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Climatic and Socio-Economic Influences on Malaria and Cholera Risks in the Lake Victoria Region of Tanzania

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AIACC Working Paper No.12
June 2005

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An electronic publication of the AIACC project available form www.aiaccproject.org

[1] This paper reports on research supported by grant number AF91 from Assessments of Impacts and Adaptations to Climate Change (AIACC), a joint project of START, the Third World Academy of Sciences, and the UN Environment Programme, Comments are welcome and should be sent to the corresponding author.

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Climatic and Socio-Economic Influences on Malaria and Cholera Risks in the Lake Victoria Region of Tanzania[2]

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Abstract
This paper examines the relationships between socio-economic characteristics, vulnerability, and adaptation to climate-induced malaria and cholera in the Lake Victoria region, Tanzania. It focuses on the Biharamulo and Muleba Districts of the Kagera Region, located in the northwestern part of the country. The paper also aims at informing policy-making in response to climate change that is related to malaria and cholera. A variety of methods were employed in the collection and analysis of data for this study, including collection of secondary data, participatory discussions and stakeholder workshops, household interviews, and field observations. Data analysis was undertaken using the SPSS software. A random sample of 300 households was interviewed, 150 from each of the two villages (Bugarama and Chato), representing malaria and cholera case studies respectively. Interviews were undertaken with the heads of households. However, where other members of the household were present they were free to contribute. We selected these two villages because they are in areas with conditions suitable for studying highland malaria and cholera, respectively.

It has been established that the vulnerability and impact of climate change-induced malaria and cholera are influenced by the socioeconomic characteristics of the different communities. Findings from this study show that the majority of respondents had similar perceptions regarding the causes and seriousness of malaria, factors that influence its severity, and how the disease can be controlled or treated, regardless of their levels of education or wealth. Furthermore, there is no clear correlation between the presence of stagnant water and the number of household members hospitalised due to malaria. These findings suggest that occurrence of malaria is associated with multiple factors beyond terrain features, including climate variability. The importance of climate variability on disease outbreak is revealed by the local understanding of the periods with malaria and cholera outbreaks. It is understood in the study area that there are more pronounced malaria and cholera outbreaks during periods with above-average rainfall.

The study found that women, children, and the elderly are more vulnerable to malaria. Lack of insecticide-treated bednets contributes to this vulnerability. Although more households are using bednets, they are often unable to afford enough of them for the entire household, due to large families and low incomes. Women and children are also exposed to mosquito bites while weeding bean fields. Men, who were reported by participants to spend much of the evening away from home and only return late at night, are less exposed to mosquito bites, and consequently less vulnerable to malaria. Many people use local herbs for the disease, which appears to be a crucial adaptation strategy, particularly given the high poverty level in the area.

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As for cholera, disease outbreaks were associated with unusually wet seasons. This was attributed to above-average rainfall during the wet seasons, when many toilets flood or collapse because of the sandiness of the soils. This caused the waste from the toilets to leak into the surroundings and often ending up in water bodies, such as the lake. Such waste can spread cholera organisms. Outbreaks were also associated with not using toilets and poor disposal of other wastes. Despite the fact that only a few households reportedly encountered cholera during the last outbreaks, it was evident that many people are vulnerable because of drinking untreated water. It was also evident that the community does not have adequate adaptation mechanisms for cholera. This situation calls for rigorous community health education.

1. Introduction

The study reported in this paper is part of a research project undertaken to evaluate the vulnerability and adaptations to malaria and cholera in the Lake Victoria Region, East Africa. Malaria is endemic to the region and has been creeping upwards from lowlands to highlands. Cholera is also common in the region, particularly in areas around the lakeshore. Climate change combined with land use changes, human population, and other socio-economic factors may aggravate the prevalence of malaria and diarrhoeal diseases in the lake region.

Scientific evidence shows that global environmental change is affecting East Africa. Both climatic and environmental changes have resulted in declining agricultural productivity, deterioration of water quality and quantity, and loss of biodiversity. Increasing human and animal population pressures and other changes have altered land use, land cover, and desertification, and resulted in general environmental degradation (Hulme, 1996).

Global climate change, including changes in water availability, quality, and quantity, can affect the vulnerability of natural and socio-economic systems, including human health and well-being. The apparent correlation between disease outbreaks of malaria, cholera, Rift Valley Fever, and meningitis (all of which are sensitive to climate variability (IPCC, 2001) with strong El Niño years (e.g. 1982-83 and the 1997-98) supports a causal link between water and health. Integrated climate-disease models show that rates of infections can be affected by climatic anomalies. Globally, El Niño events are associated with temperature rise and, consequently, above-average rainfall.

Malaria and cholera epidemics have occurred in the East African region over the past few decades. Health authorities have had a problem in deciding what factors contribute to these problems and therefore which policy interventions to institute. For example, in Tanzania epidemics were attributed to drug resistance, home treatment of malaria, deforestation, traditional beliefs, and changes in vector biting behaviour after cattle were decimated by East Coast Fever (Mbooera and Kitua, 2001). 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-sensitive illnesses. According to the IPCC 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 a variety of factors, including its socioeconomic characteristics. The issue of attributing of the impacts of climate variability to water and health is essential to policy makers in these sectors. However, to date very few studies have addressed this problem, primarily due to a shortage of research funding and low research capacity. This study is part of a research project called "AF91 - Capacity building to evaluate and adapt to climate change-induced vulnerability to malaria and cholera in the Lake Victoria Region," funded by Assessment of Impacts and Adaptation to Climate Change" (AIACC).

This article explores the vulnerability to climate change impacts and adaptation, particularly to malaria and cholera, of the communities in the Lake Victoria Region with a case study from Tanzania. The paper aims to provide an understanding of the relationships between socioeconomic characteristics and vulnerability, and adaptation to malaria and cholera. It also aims at informing policy-making relevant to climate change-related malaria and cholera. The paper is organised into six main sections. Section one provides an overview of climate change and its impact to the region, and the AF-91 project. Section two provides a description of the study area. Section three describes the methods. Section four addresses issues related to malaria, while section five looks at issues related to cholera. Finally, a concluding discussion is presented in Section six.

2. The study area

This study was conducted in the Lake Victoria region of Tanzania, with a focus on the Kagera Region located in the northwest (Figure 1). The Lake Victoria region has experienced dynamic changes caused by both natural forces and human activities. Lake Victoria itself is the second largest fresh-water lake in the world and it has a total area of 68,800 km^2 with 6, 51, and 43 percent of its area located in Kenya, Tanzania, and Uganda, respectively. It drains approximately 181,000 km^2 in these three countries plus Rwanda and Burundi. It supports about 30 million people in riparian communities of Kenya, Tanzania, and Uganda. Above all, the lake is one of the sources of the Nile river waters on which Sudan and Egypt depend for livelihood. Therefore, anticipated climate change impacts could have far reaching consequences on both the environment and human health in the region. Deforestation in the river catchment areas is affecting both the quantity and quality of river waters. Agricultural, industrial, and human waste disposals into the water systems have became major sources of water-borne diseases.

Kagera region has six districts: Bukoba Rural, Bukoba Urban, Biharamulo, Karagwe, Muleba, and Ngara. Kagera region has a total population of 2,033,888 (URT, 2003). The study involved the two districts of Biharamulo and Muleba. Muleba district has a population of 386,328, the majority of which are Haya, while Biharamulo district has a total population of 410,794 (URT, 2003) and is dominated by the Subi, Zinza, Sukuma, and Rongo ethnic groups.

Agriculture is the main economic activity in the Kagera Region. The main food crops grown include banana and beans, while less important ones include maize, cassava, sorghum, groundnuts, sweet potatoes, and yams. Cash crops include coffee, cotton, and tea. The Kagera Sugar Company grows sugarcane on a commercial scale. Fishing is another important activity, particularly for villages adjacent to the Lake Victoria shore; e.g., Chato village in Biharamulo district.

Two villages were selected for this study: BUGARAMA in Muleba District (Nshamba Division) and CHATO in Biharamulo District (Chato Division). The studied villages were selected based mainly on altitude. One village was selected in the highlands (>1500 m asl) to study highland malaria, while the other was selected at the lakeshore for studying malaria and cholera. The actual identification of the study sites was done using topographical maps and by collaborating with respective district authorities. The malaria case study was conducted in Bugarama, while the cholera study was conducted in Chato. Bugarama village is located above 1500m above sea level, and Chato is located at the lakeshore, making it suitable for the cholera part of the investigation.

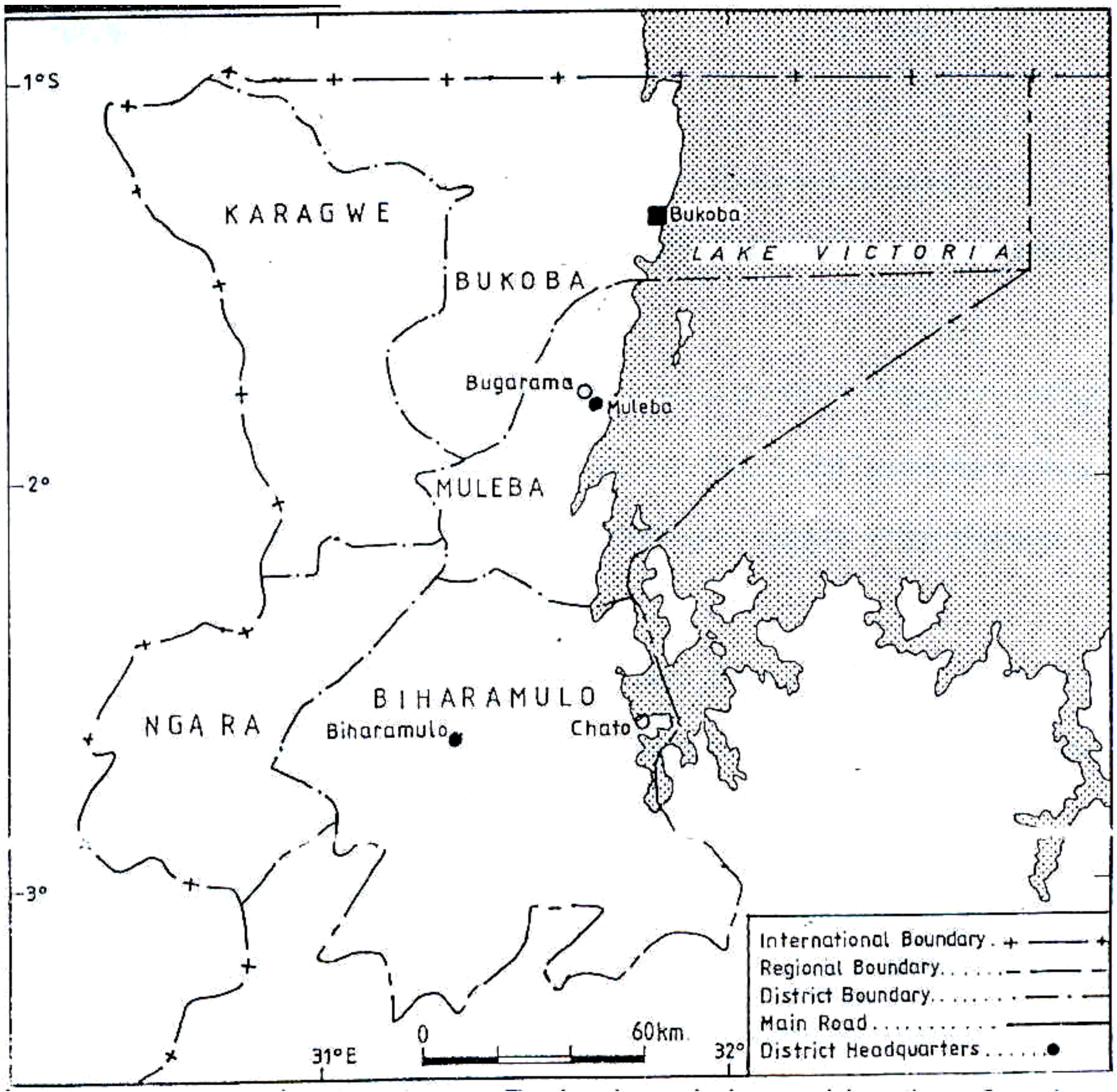

Figure 1. Map showing the western part of the Lake Victoria Region and the location of the Kagera Region in Tanzania, along with its administrative districts and the case study villages (Bugarama and Chato).

3. Methods

A variety of methods were employed in the collection and analysis of data for this study, including collection of secondary data, participatory discussions, household interviews, and field observations. Data were analysed using SPSS software. Details of the different methods used are outlined in the following sections.

3.1 Secondary data collection

The secondary data was obtained from review of relevant published and unpublished literature, as well as reports obtained within and outside the study area, including records from hospitals and health centres, ministerial offices, and local institutions. The secondary data from such sources were used to select the villages relevant for the investigations of malaria and cholera, as well as to establish disease patterns. The secondary data collected included, among others, population characteristics of the study areas, climatic (rainfall and temperature) and hydrological records, hospital records for both malaria and cholera, and land-use patterns.

3.2 Primary data collection

The primary data sources were the sampled villages. The main source was informal and formal interviews conducted with individual households and key informants. Reconnaissance surveys and direct observations contributed to and supplemented the interview data. Both qualitative and quantitative methods were used in primary data collection to provide historical and current information on the patterns of malaria and cholera and other socio-economic characteristics, including participatory approaches (such as Participatory Rural Appraisal (PRA) for qualitative data), questionnaire surveys for quantitative data, and direct observations. These methods have strengths and limitations, as discussed in Mettrick (1993), Chambers (1992), and Mikkelsen (1995). Therefore, a variety of methods were combined during the fieldwork to obtain more reliable field data.

Participatory approaches

Group discussions were conducted in the two selected villages, with the participants drawn from all the sub-villages (vitongoji) based on various demographic factors (e.g., sex, age, wealth, level of education). These discussions aimed at obtaining a general overview of experiences with the malaria and cholera situations in Bugarama and Chato village, respectively, and the local perspectives on disease vulnerabilities and adaptation mechanisms (curative and preventive). Essentially, this exercise aimed at identification and description of indigenous knowledge of impacts in local communities, the socio-economic factors associated with vulnerability, and adaptation to such impacts. The research team facilitated the discussions, but every participant had an equal chance to express their opinions. Notes were taken on issues once consensus was reached among the participants. To generate the information needed, the discussion began with an introductory analysis of economic activities in the village, including socioeconomic groups and the criteria used to classify them; then we discussed malaria and cholera, focusing on the following issues: conditions that enabled villagers to predict malaria/cholera outbreaks, whether the incidences of malaria/cholera had been increasing over time, time of the year when malaria/cholera is a problem, identification of symptoms of malaria/cholera, age groups (e.g. infants, youths, adults, elderly, etc.) most affected by malaria/cholera and possible explanations for why, how the malaria/cholera problem is addressed (e.g. availability of health facilities, whether people afford to get medical services, etc.), and problems of water availability.

Interviews with households and key informants

A random sample of 300 households was interviewed, 150 from each of the two villages (Bugarama and Chato), representing malaria and cholera case studies respectively. The selection of respondent households for interviews was based on village registers, with equitable proportion of representatives from each sub-village available, as well as different parts of the landscape. No prior knowledge of medical histories of household members was required. Household interviews were undertaken to collect information on:

- Socio-economic characteristics of different groups of people and localities (household resource endowments, poverty levels, livelihood coping strategies, and infrastructural status).
- Detailed interviews on climate-related human health problems and management strategies at the household level, and on water availability and use.
- Historical perspective on hydrological issues based on local people's experience.
- Exposure to diseases, and accessibility and availability of health services to the household.

Interviews were undertaken with the heads of households. However, where other members of the households were present and willing to participate they were free to contribute. Interviews with other key informants aimed at (i) identifying the most vulnerable areas and any known adaptation mechanisms; (ii) collecting and examining past and present medical records of diseases associated with weather and climate variability; and (iii) identifying policy issues (if any) related to linkages among climate change, water resources, and human health. One issue was to determine whether health facilities have the capacity to handle major climate related epidemics of malaria and cholera.

Field observations

Field observations were undertaken to identify and describe the water resource base of the area, land-use along selected transects, various landscape features, and the presence of stagnant waters.

3.3 Stakeholders' workshop

The stakeholders' workshop was conducted in Muleba Town, Tanzania, on July 15-16, 2003, as part of the second fieldwork. The objective of the workshop was two-fold. The first objective was to present the study and preliminary research findings of the study to various stakeholders from the two districts, Biharamulo and Muleba. Two presentations were made including a brief outline of the impacts of and adaptation to climate variability and change, and preliminary findings from Bugarama and Chato Villages. The second objective was to solicit additional information from the stakeholders to fill in data gaps and complement the dataset collected during the first and second rounds of fieldwork. To achieve this, workshop participants were given the opportunity to discuss and comment on the findings. This exercise enabled participants to understand the project better, scrutinise the report, and identify additional information to be collected and/or included in the study. During the workshop, participants also attempted to address potential and/or ongoing interventional measures for malaria and cholera, both at the village (local) and district levels. A total of nineteen people participated in the workshop, including two representatives of village leadership from each of the case study villages; District Medical and Health Officers from both Muleba and Biharamulo districts; the District Executive Director for Muleba; one representative from each of the public health centres/facilities in the vicinities of both Bugarama and Chato Villages; and representatives of the administrative bodies at district level. The authors of this paper facilitated the workshop.

4. Factors Contributing to Vulnerability and Adaptation to Malaria

4.1 Demographic characteristics

This section reports on demographic results and characterises and how they influence risk, impacts, and vulnerability to malaria and cholera in the lake region. Demographic factors included gender, age, level of education, and marital status of the heads of households interviewed. The sampled households were 43.3% men and 56.7% women. The age distribution of respondents ranged from 24 to 93 years, with an average of 39. The majority of the respondents (79%) were married, and the sizes of their households ranged from 1 to 17 people, with an average size of 6.34 persons per household. This large household size makes it difficult for a household to afford bednets for all members.

Concerning the level of education, it was established the that majority of the people interviewed had acquired primary education (73%), and a few had had secondary (6.3%) and tertiary education (2.7%). About 16.3% of the respondents had no formal education. No clear relationships were found between levels of education and how people perceived the causes and seriousness of malaria and how the disease can be controlled or treated (see Tables 1 & 2). Perceptions of the causes and severity/seriousness of malaria were similar among all members of the studied community. However, some members of the community were more vulnerable to either malaria or cholera, based on aspects of age or gender. Vulnerability due to these aspects is discussed in Section 4.6.

Table 1. Percentage of responses on relationships between levels of education and perceptions of the causes of malaria.

Level of Education	Causes of malaria			Total
	Mosquitoes	Other causes	Don't know	
None	12.3	2.0	2.0	16.3
Primary education	65.7	4.0	2.0	71.67
Secondary education	6.3	0	0	6.3
Tertiary education	2.7	0	0	2.7
Others	1.3	07	1.0	3.0
Total	88.3	6.7	5.0	100

Table 2. Level of education and perceptions on the severity of malaria, expressed as percentage of responses

Level of Education	Do you consider malaria to be a severe disease?		Total
	Yes	No	
None	15.0	1.3	16.3
Primary education	67.7	5.3	73.0
Secondary education	5.7	0.7	6.3
Tertiary education	2.3	0.3	2.7
Others	1.7	0	1.7
Total	92.4	7.6	100

4.2 Landscape Characteristics

This study considered a number of factors contributing to the occurrence of malaria in Bugarama village. One was the terrain, which determines areas where stagnant water can provide suitable mosquito breeding grounds. Generally, the steeply sloping terrain in Bugarama village means that very few places could have stagnant water. Only 5.3% of the people interviewed in Bugarama village and 6.7%. Chato village reported the occasional presence of stagnant water close to their homesteads; however, this would be expected to occur in potholes in upper parts of the landscape during the rainy period and in the valley bottoms. There is a clear correlation between terrain and proportion of households interviewed whose members were hospitalised in 2002 (see Table 3). About 85.4% of households that reported that they had had members hospitalised had homesteads on hilltops and hillsides. The remaining 14.6% of such households had their homesteads located by the lakeshore. This suggests that households living on hilltops and hillsides are at much greater risk from malaria than are those by the lakeshore, and that the greatest risk may be for households on the hilltops. These findings further suggest that high-altitude areas have become more prone to malaria incidences compared to lower-altitude areas. One of the critical factors influencing this vulnerability is the extent to which health and socio-economic systems are robust enough to cope (WHO, 2003). This may also have to do with the activity patterns of household members. The latter aspects are being addressed separately in a paper to be produced as one of the AF91 project outputs.

Table 3: Malaria hospitalizations by terrain type of household locations in Bugarama and Chato villages, 2002 (Source: survey data)

Terrain of household location	Number of households surveyed	Number of households with member hospitalized for malaria	Percentage reporting malaria by terrain type
Valley Bottom	1	0	0.0
Hillside	113	60	53.1
Hilltop	36	33	91.7
Lakeshore	150	16	10.7
Total	300	109	36.3

Furthermore, Table 4 does not show a clear correlation between presence of stagnant water and proportion of households with hospitalised members. We would have expected to find more cases of hospitalisation for people living in the vicinities of stagnant waters than those without stagnant water, but surprisingly, Table 4 shows the opposite: that the presence of stagnant water does not increase the risk of hospitalisation for malaria. These findings demonstrate that occurrence of malaria is associated with multiple factors other than the terrain features and/or the presence of stagnant water. These factors are explored in subsequent sections.

Table 4: Malaria hospitalizations for households with and without stagnant water present, Bugarama and Chato villates, 2002 (Source: survey data)

Presence of stagnant water at household site	Number of households surveyed	Number of households with member hospitalized for malaria	Percentage reporting malaria
Yes	36	13	36.1
No	264	96	36.4
TOTAL	300	109	36.3

Local people associated the incidences of malaria with the season when beans grow in the field, under the bananas. They pointed out that during this season, mosquitoes find suitable breeding ground in the bean fields, where the microclimate is dump and humid. Also during the rainy season there are places where stagnant water can be found; e.g., in portholes (*madimbwi* in Swahili) and cut banana stems. Both participants during the participatory assessment and respondents during household interviews reported that many people, especially women and children, are bitten by mosquitoes, particularly while weeding beans. As such, a home-based analysis of malaria may not be sufficient in understanding the dynamics of the disease in this area. These observations support information in Table 3 that it is not only significant water bodies that provide breeding sites for mosquitoes. It should be noted however that this study did not attempt to identify the types of mosquitoes that are prevalent in the bean fields, in houses, or in other breeding grounds. This could be achieved with the help of an entomologist, and suggests a need for follow-up studies to ascertain the species of mosquitoes involved and their activity patterns.

The association between landscape characteristics and malaria is based on hospitalized malaria cases; hence there may be biases by socio-economic class because of the time and money involved in hospitalization; not all cases of malaria are hospitalized. Most of the households reported incidences of a household member having malaria even without needing to be hospitalised. However, the reported relationship between landscape characteristics and malaria provides an indication of plausible patterns.

4.3 Wealth Characteristics and their influence on vulnerability to malaria and cholera

Through group discussion the local people in Bugarama village identified three socio-economic/wealth groups: the Washongole, or the rich people; Watu wa kati (wa kawaida), the common people; and Kacheku or Umwolu/Aboru, the poor people. The three groups were characterised based on wealth that they own, as well as other aspects; e.g., ability to pay for the education and health services of their children. Some of the criteria that characterise each of the three socio-economic categories are summarized below.

Washongole – have lots of resources (physical and financial resources); are self sufficient in most respects; own good houses; have many herds of cattle; have big farms; make and sell local brew (*rubisi*, etc.); have educated children; and are able to pay for health services.

Watu wa kati (wa kawaida) – own good houses; do not have cattle; have small farm plots; have a little money; and may not be able to send children to school/hospital.

Kacheku or Umwolu/Abworu (singl/pl) – own houses that are not very good or may not have one at all; do not have sufficient food for their households and in many cases depend on “*kuhemea*” (receiving food stuffs from other households); most of the time is spent on casual labour; have one meal a day; may have a small farm plot that is not well attended and does not produce good crops; and have big families with many children.

Of the three socio-economic groups, the “Watu wa Kati” category has the largest number of people (about 60%), followed by the “*Abworu*”. There are very few “Washongole” in Bugarama— mainly the businessmen. It was pointed out by participants during the discussion that, traditionally, women did not get a share of wealth/inheritance from their parents, and as such there were no female-Washongole. Women could only be found in the other two socio-economic groups, with most women in the third category. Today, however, there are a few females (married or unmarried) who are wealthy (e.g., having a big shamba, a good house, money, etc.) and may be called Washongole. A local terminology “*kiumbi keire*” (Haya) is used to describe this group of rich women, regardless of how they got this wealth.

The local communities believed wealth characteristics to influence the way in which households adapt and/or respond to either malaria or cholera. Wealthy households can afford medical and other social services and are thus less vulnerable to disease outbreak compared to the poor households.

4.4 Water availability and incidences of malaria

Local experience in Bugarama indicates that years with drought are often followed by outbreaks of malaria, reflected by large number of cases that are also more clinically severe. The relationship between drought and malaria is also reflected in the local name for malaria, "*mushana*", a local term that also means periods of drought (or extended dry seasons). Participants in group discussions pointed out that such dry years are often accompanied by food shortages, resulting in lower levels of nutrition such that the body becomes weak and easily succumbs to diseases such as malaria. During such years, young children were reported to suffer from anaemia. It should be noted that when people in this village, and elsewhere in Muleba district, talk of food shortage, they actually refer to poor harvests of bananas, their staple food crop.

It was rather difficult to construct a timeline of malaria outbreaks. However, local memories were able to reflect on particular climatic conditions that were associated with outbreaks of malaria during the last thirty years. Participants reported during the participatory assessment and stakeholder workshop, for example, that in 1970 there was a severe famine attributed to drought, which was followed by a malaria epidemic. In 1974 the area again experienced drought associated with food shortage, and people received food relief (the yellow corn, locally known as *yanga*). According to local knowledge this season also had many cases of malaria, although only a few people died. It was further reported that before the El Niño rains of 1997/98 there was drought that was followed by several cases of malaria. During the El Niño season (1997/98), the area experienced severe food shortage/famine largely because of above-average rainfall that caused the crops not to grow well (and some were destroyed in the fields); malaria was again rampant. Malaria outbreaks have been common in years subsequent to the El Niño season (1997/98).

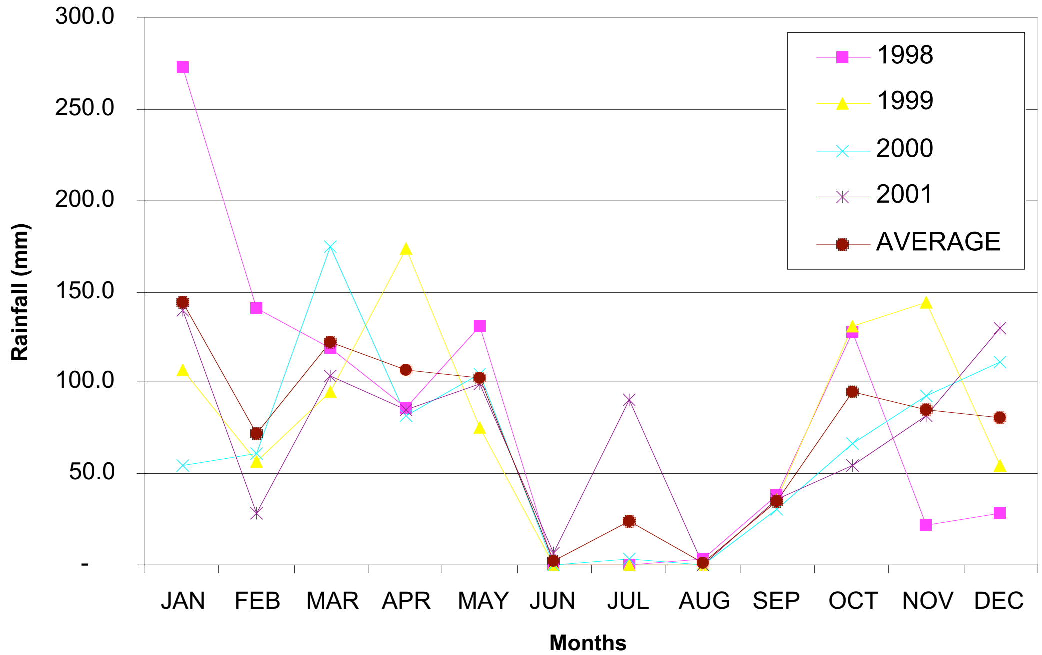

Figure 2: Mean Monthly Rainfall in Muleba District (1998-2001)

Concerning the time of the year with more pronounced malaria outbreaks, the local knowledge indicated that the rainy season (usually between September and April; see Figure 2) and the period just after the end of the rainy season are the periods when there are more cases of malaria. This is the period when water is most available for the mosquitoes to breed.

It should be noted here that while establishing the relationships between water availability and incidences of malaria, some caution should be taken in drawing firm conclusions. Relying on households to diagnose diseases and to recall when such incidences occurred along with climatic and other events that may have contributed may have a number of problems related to memory recall. Thus, caution should be taken in drawing conclusions from such evidence, especially if it is not verified by additional means. However, such information provides necessary insights for establishing general patterns.

4.5 Knowledge, Perceptions, and Practices of Malaria

4.5.1 Local Knowledge and Perceptions

Information on local community knowledge and perceptions about malaria was gathered through a Participatory Rural Appraisal (PRA) and further discussed during the stakeholders' workshop. One of the observations during PRA sessions and the stakeholder workshop was that malaria invaded the highland parts of the study area later than the 1960s, and has become a chronic problem, particularly in Muleba District. The local perception of the emergence of malaria in the highlands of lake Victoria basin during the past few decades is also supported by scientific analyses. Wandiga et al. (forthcoming), for example, reported also that while the disease is endemic in the lowlands of the Lake Victoria catchment basin, it was rare in the highlands of the catchment basin 30 or more years ago. Climate variability and change combined with anthropogenic drivers (land use change and population increase) have aggravated malaria in the highland areas of the Lake Victoria region.

Health officials from Muleba District pointed out at the workshop that towards the end of the rainy season and during the dry season of 2003 (for example), malaria was particularly serious in Muleba district to the extent that at some of the Health Centres (e.g. Kaigara, located in Muleba town) tents had to be used to accommodate the increased number of hospitalised patients. Some of the offices used by the medical staff at the Health Centre had to be used to accommodate more in-patients. It was further pointed out by the district health workers that periods with high rainfall do not usually have many mosquitoes because breeding grounds are disturbed by the heavy storms. These are usually cooler periods of the year. However, the mosquito population grows significantly as temperatures increase after the rains. The high incidence of malaria during this period may be connected to the fact that dry periods are often warm, a factor that favours the prevalence of malaria mosquitoes. Wandiga et al. report that over the last forty years (1960-2004) there has been a considerable increase in temperature in the highlands of up to 0.6 C, which has enabled malaria vector mosquitoes to find new habitats in the highlands, hence the creeping of malaria in higher altitudes like those of Muleba.

Those who took part in the participatory assessment as well as respondents during household interviews reported that anaemia was one of the key symptoms of malaria diagnosed at hospitals and health centres. Anaemia is also well known scientifically to be a side-effect of malaria (cf. (Mwisongo and Borg, 2002). It was further confirmed during informal discussion with the district health workers and attendants at health facilities in the vicinities of the study area that apart from common symptoms such as fever, most of the patients diagnosed for malaria, particularly children, were anaemic. Both Health experts and the local communities attributed the anaemia to poor nutrition that makes people weak and vulnerable to malaria and other diseases. They further reported that inadequate food provisioning was responsible for causing many people, particularly children, to succumb to malaria. Local experiences indicated that this is often the case in years when there is no good banana crop. Many people in Muleba district decline to eat other foods (e.g. maize meal, rice, etc.) except in periods of absolute food (i.e., banana) shortage.

It was pointed out by the local community that mosquitoes would only breed in stagnant (as opposed to running) water. Hence, it was unlikely that people living close to flowing rivers suffered more from malaria. Instead, in places like Muleba District (and hence Bugarama village), mosquitoes were reported by the local community to breed in the vegetation, particularly in banana leaves that trap and accumulate sufficient water (sometimes during the dry season, from dew) for mosquitoes to lay eggs and breed. This is also the case for places with stagnant water (although because of the sloping terrain of Bugarama, very few places would have stagnant water). Concerning the biting behaviour of mosquitoes, health workers participating in the stakeholder workshop reported that two types of mosquitoes that can be characterized based on their activity patterns are found in the area. Those that bite inside the houses and spend the rest of the time outside, the endophilis mosquitoes; and those that bite while outside and spend the rest of time inside the houses, the exophilis mosquitoes. According to these health workers' expert knowledge it is the latter type that is believed to bite women and children while they weed beans in the field. However, no study has been conducted in the Muleba or Biharamulo districts on the behaviour of mosquitoes; thus, in-depth studies are needed to establish the mosquito activity patterns and the best ways to avoid or control them, both in houses and in the bean fields.

A comparison of vulnerability to mosquito bites between men, women, and children revealed that women and children go to sleep much earlier in the evening, making them more vulnerable to mosquitoes, which are at the peak of their activity period at that time. Being asleep, the women and children can do little to protect themselves. Men, who were reported to spend much of their evenings in the local pubs and usually come home late in the night, tended to have lower exposure to mosquitoes bites, and consequently were less vulnerable to malaria. Also, men are not exposed to mosquito bites in bean fields because traditionally Haya men do not weed beans. Many households were unable to buy mosquito nets sufficient for all members. This was partly attributed to large household sizes.

According to Mwisongo and Borg (2002), the severity of malaria in the Kagera region, and hence in the study areas, can be attributed to, among other factors, the increasing resistance of malaria parasites to various medicines, including the recent prescription of the sulphur-based anti-malaria drugs, or SPs (Amodiaquine, Fancidar and Metakeflin). Late diagnosis of the disease is likely to be another cause of the severity of malaria in the area. Discussions with district health officials in Muleba during fieldwork for this study also found out that many malaria patients, particularly children (>50%), are not taken to health facilities soon enough after they have started suffering from malaria (i.e., showing some disease symptoms). The late diagnosis and treatment of the disease may be responsible for increasing the number of death cases due to malaria because of untimely medication. Concerning treatment of malaria by local medications, it was noted during the stakeholder workshop that some of the traditional medicines used in Muleba district seem to be more effective than quinine in treating malaria. The National Institute for Medical Research (NIMR) is conducting analyses of some of the herbs used (Mwisongo and Borg, 2002).

Concerning the association of malaria with climatic changes/ variations, 61% of respondents reported the existence of a relationship between malaria and climate/weather factors. This was reflected in their understanding that, for example, malaria outbreaks occur following periods of drought or extended dry seasons (often warm periods). Thirty-seven percent of the respondents reported that there was no relationship between malaria and climatic/weather factors, while the remaining 2% were not sure. Established evidence indicates that periods with drought correspond with warm periods that usually provide ambient conditions for the vector mosquitoes, sometimes leading to malaria outbreaks (see Wandiga et al., forthcoming).

East African highland communities living at altitudes above 1,100m asl are more vulnerable to malaria epidemics due to climate variability and change, lack of immunity, and poverty (Wandiga et al., 2005). The ability of these communities to cope is strongly challenged by these factors. Since the effect and intensity of the disease is very closely associated with poverty, its eradication is essentially linked to poverty alleviation and thus in our view it deserves the unique title of a 'political disease,' despite the fact that it is at the same time a medical challenge.

Malaria outbreaks are sensitive to maximum temperature (Githeko and Ndegwa, 2001). Analysis of trends in temperature data indicated that in the highlands of Kabale, Uganda there has been an increase of 1.17ºC in mean annual minimum temperature between 1960 and 2001. In Kericho, Kenya the mean annual maximum increased by 3.5ºC. In Bukoba, Tanzania the mean annual maximum and minimum temperatures were found to have increased by 0.21 and 0.49ºC respectively between 1960 and 2001 of 0.70 O C. However, Bukoba lies on the shores of Lake Victoria at an altitude of 1,100m asl. During the 1997/98 El Niño, malaria admission data indicated that the epidemic months corresponded with the onset of abnormally frequent short rains, or that the El Niño years were preceded by a season of abnormally high maximum temperatures. This was confirmed with the observation of anomalies in the mean monthly maximum of 2.2-4.5ºC between January and March in 1997 and 1.8-3.0ºC between February and April in 1998. Other cases of malaria epidemics follow the trends described above, with the highest incidents in March, April, May and July, August, and September during the long and short rainy seasons respectively (Wandiga et al., 2005).

Wandiga et al. (2005) also observed that climate variability is occurring on a warmer mean climate state, resulting in a higher net temperature that would otherwise not occur in the absence of a general climate change. It seems that there are possibilities of epidemics increasing from the usual 2-3 months to 4-6 months, as has been observed in Kabale, Uganda. Such conditions lead to very high mortality and morbidity rates. The data shows that the highlands are warming at a greater rate than the lowlands, and this has a significant effect on malaria transmission. It further proves that either the maximum or minimum temperature is rising in the highlands. The observed temperature increase has enabled malaria vector mosquitoes to find new habitats in the highlands. This has resulted in high levels of malaria epidemic in the highland communities of East Africa.

The risk of a malaria epidemic is associated with positively anomalous temperatures preceding and during the months of the rainy season. Temperature controls the rate of larval and parasite development. Higher temperatures shorten the development time of the larvae and parasites in the mosquitoes. The logistic model for the effects of temperature and rainfall (Githeko and Ndegwa, 2001) indicates that the rate of growth of a mosquito population is dependent upon the initial population size before the rainy season. Climatic events that create this condition can precipitate epidemics. Rainfall increases the availability of mosquito breeding habitats, and thus the size of the mosquito population.

4.5.2 Local Malaria Practices (Local Adaptation)

Several viewpoints were raised concerning ways in which malaria can be controlled, treated, or prevented. There is an increasing use of bednets and *Ngao* (an insecticide) to impregnate the bednets against mosquitoes. However, there was a concern that not many people can afford buying bednets for the entire household. On average each household had 1.5 bednets, and only about 2.4 persons per household used these bednets. The average number of persons per household is 6.4. This indicates that on average 4 persons per household do not have access to bednets, and are thus subject to mosquito bites. Other people in the study area also believe that malaria cannot be prevented; it is only when one contracts malaria that one goes for medication. It is common knowledge in the world at large that malaria can be prevented; thus, the local perception among the studied communities regarding malaria gives a reflection that locally there is inadequate knowledge about the disease.

Many people use traditional curative measures (i.e., local herbs) to treat malaria rather than going to hospitals. Participants in the stakeholder workshop estimated that two-thirds of malaria patients are cured after using these traditional medicines. Several plants were mentioned as malaria cures of varying efficacity. The main ones were (using Haya names) *Mbilizi, Kajule, Nkaka, Ikintuntumwa,* and *Mwarobaini*. This practice is not unique to Kagera Region. It was established that over 80% of Tanzanians living in rural areas, including the Bukoba Rural District, relied on herbal remedies for their primary health care (Mwisongo and Borg, 2002). It was evident in Bukoba Rural District that some members of the communities relied entirely on herbal remedies in the treatment of malaria. Similar observations were made in Bugarama Village in this study. The community believes that traditional healers are familiar with symptoms of malaria and that they give treatment to those who are actually suffering from the disease.

Surveys carried out by the National Institute for Medical Research (NIMR) noted that traditional healers have knowledge and skills useful for malaria disease management (diagnosis, treatment, and prevention). They are capable of treating the disease using oral herbal medicines. NIMR performed further laboratory analyses of these traditional herbs to establish their efficacy and safety. The majority were established to be anti-malarial and could also treat other diseases. Toxicity varied from low to very high (Mwisongo and Borg, 2002).

Several explanations were given for using local herbs for treating malaria, including that: (1) they are quite common, well known, and familiar to most people; (2) they are easily available, less expensive, and effective as first aid before taking the patient to a hospital/health centre; and (3) pregnant women using these herbs do not encounter problems during delivery. The latter was associated with the fact that these herbs have multiple functions, such as reducing complications during pregnancy.

Concerning clinical medicines, participants during the stakeholders' workshop noted that every village has its own *Village Health Facility* and a *First Aid Kit*. Every household in the village contributes shillings 1,500/= annually to the *Village Health Facility*, which assures everyone receiving free services (medication). A Village Health Attendant is available in Bugarama village and provides first-aid services to all villagers. It was noted that households that have not contributed their dues have to look for other means of treatment when a household member falls sick; however, under "emergency" situations, even those who have not paid receive the medication on the condition that they pay their contribution upon recovery. Those considered extremely poor receive treatment free of charge, without the need to contribute. A receipt for contribution to the village health facility can be used as a security/guarantee when one goes to government hospitals such as Rubya and health centres such as Kabare. The facility attends not only malaria but also other illnesses. A health centre is also located in the neighbouring Biirabo village (centre known as Kabare). And Chato village has its own health centre.

Some of the household techniques used to overcome mosquitoes include:

(i) making the fire inside the houses and sleeping near it. Family members used fires to kill and chase away mosquitoes. Eucalyptus trees leaves and some of the herbs mentioned earlier were reported to be very effective in chasing away mosquitoes.
(ii) Using mosquito coils (21%).
(iii) Clearing of bushes around homesteads to destroy potential breeding grounds (18%).
(iv) Using screens (16%).
(v) Draining stagnant waters (15%).
(vi) Treating bednets with insecticides, mainly Ngao, once or twice a year (15%). (vii) Spraying insecticides in the houses against mosquitoes (11%).

Table 5 presents the perceptions of people with different levels of education on how malaria can be treated. It is evident that many people (78%) believed modern medicine has the ultimate cure for malaria; this did not vary across levels of education. A combination of modern and herbal/traditional medicine was perceived as an important means of combating malaria by 15.7% of respondent households, primarily those with either no formal education or some primary education. About 3% considered herbal medicine to be sufficient for treating malaria; this was a small group of people with primary education.

Table 5. Percentage of responses on relationships between levels of education and perceptions on how to treat malaria

Level of Education	How malaria is treated					
	Modern medicine	Herbal medicine	Modern medicine/ tepid sponging	Modern medicine/ herbal medicine	Modern medicine/ prayer	Total
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

4.6 Impact of and Vulnerability to Malaria by Sex and Age Groups

The control of malaria has been gaining new momentum in recent years as new tools and strategies are being developed. However, one problem is that neither malaria nor people are evenly distributed over the continent. Some regions experience very high risk of malaria all year round, while others experience only low risk, with seasonal or sporadic outbreaks, or even no risk at all. Sometimes populations are concentrated in high-risk, sometimes in low-risk areas. It is thus important to be able to distinguish between different transmissions patterns, as different control/adaptation methods or strategies are more effective in different situations (De Savigny et al., 1999). Unfortunately, reliable information is not easily available on where and at what levels malaria exists, when and why it gets transmitted, and who is at risk. While thousands of malaria studies have been carried out across Africa, the results are not readily accessible to those who need them most, such as the national decision-makers and local malaria control and health officials (De Savigny et al., 1999).

The results from the study in Muleba district currently being reported clearly show that different sex and age groups are affected at different intensities. During fieldwork and stakeholders' workshops, three key groups—infants, women (especially pregnant women), and the elderly were identified as the most vulnerable. Children 0-5 years of age were reported to be the most seriously affected by malaria; this was attributed to several factors, including: (1) poor nutrition for this age group, particularly between September and November, when even the breast-fed infants do not get enough milk from their mothers; (2) the fact that a child's nutrition relies on its elders; (3) the fact that diarrhoeal disease caused by eating potatoes results in children becoming very weak and more susceptible to malaria; and (4) the fact that many women, particularly those from poor households, spend most of their time doing casual labour elsewhere *(kuhemea*) and have little time to attend these young children. Hospital records from Ndolage and Rubya hospitals (Figures 3 and 4) support this argument. These two hospitals are the largest in Muleba District and serve a large part of the district population. Rubya, for instance, is the referral district hospital for Muleba District, and the closest to Bugarama Village.

Figures 3 and 4 demonstrate that children's death toll due to malaria reaches a climax between January and March. The climax at this early part of the rainy season may be attributed to the build-up of the mosquito population during the preceding dry season. This is the period when children suffer most from malnutrition and is the wettest part of the year (see Figure 2), thus creating many breeding sites and habitats for mosquitoes. The death toll for persons over 5 appears to be uniform over the year, indicating that there is no critical period for them as there is for younger ones. It should be noted however that the hospital records of these deaths correspond only to those cases that were hospitalised. This may be inadequate to establish conclusive patterns, particularly for the seasonality of malaria cases for people over 5 years of age. It is also necessary to disaggregate cases by gender, and to consider wealth categories of households. It is however documented that malaria is the leading cause of infant mortality in Africa, accounting for about 20% of the total (WHO, 2002). This aspect is a subject for further investigation.

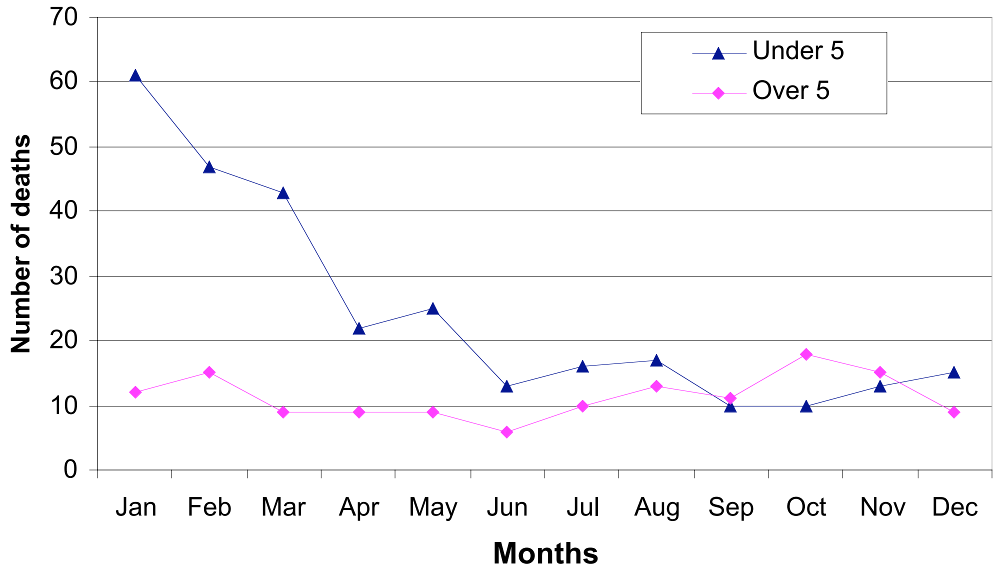

Figure 3: Total Death due to Malaria for Ndolage Hospital in 2001

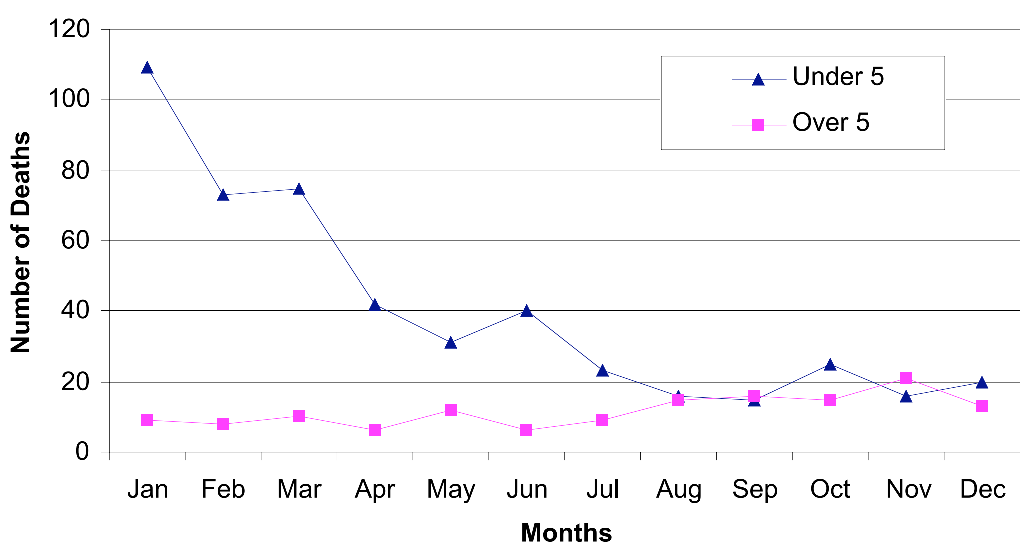

Figure 4: Total Deaths due to Malaria in Rubya Hospital in 2001

Participants during the stakeholder workshop and interviews reported that women, especially pregnant women, are the group second most affected by malaria. The main reason reported was poor nutrition; it was argued that this makes women weak and more susceptible to malaria. Non-pregnant women were also reported to be more affected than men. This was attributed to the fact that non-pregnant women work much harder on the farms than men, which, in addition to exposing them to more frequent mosquito bites, makes them weaker and more susceptible. Also, there was an assertion that adult men are nutritionally better-off compared to women because they spend long hours in pombe shops and eat good food in kiosks (local restaurants) before going home to join the households for another meal. Participant males, perhaps reflecting that this was somewhat true, did not refute this allegation.

Another explanation to why women suffer more from malaria was that during the growing season women are more involved in weeding bean fields. It was argued that the women and their children suffer frequent bites from mosquitoes that carry malaria. It was noted that traditionally Haya men do not take part in weeding beans, and so are less exposed to mosquito bites.

It was further argued that even at home women are more exposed to mosquito bites in the evenings because men are out most evenings at the bar, enjoying local brew, where there are fewer mosquitoes. It was also reported that malaria affects elderly people, although to a lesser extent than women and children. The explanation advanced was that because of their old age, the elderly are generally weak and may succumb to various diseases, including malaria.

Concerning the number of deaths due to malaria, it was revealed from household interviews that 15.7% of households had lost at least one member, with 12.3 % of households reporting having lost a child, and 3.3% of households having lost an adult member.

5. Factors Contributing to Vulnerability and Adaptation to Cholera

Local experiences in Chato village indicate that residents anticipate cholera outbreaks mostly during rainy seasons, particularly from October to January—locally known as the *mango-season.* Participants in the study associated the outbreaks with two situations: the disuse of toilets, and the spreading of mango wastes contaminated with cholera bacteria. Both situations are the result of unhygienic conditions. The following sections outline different factors that contribute to vulnerability and adaptation to cholera.

5.1 Accessibility and availability of sanitation facilities

Most people in Chato village have access to toilet facilities, including pit latrines and a few flush toilets, although it was not easy to determine how effectively these facilities are used. None of the households in the village had access to a sewage system, as is the case with many other rural areas in the country. This makes waste disposal rather difficult and generally uncontrolled, which is considered by the local community to contribute to cholera outbreaks. The local concerns regarding the association between cholera and the lack of adequate sanitary facilities corresponds well with scientific assessments (Kahwa, 2002). NaTHNaC (2004) points out that cholera is a disease that occurs in regions of the world where sanitation and food and water hygiene are inadequate or lacking. In circumstances where there is no clean water or adequate sewage disposal, cholera can spread very quickly. Such conditions are reported to be prevalent in poor countries with inadequate sanitation and lack of clean drinking water, particularly in Africa, Asia, the Middle East, Peru, and some Central American countries (NaTHNaC, 2004; WHO, 2005).

In an effort to ensure that cholera does not impact households in Chato village, several sanitary activities are undertaken at household level, including boiling drinking water (56.7%), filtering drinking water (50%), and treating drinking water with chemicals (3.3%). In this village, about 21% reported not treating or boiling drinking water. Given the reported unhygienic environment and recurrent cases of cholera in the area, the lack of treatment of drinking water makes those households vulnerable.

Reasons for not boiling or treating drinking water are shown in Table 6. Generally people in Chato village consider piped water or water from the pumped wells to be safe, and believe that it can be used for drinking without prior treatment. While this may be true, it was pointed out by respondents in the village that water taps often run dry and people have to collect water from the lake for domestic uses. Lake water source is not as safe as the water from taps and/or wells, and may expose the user to cholera: something that happened in the 1980s (as indicated on the narrative on cholera in Section 5.3). The fact that some people reported not using boiled drinking water indicates a high vulnerability to cholera when the water becomes contaminated. Other explanations had fewer responses, but they may be worth consideration when designing cholera control and adaptation measures.

Table 6. 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

Although some people did 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 could cause diarrhoeal diseases such as cholera, and 49% reported to have had at least one member of the household suffering from diarrhoeal diseases during the last five years. Those cases were associated with drinking untreated water from the lake. These people reported that they had learned about the consequences of drinking untreated water through the sources presented in Figure 5.

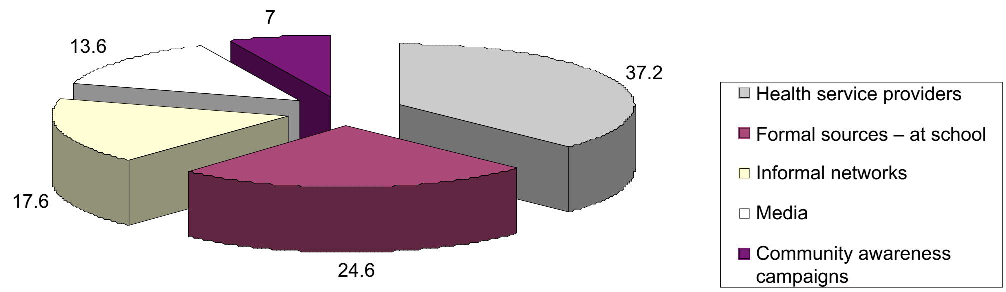

Figure 5. Sources of information in Chato village on the consequences of drinking untreated water

5.2 Knowledge, attitude, and practice of Cholera.

Concerning knowledge about cholera, all of the people interviewed reported to be aware of the disease and various ways by which one can get it, including drinking untreated water, eating contaminated foods, dirtiness, and the presence of flies.

Regarding what should be done when someone in the household gets cholera, the majority (96.9%) of respondents in Chato village indicated that the infected person was to be taken to a health facility. Only 1.8% of respondents reported that cholera could be treated at home. In such cases, the reported treatment included drinking a lot of water and, where possible, using oral rehydration salts.

5.2.1 Time of the year when cholera is a problem

An inquiry on the locally-perceived relationship between cholera and weather/climatic factors revealed that cholera outbreaks are generally associated with unusually wet seasons. This was attributed to many toilets being flooded and many collapsing because of the sandiness of the soils. This causes the waste from the toilets to spread into the surrounding areas, often ending up in water bodies such as the lake. This waste can spread cholera organisms. It was revealed during the stakeholder workshop that the many cases of cholera during the wet season might also be attributed to the fact that many people in Chato village do not use toilets. Therefore, a great deal of faecal material may find its way into the bodies of water that serve as sources of water for domestic use. The association between cholera outbreaks and rainy seasons is also documented in literature (cf. Christie, 1876; Mhalu et al., 1987). Christie (1876) noted, for example, that most cholera epidemics along the East African coast started during monsoons.

It should be noted however that the available information on cholera in the study area is based on only two outbreaks. This may be inadequate to enable us to draw firm conclusions on cholera patterns and the disease's association with climate change and/or variability. Longer-term datasets would be needed to establish firm associations between cholera and climate change/variability.

5.2.2 How the local people identify cholera (symptoms)

Participants in the group discussion narrated the various symptoms that they use to determine a case of cholera, including frequent diarrhoea that is watery with whitish colour, vomiting (vomited material with bluish-green colouration), general body weakness, Loss of water from the body, and loss of appetite.

These symptoms are much the same as those that are clinically diagnosed, reflecting the fact that many people in the village came to know about cholera symptoms and consequences through the health services providers (e.g. the Chato Health Centre). Regarding the nature of the disease, WHO (2005) describes cholera as an acute enteric disease varying in severity, with most infections being asymptomatic (i.e., they do not cause any illness). In mild cases, diarrhoea occurs without other symptoms. In severe cases, there is sudden onset of profuse watery diarrhoea with nausea and vomiting and rapid development of dehydration. These symptoms are generally in-line with those identifed by the local community in Chato village. In severe untreated cases, death may occur within a few hours due to dehydration leading to circulatory collapse (WHO, 2005).

5.2.3 How they address the problem (adaptation)

The following are the local or actions used to treat or prevent cholera.
(i) General cleanliness;
(ii) Washing hands with soap;
(iii) Boiling drinking water; and
(iv) The use of health facilities when one falls sick.
The village is fortunate in that the Chato Health Centre, which services the Chato Division (and other neighbouring divisions), is located in Chato village.

It was noted that currently there are no traditional medicines or cures for cholera in the village. The disease is considered new to the area, and as such, traditional herbalists have not yet invented any curative or preventive medicines. The locally-reported means (above) of preventing cholera are inline with the WHO recommendations for combating the disease. WHO (2005) recommends that all precautions should be taken to avoid consumption of potentially contaminated food, drink, and drinking-water. Oral rehydration salts should be carried to combat dehydration in case of severe diarrhoea.

5.3 Impacts (Trend in Incidences of Cholera)

It was rather difficult to develop a historical time line for outbreaks of cholera and their impacts, but the local people remembered two outbreaks. The first was in 1983, when a cholera patient was brought from a neighbouring village of Bukamila. His arrival was followed by an outbreak. Narratives concerning this outbreak indicated that the equipment used to carry the cholera patient was thrown into the lake close to where people collected water for domestic use. It appears that the equipment provided the source of the cholera pathogen. The other outbreak was that of 1997/98, during the El Niño rains. During that season, 19 people died of cholera. Analysis of secondary data from the health facilities is on-going and will be used to substantiate this local information, as well as to establish other periods with cholera epidemics.

Only a few (8, i.e. 5.3% of households in the Chato village) households had encountered cholera during the last outbreak (during the El Niño rains of 1997/98). The number of people who had cholera ranged between 0 and 4 per household. In all households, those who had cholera were subsequently hospitalised. 2 of the 8 households reported that they had lost at least one member due to cholera. All of the deceased were adults. In some cases, the respective households had to spend some of their resources to attend the cholera patients. The amount of money reported to have been used ranged between 1800/= and 30,000/= shillings, with an average of shillings 12,226/= per household.

6. Conclusion

It is the perception of households in the study sites that malaria and cholera outbreaks are seasonal and that this seasonality is related to climate variability. Consistent with this perception are deaths from malaria of children 5 years of age and younger that are reported from two area hospitals, which show a marked seasonality that corresponds with the early part of the rainy season. However, reported deaths of persons older than 5 do not show a seasonal pattern, which is unexpected and unexplained. Only two cholera outbreaks are recalled by households in Chato village, one of which appears to be related to occurrence of an El Niño event. Other studies have found evidence that malaria and cholera incidence are influenced by climate variability. Because of the findings of these other studies, and the consistency of most of our evidence from the study area in suggesting seasonality in malaria and cholera outbreaks, we conclude that changes in climate variability would very likely result in changes in the number of cases of these diseases in the area.

Results from this study show also that both malaria and cholera are associated with socioeconomic factors, mainly influenced by poverty levels. The more wealthy households who can afford to buy bednets and have access modern medication are less vulnerable to than the poor households to malaria. However, climatic variability plays an important role, in that seasonal weather conditions have been changing, leading to increased susceptibility to diseases such as malaria. It was established, for example, that the rainy season (usually between September and April) and the period just after is when there are large number of malaria cases. Prevalence of malaria epidemics in high-altitude areas like that of Bugarama village, for example, demonstrates that there have been variations in climatic conditions, which have enabled mosquitoes to find suitable habitats in areas that historically did not have malaria. This has resulted in climate change-induced malaria.

Vulnerability to the climate change-induced malaria in the highlands of Muleba district is also influenced by socioeconomic factors, particularly poverty levels. Women and children are exposed to mosquito bites while weeding the bean fields, as well as at home, making them more vulnerable to malaria. Men are not exposed to mosquito bites in bean fields because traditionally they do not work in these fields, making them less vulnerable. Since most of the farming is undertaken during the rainy season, the susceptibility to mosquito bites in fields and hence the vulnerability to malaria follows the seasonality of climate conditions.

Although there is an increase in the use of bednets (both insecticide-impregnated and untreated), many households are unable to buy enough mosquito nets for all household members. On average, each household had 1.5 bednets, and only about 2.4 persons per household used them. This indicates that, on average, 4 persons per household do not have access to bednets and are vulnerable to malaria. This was attributed to large families and poverty. Most of the households reported very low incomes indicating that this community is generally poor. It was also established that because of high poverty levels many people cannot afford modern medication; hence, they use traditional curative measures (local herbs) to treat malaria, rather than going to hospitals. Most of these anti-malarial herbs could treat other diseases. This appears to be a crucial adaptation strategy, particularly given the high poverty level in the area. It is imperative however that while addressing climate change issues, aspects of poverty alleviation need to be considered as they influence local adaptation mechanisms, and hence vulnerability to climate change-induced malaria.

Local experiences in Chato village showed that cholera outbreaks are anticipated mostly during the rainy season, particularly from October to January, which confirms the association between seasonal climate variability and cholera. Outbreaks have been associated with drinking water from the lake, lack of or inadequate sanitary facilities (e.g., lack of toilets), and poor disposal of other wastes such as residues from fruits. All of these result in unhygienic conditions. In addition, during unusually wet seasons with above average rainfall, many toilets get flooded and collapse because of the sandiness of the soils. This causes the waste from the toilets to spread into the surrounding areas, often ending up in water bodies such as the lake, spreading cholera. Despite the fact that only a few households reported cases of cholera during the last outbreaks, it was evident that many people are vulnerable because of drinking untreated water. It was evident that the community does not have adequate adaptation mechanisms. This situation calls for rigorous community health education, and should be should be an integral part in addressing poverty alleviation of local livelihoods in general.

7. Acknowledgement

This study has been funded by the Assessment of Impacts and Adaptation to Climate Change in Multiple Regions and Sectors (AIACC) Programme, implemented by the Global System for Analysis, Research and Training (START) and the Third World Academy of Sciences (TWAS) under Research Grant Agreement NO. AIACC-AF91. Supplemental Grant for Capacity Building and Stakeholder Engagement in AIACC-AF91 Project was given to START by the U.S. Agency for International Development (USAID), Grant Award No. GEW-G-00-02-00006-00)." The authors are grateful to the support provided by these institutions. Furthermore the authors acknowledge the assistance given to us by Professor Shem O. Wandiga of the Kenya National Academy of Sciences and Principal Investigator of this project. Many thanks to all the researchers in the AF91 project for their valuable discussions during various stages of the study, and to the communities where the study is being conducted for participating in this study.

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