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Adaptation to Climate Change/Variability-Induced Highland Malaria and Cholera in the Lake Victoria Region[1]

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1. Introduction

Global climate change and its interactive components, such as water availability, related vulnerability of natural and socio-economic systems and health, changes in land use, as well as availability, quality, quantity of water and related policies, affects human well-being. The apparent correlation between disease outbreaks, such as malaria, cholera, rift valley fever, and meningitis—all of which are sensitive to climate variability (McCarthy et al., 2001)—and the strong El Niño years, e.g., 1982–1983 and the 1997–1998 events indicates a causal link between climate and health. Integrated climate-disease models show that rates of infections can be affected by climatic anomalies.

Malaria and cholera epidemics have occurred to varying degrees in the East African region in the last decades. As a consequence, health authorities have had a problem in

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deciding which of these factors are the most important and therefore which policy interventions to institute. It is critical to know what to expect in the future in terms of disease trends, so that adaptive measures can be put in place. Equally, it is important to establish the population's adaptive capacity in terms of the ability to prevent and treat climate-related illnesses. According to the Intergovernmental Panel on Climate Change report (2001), adaptation refers to adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It refers to changes in process, practices, and structures to moderate potential damages or benefits from opportunities associated with climate change. The adaptive capacity of a community is determined by its socio-economic characteristics.

1.1 Malaria

Malaria causes globally about 1 million deaths annually, out of which, more than 90% occurs in Africa. It is the number-one killer of children, pregnant women, and the elderly on the continent (Greenwood and Mutabingwa, 2002; McMichael et al., 1996). It constitutes 10% of the continent's malaria overall disease burden (Africa Malaria Report, 2003). The disease deprives Africa of U.S.$12 billion every year in lost Gross Domestic Product (GDP) (Mocumbi, 2004) and traps malarious countries into poverty (Sachs and Malaney, 2002). In Kenya, 40,000 infant deaths are attributed to malaria every year. In 2002 and 2003, in Uganda, there were 5,694,342 and 7,147,152 cases of malaria, resulting in 6,735 and 8,500 deaths, respectively. In Tanzania, malaria causes between 70,000 and 125,000 deaths annually and accounts for 19% of the health expenditure (De Savigny et al., 2004*a*,*b*). Thus in the East African countries, malaria is ranked as the first cause of morbidity and mortality in both children and adults.

The malaria disease is endemic in the lowlands, but it is epidemic and highly unstable in the highlands of the Lake Victoria region (see Figure 1). Such zones of unstable malaria are more sensitive to climate variability and environmental changes than those where the disease is endemic (Mouchet et al., 1998). Highland malaria in East Africa has a long recorded history dating back to the 1920s and 1950s (Garnham, 1945; Roberts, 1964). Highland malaria refers to the malaria prevalent in high-altitude areas (+1,100 m above sea level). The early highland malaria epidemics were not as severe or as frequent as they have been over the past two decades For instance, from the 1960s to the early 1980s, there were virtually no recorded malaria epidemics in the East African highlands. The resurgence of highland malaria epidemics over the past two decades has been closely associated with climate variability (Lepers et al., 1988; Khaemba et al., 1994; Lindsay and Martens, 1998; Malakooti et al., 1998; Mouchet et al., 1998; Some, 1994; Matola et al., 1987; Fowler et al., 1993) and El Niño events that lead to elevated temperatures and enhanced precipitation, which increase malaria transmission (Kilian et al., 1999; Lindblade et al., 2000). Analysis of data for diurnal temperature range spanning the 1950–1959 period led Hay et al. (2002) to dispute this claim, asserting that their climate data analysis showed no significant changes in temperature or vapor pressure at any of the highland sites reported to have had high malaria incidences.

Although malaria is one of the most climate-sensitive vector-borne diseases (Epstein, 1995; Morse, 1995), several other factors have been identified as contributing to its emergence and spread. These include environmental and socio-economic change, deterioration of health care and food production systems, and the modification of microbial/vector adaptation (McMichael et al., 1996; Morse, 1995; Epstein, 1992, 1995). Increases in population density in the highlands led to an increase in human exposure and stressed limited productive land (Lindsay and Martens, 1998). Stresses on productive land force farmers to clear forests and reclaim swamps. Puddles and elevated temperatures result from lost tree and ground cover, providing ideal breeding sites for mosquitoes (Walsh et al., 1993). Papyrus, found in many of the swamps in valley bottoms of the East African highlands, excrete oil and provide shade, which inhibit *Anopheles gambiae* reproduction (Lindblade et al., 2000). Malaria has been creeping upward from the lowlands to the highlands in the Lake Victoria region in East Africa, and indications are that it has been aggravated by climate variability and change, as well as poverty.

Temperature and precipitation in the highlands, as a result of predicted climate change, are expected to rise above the minimum temperature and precipitation thresholds of malaria transmission in various parts of the region (Githeko et al., 2000). In addition to temperature and precipitation, other physical variables, such as soil moisture or its proxies (e.g., stream flow), improve transmission modeling, as they explain the interaction between precipitation, temperature, and the ground (Patz et al., 1998*a*,*b*).

1.2 Cholera

A cholera epidemic was first reported in East Africa in 1836; this was constrained along the Indian Ocean coast, killing as many as 20,000 people in Zanzibar alone and almost depopulated the coastal towns of Lamu, Malindi and Kilwa (Rees, 2000). Between the years 1870 and 1970 there were no reported cases of cholera in Africa (Waiyaki, 1996).

Thus, the trend in cholera cases in Africa appeared to be on the decline until major outbreaks began spreading across the continent: In 1970, outbreaks were reported in West Africa (Guinea) and the horn of Africa (Ethiopia, Somalia, and Sudan) and reached Kenya in 1971 (Waiyaki, 1996). The most severe cholera outbreak on the African continent was in 1998, accounting for more than 72% of the global total number of cholera cases. The countries most severely affected by the 1998 epidemic were the Democratic Republic of Congo, Kenya, Mozambique, Uganda and the United Republic of Tanzania. Cholera is now endemic in the Lake Victoria basin, at least since the early 1970s (Rees, 2000), and in East Africa, the outbreaks have been reported to the World Health Organization (WHO) since 1972. Cholera epidemics within the East Africa region in recent decades occurred during the following years: 1978 (All), 1980 (All), 1981 (Kenya, Tanzania), 1982 (All), 1988 (Tanzania), 1991 (Tanzania, Uganda), 1992 (All) and 1997 (All). Extreme and predictable events, such as El Niño, may promote favorable conditions for zooplankton and ultimately *Vibrio cholerae* in villages along the Lake Victoria shores. Studies in which *Vibrio cholerae* are related spatially and temporally to El Niño, or its proxies and predictors, may be an effective way to prevent exposure to cholera (Lipp et al., 2002).

Cholera is an acute, often fatal, intestinal infectious disease caused by *Vibrio cholera*; it may be endemic or epidemic, and most infections occurring over the past three decades or so have been predominantly due to *Vibrio cholerae* biotype El (Waiyaki, 1996). Well over 100 years ago, Snow (summarized in Waiyaki, 1996) established that cholera was transmitted through the fecal-oral route, and attributed its transmission to the following factors: (1) ingestion of contaminated water and food and (2) lack of scrupulous attention to personal cleanliness, especially hand washing following contact with bedding and other materials used by those with cholera.

Snow asserted that poverty and poor hygienic practices among the working class tended to promote transmission. Snow proposed the following strategies for control of cholera; supply of good clean water; good drainage; improved housing and less crowding; provision of public toilets; public health education on the importance of personal and domestic cleanliness; and screening of sick persons. These measures proposed by Snow are still valid today (Waiyaki, 1996). A recent study in Lake Victoria basin (Shapiro et al., 1999) noted that the specific risk factors for cholera in the region include drinking water from Lake Victoria or from a stream, sharing food with a person with watery diarrhea, and attending funeral feasts. In addition to these factors, Shapiro et al. (1999) found that cholera was more common amongst those living in villages bordering Lake Victoria, compared with those who lived in the hinterland. As early as the late 19th century, cholera outbreaks were associated with heavy rains. In more recent years, cholera epidemics have been attributed to the seasonality of sea surface temperatures (SSTs) (Patz, 2002). This is because the SST is related to the rainfall. *Vibrio cholerae* prefers to attach itself to chitinaceous zooplankton and shellfish. Zooplankton and shellfish increase in numbers, following large bursts of phytoplankton associated with warm sea surface temperatures (Colwell, 1996). Other factors, such as El Niño Southern Oscillation and disease levels before an epidemic, have also been found to significantly regulate the onset of cholera outbreaks (Pascual et al., 2000). The daily admissions for diarrhea and possibly cholera appear to be exacerbated during the onset of El Niño, as cases can increase more than 200% (Checkley et al., 2000). A study in Chesapeake Bay found the link between temperature and cholera in suboptimal environments (freshwater and high salinity) was weak (Louis et al., 2003). Lake Victoria salinity ranges between 3.9 and 7.0, which is much lower than the ocean salinity. However, the authors concluded their findings were based on a limited time record (2 years). In addition, indicators associated with nutrient load and zooplankton (e.g., discharge and precipitation) were not included in the analysis. Precipitation via intensity and discharge via distribution could also affect exposure to cholera.

The paper examines the vulnerability and coping strategies of these target populations, as well as the excess risk to which they are exposed as a result of climate change. It explains the adaptation to climate change-induced malaria and cholera by the local communities in the Lake Victoria Region with specific case study from Tanzania, Kenya, and Uganda. Details of the study have been described in the papers by Wandiga et al. (2005 and 2006), and Yanda et al. (2005).

2. Assessment of Vulnerability

A variety of methodologies were employed in the collection and analysis of data for this study, including collection of secondary data, participatory assessments through focus group discussions, household and key informant interviews, and field observations. Data analysis was undertaken using the SPSS software.

The secondary data were obtained from a review of relevant literature from various records, both published and unpublished materials, including records from hospitals and health centers, government statistical abstracts, ministerial offices, and local institutions and policy documents and the *Weekly Epidemiological Review*[2] (WER-WHO), especially for cholera data. The secondary data were used to facilitate the selection of the sites and villages relevant for the investigations of malaria and cholera, as well as establish patterns for the respective diseases.

The main data sources for this study were informal and formal interviews, including individual households and key informant interviews and focus group discussions. Various methods, including both qualitative and quantitative were used in primary data collection to provide both historical and current information on the patterns of malaria and cholera and other socio-economic characteristics. Such methods included participatory approaches, such as participatory rural appraisal for qualitative data and questionnaire surveys for quantitative data. Direct observations were made to supplement the interview data. These methods are discussed in detail in Chambers (1992), Mettrick (1993), and Mikkelsen (1995).

Participatory approaches entailed group discussions carried out in the selected villages, with the participants in the discussions being drawn from all the subvillages and representing various social groups, such as sex, age, wealth, and education level. These

[2] International Health Regulations require national health administrators to report the number of indigenous and imported cases of cholera and deaths to the World Health Organization (WHO), within 24 hours of receiving such information. This cholera data is then reported in the *Weekly Epidemiological Review* (WER) detailing the date and geographical location.

discussions aimed at capturing the indigenous knowledge base on climate impacts to local communities, vulnerability, and adaptation mechanisms (curative and preventive) to malaria and cholera.

A random sample of 900 households were interviewed, 150 from each of the six study sites (Figures 1 and 2). The sample was representative of sex, age, economic status, and education level. The household interviews were undertaken to collect information on such issues as (1) socio-economic characteristics of different groups of people, including household resource endowments, poverty levels, livelihood coping strategies, and infrastructural status; (2) detailed interviews on climate-related human health problems and management strategies at household level and on water availability and use; (3) historical perspective on hydrological issues based on local people’s experiences; and (4) exposure to diseases, accessibility, and availability of health services to the household. Interviews with key informants aimed at (1) identification of the most vulnerable areas and any known adaptation mechanisms, (2) collection and examination of past and present medical records of diseases associated with climate variability, and (3) determination of whether health facilities have the capacity to handle major climate-related disasters, such as malaria and cholera epidemics. The stakeholder workshops were conducted separately in Kenya, Tanzania, and Uganda, firstly to present the study and research findings and to complement the data set collected through participatory assessments and interviews.

The quantitative database was consequently analyzed using SPSS for Windows Version 11.0. The first round of analysis involved the generation of frequency tables. Cross-tabulation of these variables was subsequently done to establish existing correlations. These descriptive analyses yielded information on the demographic and socio-economic characteristics of the affected communities. Qualitative data that were generated from the focus group discussions (FGDs), key informant interviews, and personal interviews were analyzed using TALAS.ti for Windows Version 4.2.58. The qualitative data in this study were of a textual and audio nature. A coding scheme was developed, after which TALAS.ti was used to manage, extract, compare, explore, and reassemble meaningful pieces from the extensive amounts of data. Another diagnostic step of the FGDs was the ranking of wealth among the affected communities.

More specifically, the variables analyzed included the following: documentation of the range of available options for adaptation to malaria and cholera epidemics; availability of resources and their distribution across populations (similar to the vulnerability assessment above); structure of critical institutions (i.e., decision-making authorities); stock of human capital; stock of social capital; ability of decision makers to manage information; public awareness of malaria and cholera epidemics; and coping strategies

3. Results and Discussion

The survey reveals that the interplay of poverty and other variables do intensify the vulnerability of a population to the impact of highland malaria and cholera. This is because of a lack of economic resources to invest in health-coping mechanisms that can offset the costs of adaptation. The poverty of the communities undermines the coping mechanisms that could help these susceptible highland and lakeshore communities reduce their vulnerability to malaria and cholera epidemics. Malaria is also endemic to the Lake Victoria region and has been creeping upward from lowlands to highlands. Cholera is also common in the region, particularly in areas around the lakeshore. Climate change/variability combined with land use changes and human population may aggravate the prevalence of malaria and cholera diseases in the lake region.

3.1 Health impacts of climate change and climate variability

Scientific evidence shows global environmental change is affecting East Africa (Hulme, 1996). The apparent correlation between outbreaks of malaria and cholera with El Niño years (e.g., 1982–1983 and 1997–1998) supports a causal link between climate variability and health. Malaria and cholera are both sensitive to climate variability (McCarthy et al., 2001). Malaria and cholera epidemics have occurred in the East African region over the past few decades, and they have been attributed to several factors. In Tanzania, for example, malaria epidemics were attributed to drug resistance, home treatment of malaria, deforestation, traditional beliefs, and changes in vector biting behavior (Mbooera and Kitua, 2001). It is thus critical to know what to expect in the future in terms of disease trends, so that adaptive measures can be put in place. Equally, it is important to establish the population's adaptive capacity in terms of the ability to prevent and treat climate-sensitive illnesses, such as malaria and cholera.

Wealth characteristics of the community were considered by the local communities to influence the way in which a household adapts and/or responds to either malaria or cholera. The wealthy households can afford medical/health and other social services and are thus less vulnerable to disease outbreak compared to the poor households. For example, in Bugarama village in Tanzania, the richer people, locally known as Washongole can afford to meet health-related costs as compared to the poor group, locally know as Abworu (Yanda et al., 2005).

The data collected have shown variable annual trends in malaria cases over the period 1996–2001. The data from Litein, Kenya and Muleba, Tanzania showed a declining trend in malaria cases whereas data from Kabale showed a slightly increasing trend. Data from the three countries were compared by regression analysis to determine the degree of association. Data from Tanzania and Kenya had the best association ($R^2 = 0.59$) whereas R^2 for Kenya and Uganda was 0.3 and for Uganda and Tanzania was 0.29. Trends in malaria cases for children under 5 years old and individuals over 5 years old indicated that children under five years of age were highly susceptible to malaria attacks compared to older individuals (see Figures 3 and 4). This is consistent with the fact that young children have lower immunity (Wandiga et al., *2005 and* 2006; Yanda et al., 2005).

Experience for Tanzania's study sites indicate that the number of deaths due to malarias expressed by household interviewed revealed that about 15% of households had lost at least one member due to malaria, with 12% of households reporting to have lost a child member, and 3% of households having lost an adult member (Yanda et al., 2005). The death toll experienced during the epidemic outbreaks could be associated with parasite resistance to antimalarial drugs. However, there are no thorough studies conducted in the case study sites regarding vector or parasite behaviors related to drugs or insecticide resistance.

The first upsurge in malaria cases in Tanzania was observed in May to July, 1997, and in Kenya from June to July 1997. In Uganda, the number of cases during this period remained below normal. The most significant change in seasonal outbreaks was observed from January to March 1998 in Tanzania and Kenya, but the trends extended to May of the same year in Kabale, Uganda. In Tanzania, the epidemic caused a peak increase in cases of 146%, while in Kenya and Uganda, the increase was 630% and 256%, respectively. The peak month for admissions in all countries was March. The Kenyan hospital used in this study is a Mission hospital, and therefore the cases reported include those that should have been admitted in Kericho District Hospital. It is more likely that the increases in malaria cases in Tanzania and Uganda reflect the true trends (Wandiga et al., *2005;* 2006).

It should be noted that vulnerability to climate-related health risks is also compounded by other stress factors, such as high poverty levels, incidences of HIV/AIDS, diarrhea diseases, and respiratory diseases. All the diseases have strong health interaction and may reduce the community's adaptive capacities to climate-related health risks.

3.2 Adaptation to malaria

Malaria is one of the most climate-sensitive vector-borne diseases. In recent years, the number of epidemics of malaria has increased in the East African regions, including the Lake Victoria region, with devastating effects. In the past 20 or so years, the incidence of malaria has been aggravated by the resurgence of highland malaria epidemics, which hitherto had been rare. The resurgence of highland malaria epidemics has been closely associated with climate change and climate variability. The impacts of these epidemics have been devastating and are increasingly exposing vulnerable groups to the adverse effects of climate change and climate variability, as well as challenging their ability to cope.

In Tanzania, several viewpoints were raised concerning ways in which malaria incidences are controlled, treated, or prevented. There is an increasing use of bed nets and, more recently, the use of insecticides (e.g., *Ngao*) to fortify the bed nets against mosquitoes. However, there was a concern that not many people could afford to buy bed nets for the entire household. On average, each household of six or seven persons had 1.5 bed nets, and only about 2.4 persons per household used these bed nets. This indicates that, on average, four persons per household do not have access to bed nets and may be subject to mosquito bites, with the consequent malaria disease potential (Yanda et al., 2005).

In Kenya, the survey revealed that the majority of households do not use insecticide-treated nets (ITNs), and this has implications on the "Roll Back Malaria" campaign for two reasons. First, the size of the household and the number of mosquito nets available may affect the effectiveness of ITNs in rolling back malaria. Second, those using bed nets tend not to treat the nets with insecticides (75%), and if there happens to be treatment, it is likely to be once or twice a year (25%). Therefore, the treatment of nets with insecticides is clearly not a common practice. A household may have as many as 16 persons, with an average size of 3.7 persons, whereas the number of bed nets may range from 1 to 6, and out of those who use these nets, only 28.1% treat them with insecticides twice a year.

As one of the disease control activities, many people use traditional curative measures (local herbs) to treat malaria rather than going to hospitals. Participants in the stakeholder workshop estimated that two-thirds of the malaria patients get cured after using these traditional medicines. Several plants were mentioned to cure malaria, although to different levels of success. The main ones include (using Haya names) *Mbilizi, Kajule, Nkaka, Ikintuntumwa,* and *Mwarobaini* (Yanda et al., 2005)**.** This practice is not unique to the Kagera region. It is well established that more than 80% of Tanzanians living in rural areas rely on herbal remedies for their primary health care (Mwisongo and Borg, 2002). Similarly, a study conducted in Bukoba Rural District showed that communities rely on herbal antimalaria therapy for primary health care (Mwisongo and Borg, 2002). It was evident in Bukoba Rural District that some members of the communities rely entirely on herbal remedies in the treatment of malaria. Similar observations were made in Bugarama Village as part of the current study. Traditional healers were reported to be familiar with symptoms of malaria and were known to give treatment to those suffering from malaria.

Surveys carried out by National Institute for Medical Research (NIMR) noted that traditional healers like other cadres in medicine have knowledge and skills for malaria disease management (diagnosis, treatment, and prevention). They are capable of treating the disease by applying herbal medicine orally. NIMR further undertook laboratory analyses of these traditional herbs to establish their efficacy and safety. The majority was established to be antimalarial, and they could treat other diseases as well. However, the toxicity varied with different herbs, as they ranged in toxicity from low to high (Mwisongo and Borg, 2002).

Several explanations were given for the use of the local herbs in treating malaria: (1) they are quite common, well known, and familiar to most people, (2) they are easily available, less expensive, and effective as a first aid before taking the patient to hospital/health center, (3) pregnant women using these herbs against malaria do not encounter any problems during delivery. The latter was associated with the fact that these herbs have multiple functions, among which include reducing complications during pregnancy (Yanda et al., 2005).

Concerning clinical medicines, it was pointed out during the stakeholders' workshop that every village had its own *Village Health Facility* and a *First Aid Kit*. Every household in the village contributes 1,500 shillings annually to the *Village Health Facility*, which ensures that one receives free services (medication). A village health attendant is available in Bugarama village and provides first-aid services to all villagers. It was noted, however, that households that have not contributed the 1,500 shillings to the village health facility have to look for other means of treatment when a household member falls sick. However, under "emergency" situations, even those who have not paid their dues receive the medication, on condition that they pay their contribution upon recovery. Those considered to be extremely poor receive treatment free of charge, without the need to contribute. It was pointed out that a receipt of one having paid the contributions to the village health facility may be used as security/guarantee when one goes to (government) hospitals, such as Rubya and health centers such as Kabare. The facility attends not only malaria, but other illnesses as well. A health center is also located in the neighboring Biirabo village (center known as Kabare). In Chato village, a health center (Chato Health Center) is located within the village.

It has been proposed that private expenditures for treatment and prevention, increased urbanization, and increased funding for government control can reduce malaria transmission (Sachs and Malaney, 2002). It is however clear that under the current economic environment, the three East African countries are ill prepared to react in such a manner. Sachs and Malaney (2002) also noted that economic development alone without breakthroughs in medical prevention and treatment cannot eradicate the disease. The high poverty level of the affected communities in East Africa and inadequate early warning mechanisms have limited the capacity to respond to climate disasters (such as highland malaria epidemics), hence, cannot adequately cope with climate-induced shocks, such as disease epidemics and weather extremes; consequently, responses have been reactive, slow, and often late. Prevention of epidemic malaria would, among other things, need an increased capacity in understanding the role of climate variability in influencing the disease, as well as understanding local adaptation strategies and increasing epidemic and disaster preparedness by the respective governments.

In villagers' houses some of the techniques used to overcome mosquitoes include the following:

1. making a fire inside the house and sleeping near it. Family members used fires to kill and chase away mosquitoes. Burning of eucalyptus leaves and some of the herbswere reported to be very effective in chasing away mosquitoes;
2. using mosquito coils (21%);
3. clearing of bushes around homesteads to destroy potential breeding grounds (18%);
4. house screening (16%);
5. draining of stagnant waters (15%);
6. treating bed nets with insecticides, mainly using Ngao, twice a year at most (15%); and
7. spraying insecticides in the houses against mosquitoes (11%).

Table 1 presents the percentage responses of how malaria is treated at the household level among people with different levels of education. Interviewed households were asked to indicate how they treated malaria in their households. Responses from this question were cross-tabulated with the levels of education of the heads of households. It is evident from Table 1 that many people (78%) believe that modern medicine as the ultimate cure of malaria. No variations in malaria treatment practices at household level could be discerned on the basis of levels of education. However, a combination of modern and herbal/traditional medicine is locally perceived as an important means of combatting malaria, as expressed by 15.6% of respondent households. This was mainly expressed by people with no formal education and some with primary education. About 3% considered herbal medicine to be sufficient for treating malarial disease. This constituted a small group of people with primary education.

3.3 Adaptation to cholera

Most people in Chato village, Tanzania (see Figure 2) have access to toilet facilities, including pit latrines and a few flush toilets, although it was not easy to determine how these facilities are effectively used. However, none of the households in the village had access to a sewage system, essentially because there is no sewerage system in existence in the village, as is the case with many other rural areas in the country. This makes waste disposal rather difficult and generally uncontrolled. This is locally considered to contribute to cholera outbreaks (Yanda et al., 2005).

In an effort to ensure that cholera does not impact on the household, several sanitary measures are undertaken, which include boiling drinking water; filtering drinking water, and treating drinking water with chemicals. However, in certain villages, particularly those around the Lake, the proportion of those not treating drinking water can be as high as 20%. Given the reported unhygienic environment and recurrent incidences of cholera in the area, the lack of treatment of drinking water makes the respective households vulnerable to getting cholera.

During the stakeholder workshops, participants identified and suggested strategies to reduce the vulnerability of the community to cholera epidemics, which also distinguish between the levels of responsibility at the village and district level (Table 2). Some of the measures such as observing proper hygiene and protection and proper management of water sources are used on routine basis. Other measures are used during cholera outbreaks, for example, promptness by the community in reporting cholera outbreaks and sending sick people to health centers and hospitals for treatment.

In an effort to ensure that cholera does not impact on the household, several sanitary activities are undertaken at the household level, including (1) boiling drinking water (56.7%), (2) filtering drinking water (50%), and (3) treating drinking water with chemicals (3.3%). However, in this village, about 21% reported not to treat/boil drinking water in any way. Given the reported unhygienic environment and recurrent incidences of cholera in the area, the lack of treatment of drinking water makes the respective households vulnerable to getting cholera.

Concerning reasons for not boiling or treating drinking water, the following explanations were established (Table 3). Generally, people in Chato village consider that piped water or water from the pumped wells is safe and can be used for drinking without prior treatment (Yanda et al., 2005). However, the safety of that water depends on the level of treatment at the source, and it may not necessarily be safe for drinking without boiling. The perception of the safety of piped and well water is a genuine concern. Moreover, field observations showed that many of the taps for pumped water often run dry, and people must collect water from the lake for domestic uses. The lake water source is certainly not safe for drinking. The use of lake water for domestic purposes is mainly associated with the unreliable supply of tap water. Under such a situation, drinking untreated water from the lake exposes the user to the risk of getting cholera. This happened in the 1980s. The fact that some people reported not to be accustomed to boiling drinking water indicates a high vulnerability to cholera if the water they is contaminated with cholera pathogens. Other factors have much smaller percentages of responses, but they may be worth considering when designing cholera control and adaptation scenarios.

Although some people do not boil/treat drinking water, 94% of respondents reported that they were aware of cholera and the consequences of drinking untreated water. Ninety-one percent admitted that drinking untreated water would cause diarrheal diseases, such as cholera, and 49% of respondents reported to have had at least one member of the household suffering from diarrheal diseases during the last 5 years (cf. Yanda et al., 2005). Those cases were associated with drinking untreated water from the lake. These people reported to have learnt about the consequences through the sources presented in Figure 5.

The following are local viewpoints and/or steps taken to treat or prevent the incidence of cholera: (1) general cleanliness, (2) washing hands with soap, (3) boiling drinking water, and (4) using health facilities when one falls sick. The village is fortunate in that the Chato Health Center, which caters for the Chato Division (and other neighboring divisions), is located in Chato village. It was noted that currently there are no traditional medicines/cures for cholera in the village. The disease is considered new to the area, and as such, traditional herbalists have not yet been able to invent any curative or preventive medicines.

4. Conclusions and Recommendations

The adaptations to highland malaria commonly applied by communities in this study include traditional curative measures (using local herbs), the increasing use of bed nets and, more recently, the use of ITNs. One limitation for adaptation with respect to households is their inability to afford bed nets for the entire household. On the other hand, strategies for cholera mainly include boiling drinking water and observing good practices in personal hygiene. Modern medical treatment, through an effective adaptation method, is out of reach of most households because of cost and distance to the nearest health center. Strategies that reduce poverty will significantly enhance adaptation to malaria and cholera epidemics.

The East African governments have comprehensive programs and fiscal facilities to deal with disaster preparedness, such as those related to climate variability and extremes. However, the ability to cope with such extremes, including climate-related disease epidemics like malaria is not sufficient. Preventive and curative programs for malaria and cholera that are run by civil societies or governments often predominantly rely on external sources of assistance, whose long-term sustainability is not always guaranteed.

Therefore, the local capacity to develop adaptive strategies to cope with climate variations and extremes is still very low, at all levels, and remains a big challenge.

The high incidence of poverty of the affected communities in East Africa and inadequate early warning mechanisms have limited capacity for response to climate disasters, such as highland malaria epidemics; hence, communities cannot adequately cope with climate-induced shocks, such as disease epidemics and weather extremes. Consequently, responses have been reactive, slow, and often late. There is an urgent need to develop sustainable adaptive strategies and early warning systems that will address future climate change challenges. Combined efforts that improve adaptation to current climate variability and future climate change, early warning systems, knowledge of disease, medical health infrastructure and provision of services, and improved socio-economic status would reduce the existing malaria situation in East Africa.

Future adaptation programs should take into account the diversity of factors that influence a society’s capacity to cope with the changes. Such programs should take into consideration the demographic trends and socio-economic factors, as these have an effect on land use, which may, in turn, accelerate or compound the effect of climate change. Trends in demographic, socio-economic development would definitely have a dampening effect on the potential consequences of climate change. The programs dealing with the other diseases that may increase the stress factors should be factored into the analysis of the future effects of climate change on the vulnerable systems.

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Table 1. *Percentage Responses of How Malaria Is Treated at the Household Level by People With Different Levels of Education*

Level of Education	**How Malaria Is Treated**					**Total**
	Modern Medicine	**Herbal Medicine**	**Modern Medicine/Tepid Sponging**	**Modern Medicine/Herbal Medicine**	**Modern Medicine/ Prayer**	
None	12.0	0	0.3	3.3	0.7	16.3
Primary education	56.3	3.0	0.7	11.7	1.4	73.0
Secondary education	6.0	0	0	0.3	0	6.3
Tertiary education	2.3	0.3	0	0	0	2.7
Others	1.4	0	0	0.3	0	1.7
Total	78.0	3.3	1.0	15.6	2.1	100

Table 2. *Cholera Control Strategies Suggested by Stakeholders*

	Village Level	**District Level**
1.	Construction and use of improved toilets	Awareness campaigns on how to prevent cholera outbreak
2.	Use of clean and safe water (boiled)	Outbreak preparedness – (districts need to have plans for controlling cholera in the event of outbreaks)
3.	Use of clean and safe water (boiling cooking and drinking water)	Outbreak preparedness
4.	Proper collection and disposal of wastes - Collecting solid wastes in pits and burying the pit when they fill up - Burning the wastes, whenever possible	-Planning for cholera control strategies in cooperation with community leaders -Provide equipment necessary to keep the environment clean and improve the hygienic conditions
5.	Protection and proper management of water sources	Recruit more health staff
6.	Cost-sharing in the management of water sources	Undertake environmental assessment to ascertain causes of problems and how to control the situation
7.	Washing hands before taking any food	
8.	Washing hands every after visiting toilets	
9.	Cleanness of household utensils	Establish temporary camps for patients during cholera outbreaks
10.	Community to report promptly when there is a cholera outbreak	To ensure prompt response to cholera outbreak
11.	Sick people to report promptly at health centers and hospitals for treatment	Undertake laboratory analysis to confirm outbreak

Table 3. *Percentage of Reasons/Explanations for not Treating/Boiling Drinking Water in Chato Village*

No	Reason/Explanation	Percentage of Responses
1.	Tap water considered safe	63.8
2	Not used to boiling drinking water	15.9
3	Lack of fuelwood for boiling water (boiling water is too costly)	10.1
4	No utensils for boiling water	5.8
5	Boiling water is tiresome	2.9
6	Fear to loose the taste of water	1.5
	Total	100

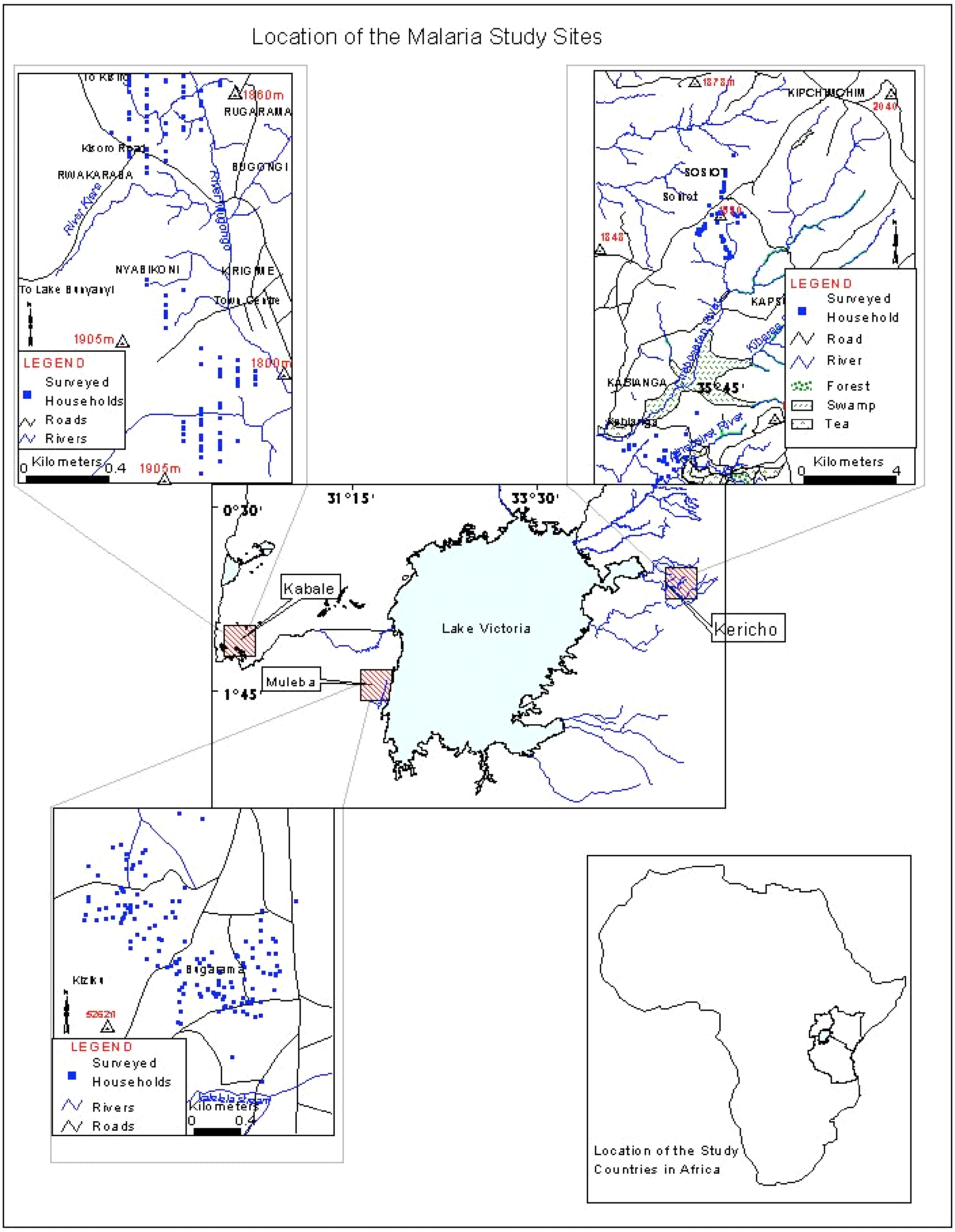

Figure 1. Map showing the Lake Victoria highland malaria region and the studied villages.

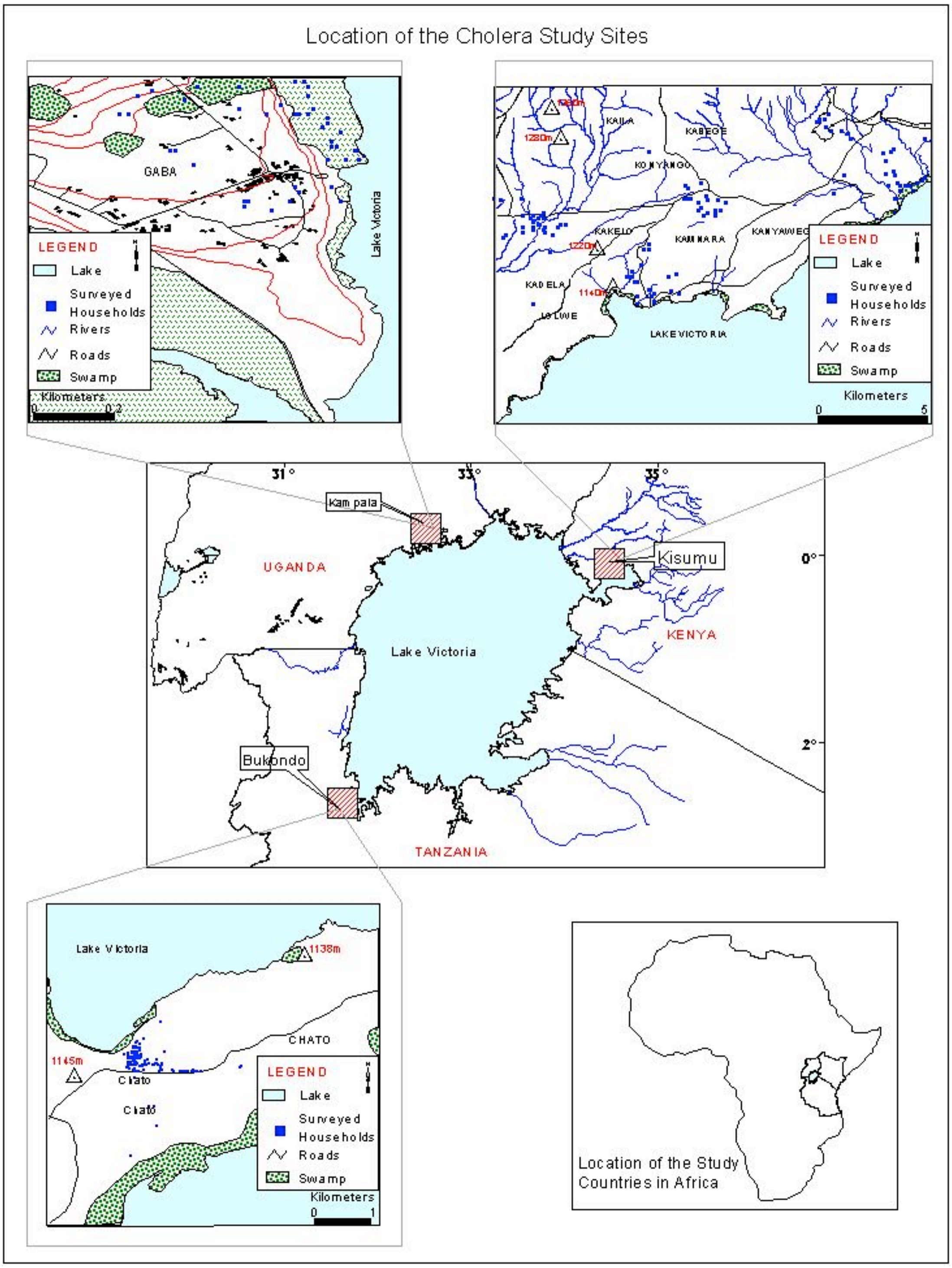

Figure 2. Map showing the Lake Victoria cholera region and the studied villages.

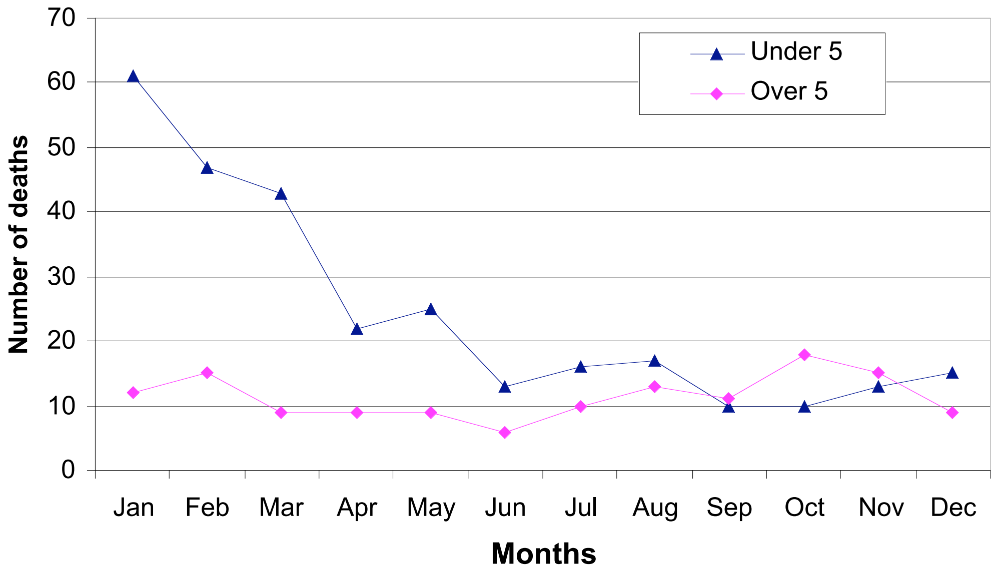

Figure 3. Total death toll due to Malaria for Ndolage Hospital, Tanzania, in 2001 (Source: Yanda et al., 2005).

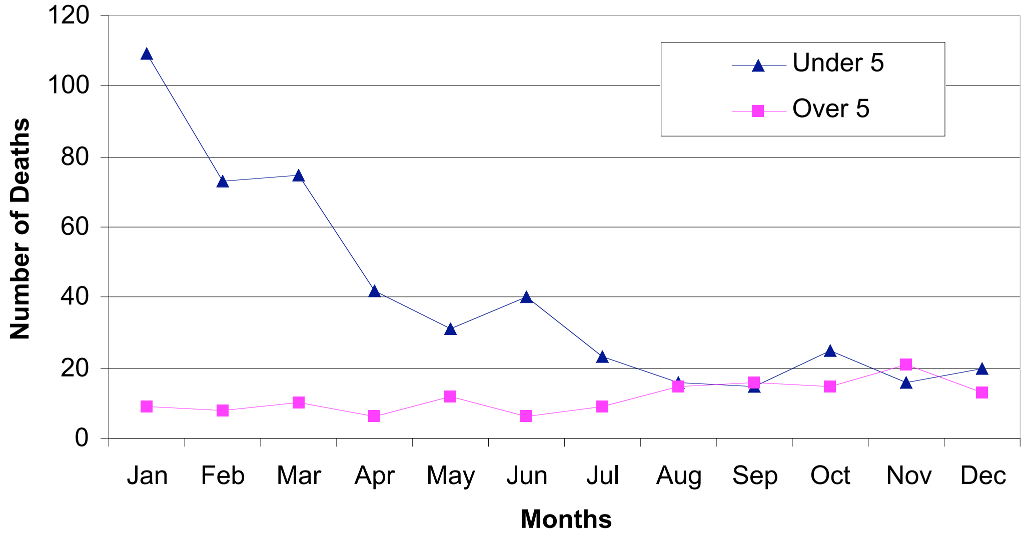

Figure 4. Total deaths toll due to malaria for Rubya Hospital, Tanzania, in 2001 (Source: Yanda et al., 2005).

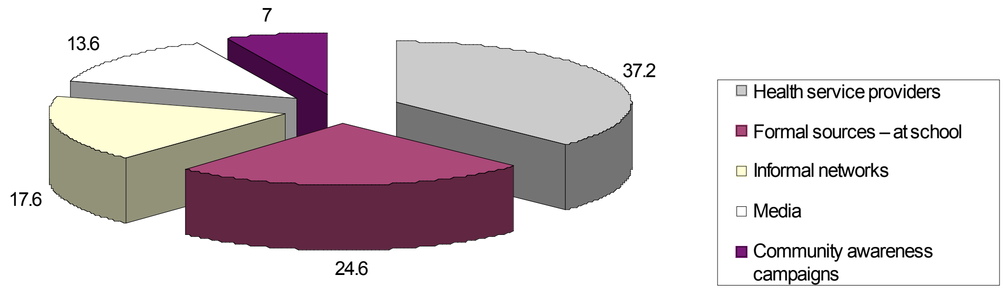

Figure 5. Sources of information on consequence of cholera (Source: Yanda et al., 2005).