine; food preparation and storage, such as covering cooked foods to avoid contamination; and correct use of disinfectants such as bleach.

- Vector control is one of the main malaria control strategies of the National Malaria Control Program (NMCP). The two main approaches promoted by the program are sleeping under a long-lasting insecticide net (LLINs) and indoor residual spraying (IRS) of households. In order to increase coverage of LLINs, the NMCP initially pursued a number of strategies including free distribution to pregnant women through antenatal care visits, provision of subsidized nets through the private sector, and sale of full-cost nets in the commercial sector. With funding from The Global Fund to Fight AIDS, Tuberculosis, and Malaria in 2007, the NMCP decided to carry out its first targeted community mass distribution campaign, beginning in central Uganda. This has now been replaced by the universal distribution LLIN campaign, which is ongoing. Indoor residual spraying is being conducted in 10 districts of Northern Uganda, where malaria burden was highest, and is supported by the Presidential Malaria Initiative.

- The Ecological Christian Organization (ECO), part of the CAN-U network, is involved with numerous activities concerning food security and malnutrition, which include an early warning meteorological system to inform action to prevent crop failure, training of animal health workers to respond to diseases in animals, and supporting the development of village-based crop advising (Kabiswa, 2014). In the Lake Victoria basin, ECO is also supporting an early warning system that informs the clearing of vegetation to control vector populations. In this region, they are also draining stagnant water to control vector-borne diseases and supporting clean water and sanitation campaigns, which involve cleaning waste material from beach areas to reduce waterborne diseases.

- The Department of Biological Sciences at Makerere University is researching the impacts of climate change on water resources, including the effects of cyanobacteria and algae (Muyodi, 2013). Future plans of this department include building its water quality monitoring and assessment capacities and directly applying their work (e.g., informing community-level interventions). Additionally, there are plans for increased coverage of climate change in their programs. The College of Agriculture and Environmental Sciences at Makerere University established the Makerere University Centre for

Climate Change Research and Innovations (MUCCRI) (Twinomuhangi, 2014). The relationship between human health and climate change traditionally has not been a focus of MUCCRI, although the Centre is currently examining strategies to cope with the effects of flooding, including cholera outbreaks (Twinomuhangi, 2014).

4.3 RECOMMENDATIONS

The following recommendations are based upon interviews with key informants, previous recommendations for policy and strategy direction, and the findings of the previous sections in this report.

4.3.1 National policy and program development

1. Improve strategic planning for prevention and/or mitigation of health issues related to climate change by conducting comprehensive disease vulnerability assessments at the sub-national level (e.g., district level) by the appropriate organizations and personnel (e.g., Ministry of Health, National Malaria Control Program, Vector Control, health and climate change experts, etc.);
2. Increase collaboration across government departments and organizations in policy development for climate change and health, and ensure the inclusion of the appropriate organizations and personnel (e.g., Ministry of Health, National Malaria Control Program, Vector Control, health and climate change experts, etc.); and
3. Coordinate with private health care facilities to collect and manage timely and accurate reporting of health data by establishing a coordination body within the Ministry of Health.

4.3.2 National sector programming

1. Improve the monitoring and surveillance of disease and mortality in regions at-risk for increased disease burden, epidemics, and/or emergence;
2. Develop and integrate early warning systems into public health practice for extreme weather events and disease/risk predictions, such as the development and integration of an early warning system within the National Malaria Control Programme;
3. Consider source reduction[2] of vector habitat as part of the national malaria control strategy; develop emergency plans for extreme weather events (e.g., flooding, drought) focusing on improved early warning, effective contingency planning, and identification of the most vulnerable and exposed communities;
4. Invest in drainage systems for sanitation and disease prevention purposes.
5. Support the conservation and regeneration of ecosystems relevant for wastewater filtration (e.g., fringe wetlands and forests) for shoreline communities across Uganda; and

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[2] Source reduction is removal or permanent destruction of mosquito breeding sites (CDC, n.d.). Examples of source reduction include careful water management of irrigation waters or removing standing water in cans, cups, and rain barrels.

6. Develop a program for the analysis and monitoring of water bodies for cyanobacteria, among other water pathogens, possibly implemented by academic institutions such as Makerere University.

4.3.3 Knowledge generation

1. Support the timely and public dissemination of health data by the Ministry of Health;
2. Support the Department of Meteorology to improve the accuracy and timeliness of temperature and rainfall data;
3. Support the timely dissemination of weather data by the Department of Meteorology;
4. Improve the understanding of how climate change is related to health via indirect pathways (e.g., social and economic disruption due to climate change);
5. Improve the understanding of how sanitation and hygiene are affected by climatic changes; and
6. Develop water quality measures based on bio-indicators that are practical and acceptable at local community levels.

4.3.4 Community capacity building and involvement

1. Support existing activities and established NGOs that support the development and delivery of services in health, water, and HIV/AIDS;
2. Strengthen the Village Health Teams by developing their capacity to identify and manage climate-related health issues;
3. Rapid Response Teams in the districts should be routinely re-trained in outbreak detection and investigation;
4. Strengthen the capacity of Regional Performance Monitoring Teams to monitor, evaluate, respond to, and report on climate-related health issues;
5. Train local communities on the impacts of climate change and adaptation/mitigation with respect to health issues;
6. Continue to engage communities in improving water resources management; and
7. Establish community-wide campaigns to impart climate change knowledge (e.g., associated diseases, early climate warning signs, and early actions).

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U.S. Agency for International Development
1300 Pennsylvania Avenue, NW
Washington, DC 20523
Tel: (202) 712-0000
Fax: (202) 216-3524
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