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Effects of regional climate variability on the prevalence of diseases and their economic impacts on households in the Lake Victoria basin of Western Kenya

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Abstract: Climate variability has a strong influence on disease prevalence and subsequently on economic wellbeing of the affected households. In this study, six regions were selected and clustered into three groups based on their climatic conditions as follows: areas prone to droughts, floods and those with relatively good weather. Respondents were interviewed and the effects of prevailing climatic conditions on the prevalence of diseases established. Malaria, respiratory tract infection, typhoid, pneumonia and diarrhoea were the major diseases among the Lake Victoria basin residents. The annual disease frequency per household was highest in Budalang'i, a flood prone region; and lowest in Bomet, a region with relatively good weather. The findings reveal the often unseen subtle effects of adverse climatic conditions on economically vulnerable communities in the Lake Victoria basin (LVB) and elsewhere, and recommends flood/drought prevention and mitigation strategies and awareness creation to better cope with the adverse climatic events.

Keywords: disease prevalence; economic impact; climate variability; households; Kenya; Lake Victoria basin.

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1 Introduction

Concerns over the potential health effects of climate variability began in the mid-1980s, with indications that uncontrolled emissions of greenhouse gases could influence the climate system and result in intensification of the greenhouse effect. Climatic changes include rising temperatures and highly variable rainfall patterns, which result in increased frequency and unpredictability of extreme weather events such as floods and droughts. The concentration of CO_2 in the atmosphere is increasing at a rate of around 2 ppm yr^{-1} (Budzianowski, 2013). Intergovernmental Panel on Climate Change (IPCC) (2007) predict future increases in flooding due to escalating storm activity and overall rise in amounts of precipitation. It has been reported that the last two decades have registered six years with the warmest temperatures. Rainfall variability has been witnessed in the Sub-Saharan Africa (SSA) with decreases recorded in the Sahel region and increases in the East and Central African region (Opondo, 2013). Consequently, climate-related disasters such as floods and droughts have doubled in these regions within the last quarter century. Mozambique, Malawi, Kenya, Madagascar and Ethiopia are examples of SSA countries likely to continue experiencing unexpected adverse weather patterns (World Bank, 2009).

Given the clear evidence that many health outcomes are highly sensitive to climate variations, it is inevitable that climate variability and change will influence all natural, human, and socioeconomic systems, thus affect not only health but many other aspects of ecologic and social systems. McMichael and Kovats (1999) singled out climate variability among the factors that create conditions favourable for the development of some disease-causing microorganisms. Climate variability and change may result in quick mutation of viruses and bacteria, thus allowing for their environmental adaptation (McMichael and Kovats, 1999). This can also present additional stresses likely to increase mutation rates of different microorganisms, thus increasing emergence and

reemergence of diseases. Climate-sensitive diseases have been identified that have important health burdens, particularly on vulnerable households.

Many parts of the Lake Victoria basin (LVB) are already experiencing more frequent droughts – often followed by heavy rains and floods, as well as rising temperatures, probably as a result of global climate change. The increased health risk of floods resulting from climate change and climate variability in poor developing countries has been recognised (IPCC, 2007). Drought and high temperatures have also been linked to famine and malnutrition, which weakens the body's resistance to diseases, particularly among the poor households. A report by the US Climate Change Science Program (Ebi et al., 2008), cites human health as one of the most worrying effects of climate change, with incidences of diseases such as malaria among communities thought to increase with variations in climate. Both floods and droughts can also influence water-borne diseases, with cholera and diarrhea being potentially most problematic and of economic importance (McMichael et al., 2001). Malaria is endemic in the lowlands but has also been reported as being epidemic and highly unstable in the highlands of the LVB region (Wandiga et al., 2010). In this respect, malaria is ranked as the first cause of morbidity and mortality among children and adults in many tropical regions of the world (WHO, 2010). To estimate the potential economic costs of the health impacts of climate variability, it is important to understand the current vulnerability in relation to disease exposure-response-relationship.

The economic impacts of floods and droughts on households can arise through climate-related human diseases. These diseases can push more people below the poverty line or impoverish further the existing poor due to costs incurred during treatment and the productive time lost by the patient and the caretaker in case of hospitalisation (Cooley et al., 2012). Concerns about the link between ill-health and economic impoverishment have placed human health at the centre of development agencies' poverty reduction targets and strategies and increased the weight of arguments for substantial health sector investments to improve access to medical services for the world's poorest people (Cutter et al., 2009). It is thus clear that high poverty levels and high vulnerability to climate-related diseases among households are intricately linked. Climate variability that result in unusual heavy rains, that results in floods and the subsequent long dry spells (droughts) are therefore likely to worsen the already existing poverty levels among households living within the LVB of Kenya, given their implications on portable water resources and associated negative health outcomes, coupled with subsequent direct and indirect costs incurred during treatment (Wandiga et al., 2010).

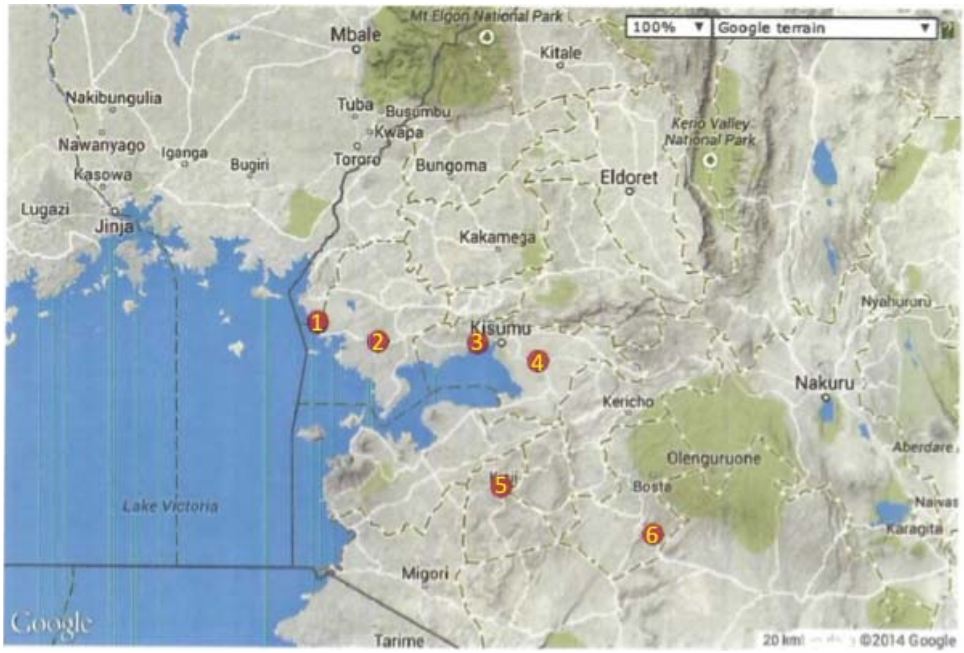
This study sought to establish the effects of regional climate variability on the prevalence of diseases and their economic impacts on households in the LVB of Western Kenya. The overreaching goal was to provide information to policy makers for advising LVB communities on climate variability induced diseases and their subsequent negative economic implications on households living within the basin. The study seeks to inform LVB residents on the dangers and risks of settling in regions prone to adverse climatic events and conditions, while providing key stakeholders with the information necessary for designing appropriate mitigative, preventive and early warning systems aimed at informing response strategies for coping with adverse climatic events such as floods and droughts.

2 Methods

2.1 Study area

The study was carried out in July and August 2011 in six regions within the LVB of Kenya, located at latitude 0° 20'-3° 00'S and longitude 31° 39'-34° 53'E. The entire LVB covers an area of 194,000 Km^2, with an approximate human population of 12.5 million people in the LVB of Kenya alone (Odada et al., 2009). The study regions were selected and clustered into three groups based on their local climatic conditions as follows; regions prone to droughts included: Rarieda and Bondo in Siaya County; regions prone to floods included: Budalang'i in Busia County and Nyando in Kisumu County; and regions with relatively good weather included: Bomet in Bomet County and Kisii central in Kisii County (Figure 1). A minimum of 80 respondents were selected from each region, to yield a total of 480 respondents for the six study regions. The geographical features of the different study regions are briefly described below and Figure 1 shows the primary sampling sites for this survey.

Figure 1 Study area showing location of study sites: (1) Budalngi (2) Rarieda (3) Bondo (4) Nyando (5) Kisii Central (6) Bomet (see online version for colours)



The Nyando region covers 1,168.4 Km^2 and is located within the LVB, much of it being in the Kano plains, and lies between 1,120 m and 1,150 m a.s.l. The region receives an annual average rainfall of about 1,835 mm, while the frequency of heavy precipitation events especially in the lower areas is higher (Gichere et al., 2013). Major floods documented in the region occurred in 1937, 1947, 1951, 1957 to 1958, 1961, 1964, 1985, 1997 to 1998, 2002, 2003, 2007 and 2009 (Gichere et al., 2013; Eitel and Ochola, 2006). The *El Nino* related floods of 1997/1998 constituted one of the greatest flood episodes

experienced in Nyando and other parts of Kenya in recent years. The Budalang'i Division covers an area of 188.3 Km^2 and lies within the Western part of Kenya near the shores of Lake Victoria. Budalang'i constituency has a population of 66,723, and a population density of 354 persons per square kilometres (KNBS, 2010). It is one of the major flood prone regions in Western Kenya (Gichere et al., 2013; Mango, 2003). Major flood disasters occurred in 1945, 1948, 1951, 1961 to 1962, 1975, 1977, 1978, 1997 to 1998 (*El Nino* rains), 2001, 2002 and 2003 (Mango, 2003). The latest flood disaster was experienced in December 2011. Floods have often left a history of destruction in Budalang'i displacing not less than 25,000 people every time they strike in recent times (Gichere et al., 2013). These disasters have direct, indirect, and secondary effects on development, health and economic status of the region's inhabitants.

The Bomet region covers 824.6 km^2 and is located in the highland regions of the Rift Valley Province of Kenya. It has a total population of 397,104, an urban population of 98,507 and a total of 56,084 households (KNBS, 2010). Bomet region receives relatively well distributed rainfall, which favours agriculture and livestock keeping; the two main economic activities in the region. However, Bomet region experiences diseases such as malaria, respiratory tract infections, and diarrhea that are all climate-related, and according to The Little Fact Book (2002), Bomet County has a life expectancy of 57 years and a poverty level of 61.8%.

The Kisii central region lies between latitude 0° 41' N and longitude 34° 46' E. It is one of the most densely populated regions in the LVB (KNBS, 2010) with a county population of 365,745 and an area of 335.5 km^2. It has an urban population of 82,628 and a total of 60,739 households. The economy of the region is derived from agriculture driven by its good climate and commerce largely favoured by its central location.

Rarieda district has a population of 134,558, the district belongs to the poorest regions of Kenya, of which a proximately 70% of the people have less than 1 $ available per day and thus live beneath the poverty line. Nyando district has a population of 350,353. The District economic capital is the town of Awasi, located 30 kilometres east of Kisumu City. The district is prone to perennial floods, often twice in a year during the short and long rains seasons. The Bondo region within Siaya County lies between latitude 0° 26'N to 0° 90'S and longitude 33° 58' E and 34° 35' W, and covers an area of 1,972 km^2 of which 972 km^2 is land mass and 1,000 km^2 is covered by Lake Victoria. Bondo has a population of 157,522 (KNBS, 2010), with approximately 47.2% of the population being poor of which 41.1% of households live below the poverty line (NEMA, 2007).

The regions have a modified equatorial climate with strong influence from local relief and the expansive lake, which influences rainfall amounts and distribution. Predominantly, the region has warm, dry and humid climate with mean annual rainfall ranging between 800 mm to 1,600 mm. Agriculture and fishing form the key sources of livelihoods in the three regions.

2.2 Data collection process

2.2.1 Primary data collection by use of questionnaire

A total of 480 adult respondents each representing a household were randomly selected (80 from each study area) to participate in the study. The inclusion criteria included adults aged between 18 and 80+ years, living within the six selected regions and who gave their informed consent to participate in the study. The survey questionnaire included

three main themes, namely; social, health and economic. The respondents were asked questions on health including: illnesses among household members within the last 12 months, their types and perceived causes (if climate-related), the frequency of illness, the rating of their health status, month of illness occurrence and duration the patient was bed ridden. In addition, questions on who took care of the sick household member, number of days the caretaker took with the patient and impact of the illness on household livelihood were asked.

Additional questions were also asked to establish the economic impact of the diseases on the communities. The respondents were asked questions on action taken when a household member fell ill, mode of transportation to hospital and the direct financial expenditures. The respondents were further asked if they had witnessed any death(s) within their household in the last 20 years, the month of occurrence and the cause. Questions on socio-demographic status included: household head's education level, gender, religion, age, marital status, land ownership, duration over which they had lived on their current land, and sources of income and their adequacy for the household.

2.3 Data analysis

Data was cleaned and entered into Epi-info database and subsequently analysed using Epi-info and Microsoft Excel. R software (R Core Team, 2012) was used to perform both descriptive and inferential statistics. The association between seasons (or climatic events) and economic impacts or health outcomes (disease prevalence) was analysed using Chi-square (χ^2) test, while the odds ratio (OR) as a measure of the strength of association was used to measure the risk of a particular outcome (e.g., disease) given a certain factor or exposure, e.g., floods. A conventional significance level of $p < 0.05$ was chosen.

2.4 Ethics statement

The protocol to initiate this study was developed by the authors and approved by the School of Graduate Studies (SGS), Maseno University, Kenya. Permission to carry out household interviews was obtained from relevant administrative heads including, district officers (DOs), Chiefs, Assistant Chiefs and Village Heads. Written informed consent was also sought from all the respondents before the interviews were conducted.

3 Results

3.1 Demographic and socio-economic characteristics of the study population

The household populations in the surveyed homesteads constituted 3,809 persons, of whom 48.2% were male and 51.8% were female. Most (average 51.5%) of the household population was aged below 20 years, while those aged above 51 years constituted 10.5% across all the study regions (Table 1).

Most households owned less than four acres of land, with a majority (35.5%) owning less than one acre. Most (92%) of the households inherited the land on which they lived. Other modes of land acquisition included buying (6%), receiving as a gift (2%) and other undisclosed means. Most of the respondents had lived on the same piece of land for more than ten years, with a majority of those from Budalang'i reporting to have lived on their

land much longer (mean 39.6 years) compared to the other study regions. The maximum number of years lived on land was 82 as reported by a respondent from Rarieda and the minimum was 1 year, reported by a respondent from Nyando region.

Table 1 Age group (%) of the members of the households studied

Age groups (yrs)	*Flood prone*		*Drought prone*		*Favourable weather*		*Mean age groups*
	Nyando	*Budalang'i*	*Bondo*	*Rarieda*	*Bomet*	*Kisii Central*	
< 20	47.8	56.6	54.7	52.4	55.1	42.6	51.5
21–34	28.2	19.1	21.8	23.4	22.4	31.6	24.4
35–50	16.5	11.6	12.3	12.5	13.2	18.1	14.0
> 51	7.5	14.6	11.4	11.7	10.4	7.7	10.5

The dominant livelihood source for the LVB households was crop farming (68.7%). Other livelihood sources mentioned were: fishing (12.1%), business (12.9%), casual labor (3.8%), salaried employment (2.3%) and other unspecified sources (0.2%). Majority (81.8%) of the respondents reported that all their sources of income generated during the previous year were not adequate for their household. Crops grown in the farms were the main source of food for most households, as reported by 48% of the respondents while 45% of the respondents cited food bought from the market as the main source of food for the households. Other sources mentioned were fish from the lake and animal produce. Most households practiced agropastoralism (60.2%), while others practiced crop agriculture (38.6%) and pastoralism (1.3%) as their main land use activity.

Considering climatically different regions, about three quarters (74.0%) of households from Budalang'i and Nyando regions reported to have been affected by floods while 67.7% of respondents from Rarieda and Bondo regions had been affected by droughts. More than half (52.7%) of the households in regions with relatively good weather (Kisii and Bomet) also reported to have been affected by adverse climatic events (floods or drought). The major effects of adverse climatic conditions on households was crop failure (72.9% of responses), while 11.8% mentioned famine and poverty. However, no respondent mentioned migration as an option, though majority of the flood or drought affected households reported seeking refuge in their relatives' or friends' houses within their communities or in their neighbouring communities. In addition, households residing in areas that were highly prone to floods reported relying on temporary shelters provided by the Kenya government and nearby schools or churches or setting up temporary tents in relatively raised and safer areas during flood events.

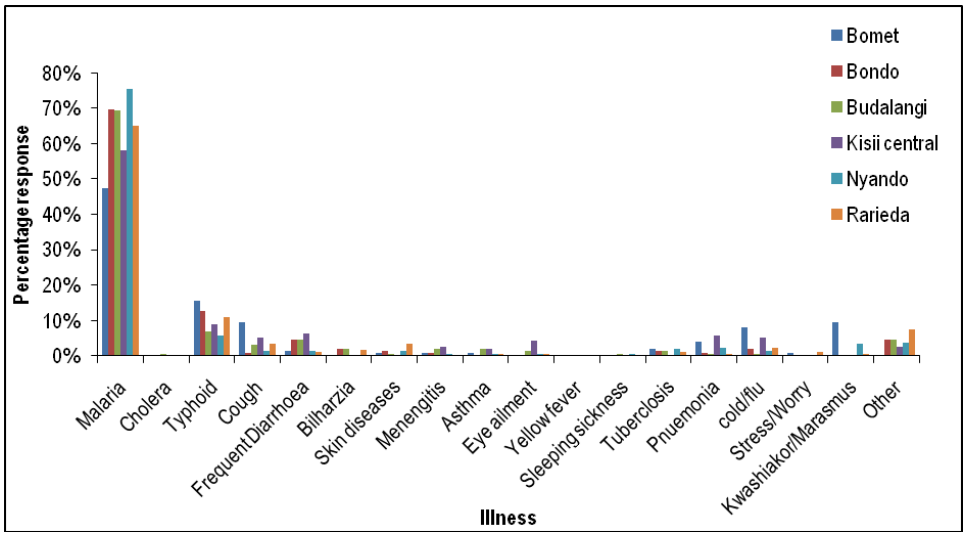
3.2 Effects of regional climate variability on the prevalence of diseases and their economic impacts

Most (95.6%) respondents reported that at least a family member had suffered illness within the last 12 months. Up to 89.2% and 91.1% of households from Bomet and Kisii central regions, respectively, and over 97% of households from other study regions (Bondo, Budalang'i, Nyando, and Rarieda), reported that at least a member of their households had suffered illness within the previous one year. Further analysis showed that, those living in flood and drought prone regions were almost seven times more likely

to suffer from illness, compared to those from regions with relatively good weather (OR = 6.5, 95% CI {2.97–14.2}, $p < 0.0001$).

The most common causes of illnesses were malaria (mostly reported in Bondo, Budalang'i, Nyando, and Rarieda, and less in Bomet and Kisii central), and typhoid. Based on study responses, Bomet region recorded the lowest malaria cases but highest typhoid cases, while Nyando region recorded the highest malaria cases but lowest typhoid cases. Like Nyando, relatively high malaria cases were also recorded in Budalang'i region (both flood prone regions), and Bondo (a drought prone region), Figure 2. Malaria was thus the most common (63%) cause of illness among household members followed by typhoid, then tuberculosis. Health records of the previous 12 months obtained from health facilities within the study regions also indicated that malaria was the dominant cause of illness across all the regions followed by respiratory diseases, typhoid and pneumonia.

Figure 2 Common causes of illness in the six regions within the LVB of Kenya (see online version for colours)



The Annual disease frequency per household was 9.113 for flood prone Budalang'i/Nyando regions, 9.043 for drought prone Rarieda/Bondo regions, and 6.216 for normal weather regions of Bomet and Kisii central. A chi-square test revealed a significant association ($p < 0.001$) between the number of people affected and the three climatically different regions. The largest proportion of respondents (71.9%, CI = 71.7–72.2), from flood prone regions (Budalang'i and Nyando) reported having experienced climate-related diseases, compared to 67.7% (CI = 67.4–68.1), from drought prone regions (Bondo and Rarieda) and 52.7% (52.5–53.0) from regions with favourable weather (Kisii central and Bomet), (Table 2).

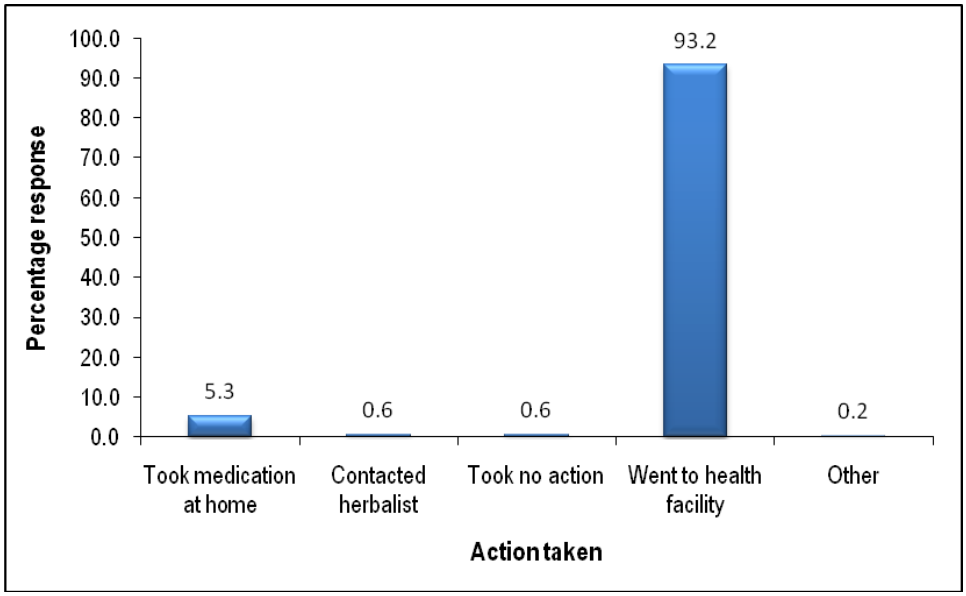
Considering responses from all the regions studied, 15% of the respondents rated their health status as poor, 42% as fair, 39% as good, and only 3% as very good. No respondent rated their health status as excellent. When regions were considered separately, 53% of respondents from Bomet and 42% from Kisii central regions rated their health status as good, while less than 40% of the respondents from all the other

regions (Bondo, Budalang'i, Nyando, and Rarieda) rated their health status as good, with a majority rating their health status as fair. Further statistical analysis showed that households from flood prone and drought prone regions were 17% more likely to rate their health status as fair than poor, 31% as poor than good, 44% as poor than very good, and 100% as poor than excellent (*p-values*, 0.08, 0.002, 0.22, and < 0.001, respectively). As regards the frequency of sickness among household members, only 2% of the respondents reported that their household members got sick at least weekly, 46% at least monthly, and 28% at least quarterly. However, 24% of the respondents reported that it took time for their household members to get sick, with a considerable number of the respondents being from Bomet region.

Table 2 Annual disease frequency per household per climatic region, n = 480

	Flood prone (Budalang'i /Nyando)	*Drought prone (Rarieda/Bondo)*	*Favourable weather (Bomet/Kisii)*	*Coefficient*	*p-value*
Total household population in study area	97,470	68,329	156,748	0.816	0.001
Total number of people affected	70,102	46,278	82,623		
Proportion of individuals affected in the households surveyed	71.9% (95% CI = 71.7–72.2)	67.7% (95% CI = 67.4–68.1)	52.7% (95% CI = 52.5–53.0)		
Annual disease frequency/household	9.113	9.043	6.216		

Figure 3 Action taken when household member last fell ill within the LVB of Kenya (see online version for colours)



On average, most (93.2%) respondents from the six study regions reported that they went to a health facility when their household member last fell ill, while 5.3% took medicine at home. Very few others consulted herbalists or took no action, Figure 3.

Table 3 Effects of climatic variability on annual disease burden among populations of climatically different regions

Disease history	*Number and proportion of individuals affected*			
	Favourable weather (Kisii and Bomet)	*Flood prone (Nyando and Budalangi)*	*Drought prone (Bondo and Rarieda)*	*Total*
The number of households that had experienced climate-related disease, e.g., malaria, typhoid, diarrhea (%)	n = 82 (13.0%)	n = 84 (58.4%)	n = 83 (26.6)	n = 249 (100.0%)*
Households that reported to have spent too much time with the patient (%)	n = 77 (11.2%)	n = 68 (71.4%)	n = 81 (17.4%)	n = 226 (100.0%)*
Households whose members' health had deteriorated as a result of adverse climate (%)	n = 74 (35.2%)	n = 80 (31.0%)	n = 79 (33.8%)	n = 233 (100.0%)
Household member reported to have spent more than a month in care of a patient (%)	n = 74 (15.0%)	n = 81 (45.7%)	n = 78 (39.3%)	n = 233 (100.0%)*
Household whose member(s) was reported to have become sick at least monthly due to adverse climate (%)	n = 81(48.0%)	n = 82 (20.4%)	n = 83 (31.6%)	n = 246 (100.0%)*
Households that spent money on transportation to seek health care (%)	n = 82 (34.3%)	n = 79 (56.8%)	n = 81 (8.9%)	n = 242 (100.0%)*
Households that spent money on private/public health facilities as a result of climate-related disease (%)	n = 76 (35.9%)	n = 79 (37.5%)	n = 82 (26.6%)	n = 237 (100.0%)

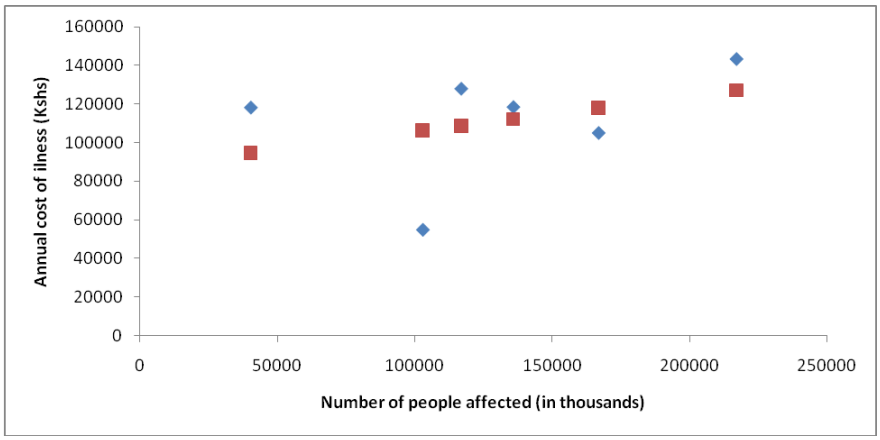
Note: *p-value < 0.05.

Considering each study region separately, 100% of respondents from Budalang'i reported that they went to the health facility when their household member last fell ill. However, 4% of respondents from Bomet, Bondo and Kisii central regions, 12% from Nyando and 8% from Rarieda reported that they took medication at home when their household member last fell ill. As regards the effects of climate variability on household disease burden, the largest proportion of respondents (58.4%) from flood prone regions (Budalangi and Nyando) reported having experienced climate-related diseases, compared to 13.0% from relatively good weather regions and 26.2% from drought prone regions. In addition, a significantly high proportion (45.7%) of respondents from flood prone regions reported having spent more than a month caring for their sick household member(s)

($p < 0.05$). An almost equal proportion of respondents across the three climatically different regions observed that the health of their household members had deteriorated as a result of adverse climatic conditions (Table 3).

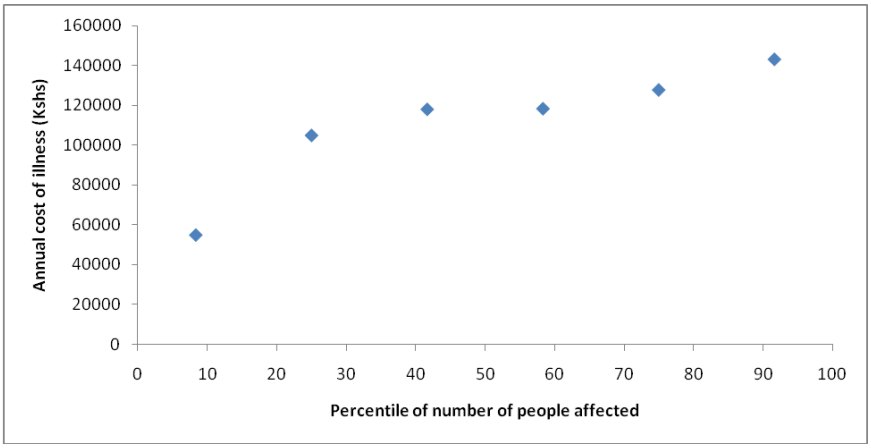
With regards to transportation cost to seek medical care, significant differences were observed among responses obtained from the three climatically different regions. Over half (56.8%) of respondents from flood prone regions (Budalangi and Nyando) reported spending some money on transportation to seek medical care, compared to 34.3% of those from relatively favourable weather regions (Kisii central and Bomet) and 8.9% of those from drought prone regions (Bondo and Rarieda). An almost equal proportion of respondents from the three climatically different regions however, reported having spent money on hospital bills after their household member was taken ill. In addition, a significant proportion (26.6%, CI = 26.0–26.8) of respondents from flood prone regions reported having spent more than a month caring for the sick. In the same region a large proportion (50.5%, CI = 50.1–50.9) of the population spent more on transportation to the health facility, while almost equal proportions of respondents across the three climatically different regions observed that the health of their household members had deteriorated as a result of adverse climatic conditions. With regards to transportation cost to seek medical care, significant differences were observed among responses obtained from the three climatically different regions. Over half (56.8%) of the respondents from flood prone regions (Budalang'i and Nyando) reported spending at least some money on transportation to seek medical care, compared to 8.9% of those from relatively favourable weather regions (Kisii central and Bomet) and 34.3% of those from drought prone areas (Bondo and Rarieda). An almost equal proportion of respondents from the three climatically different regions however, reported having spent money on hospital bills after their household member was taken ill (Table 3).

Figure 4 Regression of the annual cost of illness against number of people affected within the LVB of Kenya (see online version for colours)



Notes: Blue: Annual cost in thousands
Red: Predicted values

Figure 5 The normal probability plots of annual cost of illness against the number of people affected within the LVB of Kenya (see online version for colours)



High medical bills (72%), inability to work (24%), too much time spent on the sick (3%) and slowed economic development (1%), were cited as some of the impacts of diseases to the household by the respondents. High medical bills were cited by most respondents (over 90%) from Budalang'i region, and 62% of respondents from Nyando (both of which are flood prone regions). A regression analysis, showed a positive linear relationship between cost of illness and the number of individuals affected by adverse climatic conditions ($R^2 = 0.362$, $p = 0.0316$), Figure 4 and Figure 5.

4 Discussions

The findings from this study highlight the often unseen or ignored subtle effects of adverse climatic conditions on economically vulnerable communities living within the LVB and elsewhere. Results showed that malaria, respiratory illnesses, typhoid, pneumonia and diarrhea (all weather-related diseases) were the major causes of illness among the LVB inhabitants, while the annual disease frequency per household was significantly higher in Budalang'i (a drought prone region) compared to other regions with lowest disease frequency recorded in Bomet (a region with relatively good weather). This could have resulted in the significantly higher medical expenses and lost earnings resulting from climate-related diseases among households from climatically different regions.

4.1 Demographic and socio-economic characteristics of the study population in relation to extreme climatic events in the LVB of Kenya

Results from this study showed that most of the respondents had lived within the same community for more than 10 years, and had inherited the land on which they lived. Surprisingly, most respondents from Budalang'i, a flood prone region, reported to have lived on their land longer (mean 39.6 years) compared to respondents from other study regions. Though migration is always significant in the spread of diseases to new areas (McLeman and Smit, 2005), results obtained from respondents showed that no household

considered migration to distant regions as a permanent option against the adverse climatic conditions. This could be a reflection of socio-economic vulnerability and 'lack of alternatives and opportunities' probably due to perpetual poverty, lack of awareness, and blind value and safety attached to living in ancestral land among the LVB communities. This could have a historical explanation as is expounded in the paragraphs that follow.

Some anecdotal reports from the flood prone regions of Budalang'i and Nyando in the LVB point out that the communities from these regions consider seasonal flooding as a blessing since floods have been associated with lots of fish and easy fishing opportunities, irrespective of the risks involved (Odada et al., 2009). Flooding in these regions are often caused by heavy rains which result in overflowing of rivers Nzoia and Sondu-Miriu that flow through the low lying Budalang'i and Nyando regions, respectively. The proximity of Budalangi and Nyando regions to Lake Victoria and the fact that the two rivers drain into Lake Victoria in these points is thought to favour anadromous type of fish, which prefer to swim upstream (against the current) to breed and spawn (Odada et al., 2009). This probably explains the fish abundance during floods and the reluctance of locals to permanently relocate from these flood prone regions to safer areas. However, the validity and accuracy of these reports need to be investigated in future studies and if found to be true then there will be a need to create mass awareness of the negative health and economic impacts associated with flooding.

4.2 Adverse climatic events and disease prevalence/burden

Climate change is a global reality (IPCC, 2001) and the changing climate will inevitably result in water scarcity, food insecurity, human diseases, among other negative effects (Hanjra and Qureshi, 2010). A warmer and more variable climate threatens to lead to higher levels of air and water pollution, increase disease transmission, compromise crop production and thus increase the vulnerability of the poorest members of the community to the adverse effects of climatic events like floods and droughts. Lack of access to clean water supply and sanitation, coupled with poor hygiene is already contributing immensely to the high burden of diarrheal diseases among the poor (Wardlaw et al., 2010). According to Noji (1997), the risk factor for communicable disease transmission after extreme climatic events is often associated primarily with the size and characteristics of the affected population or household, their proximity to safe water and sanitation facilities, their nutritional status and their level of access to healthcare services. Climate change therefore, puts to risk the protection and improvement of human health and well-being especially among the poor households.

Consistent with our study findings, McCarthy et al. (2001) observed that the apparent correlation between outbreaks of malaria and cholera with *El Niño* years (e.g., 1982 to 1983 and 1997 to 1998) supported a causal relationship between climate and health. A number of other researchers have also investigated the relationship between malaria and climatic factors as reviewed in IPCC (2007). Zhou et al. (2003) and Wandiga et al. (2010) both working in the African highlands, though their study design and objectives were totally different from our study, indicated that climatic factors such as temperature and precipitation play an important role in explaining the variation in malaria cases. Also, these studies were conducted on a small scale (in a specific region of a country) creating a need for larger scale investigations.

The prominence of malaria over all other climate-related diseases was not a surprise in the current study since the LVB region is regarded a malaria endemic region (Minakawa et al., 2012). Owing to its high malaria prevalence, the LVB of Kenya has been classified by the government of Kenya as one of the four malarial eco-epidemiological zones and a stable endemic area which experiences high transmission throughout the year due to climate favourable for rapid development of parasites in the mosquito (DOMC/MOPHS, 2011). Previous studies showed an estimated 243 million malaria cases with over 863,000 deaths being reported in 2008 alone, most (89%) of them occurring in Africa (World Malaria Report, 2009). The impact of altered distribution of some infectious disease vectors owing to changing weather patterns on human health has also been reported by IPCC (2007). Githeko et al. (2006) however observed that prevalence of highland malaria was differentiated by elevation, with high prevalence recorded at the valley bottom, then hillside and finally hilltop, in that order.

In the current study, malaria cases were reported by most respondents as the major cause of illness within their households. This was also supported by hospital records collected from each study region, including highland regions where cumulative incidences of malaria were previously rare. Hospital records from Kisii central region during the year 2011 for instance, showed an increase in malaria cases most of which occurred during the month of April, when the region experiences high rainfall amounts (Njue et al., 1997). High incidences of malaria in flood and drought prone areas as well as in the highland areas of Kisii central could have been attributed to changes in weather patterns such as a rise in temperatures as well as flood waters which created pools of water following flooding events, thus providing perfect habitats for the development and survival of malaria transmitting mosquitoes. These findings are a confirmation that there have been changes in weather patterns particularly an overall increase in temperature in the highland regions. Baliraine et al. (2010), reported that the Kenyan highlands (1,500 m and above) were malaria-free before the 1910s, but the 1980s and 1990s saw the resurgence of malaria in the East African highlands (Omumbo et al., 2011). Likewise, studies by Githeko et al. (2000) in the western parts of Kenya showed that malaria epidemics have spread to 15 districts presently, from only three in 1988.

In the current study, annual disease frequency per household was 9.113 for flood prone Budalang'i/Nyando regions, 9.043 for drought prone Rarieda/Bondo regions, and 6.216 for normal weather regions of Bomet and Kisii central. A chi-square test revealed a significant association between the number of people affected and the three climatically different regions. Results from this study also showed that those living in flood prone or drought prone regions were almost seven times more likely to suffer from illness, compared to those from regions with relatively good weather. Also, the highest annual disease frequency per household based on hospital records and percentage of the households that reported to have been sick was in Budalang'i (10.113), a flood prone region, and lowest in Bomet (4.937), a region with relatively good climate, implying that households from Budalang'i were likely to visit a health centre up to ten times in a year as compared to five times per year for those from Bomet region.

Though this study did not consider chronic diseases, many researchers have reported that chronic diseases also cause high mortalities among populations and are also costly. For instance, WHO (2011) estimated that there were about 57 million deaths worldwide, of which 36 million (63%) were attributed to chronic diseases in 2008. However, unlike the climate-related illnesses which affect virtually everybody, chronic diseases are often thought to primarily affect older populations, though studies now show that these chronic

diseases are the leading cause of death for both males and females in every region worldwide except Africa (WHO, 2005). This therefore implies that unlike climate-related diseases, chronic diseases are more prevalent among the wealthier and older populations and hence appear to be restricted to certain groups within the society. This therefore leaves climate-related diseases as the leading cause of illnesses among the LVB inhabitants most of whom are poor.

4.3 Economic impacts of climate-related diseases in the studied regions

The results in this study showed that on average, most (93.2%) respondents from the six study regions reported that they went to a health facility when their household member last fell ill, and only 5.3% took medication at home, while less than 2% either consulted herbalists or took no action. Diseases triggered by climate change markers and adverse climatic conditions present the affected households with high medical costs while negatively affecting their daily productivity and economic well being. The poor households, like was the case for a majority of households in the LVB of Kenya, are particularly vulnerable due to their limited capacity to cope with climate-related illnesses (WMO, 2002). Malaria for instance presents the affected households with a heavy economic burden due to its recurrent nature and severity on the patient forcing some to be bed ridden for several days thus incurring huge economic losses in terms of forgone income. The World Health Organization estimates that there were about 219 million cases of malaria in 2010 and an estimated 660,000 deaths, with about 90% of the deaths occurring in Africa (World Malaria Report, 2012).

The overall amount of money spent on treatment of the affected household member(s) is usually high as was also reported in the current study especially in flood prone areas, where malaria transmitting mosquitoes are usually abundant due to the numerous suitable microhabitats created by receding flood waters. The World Health Organization in their report also concur that the international disbursements for malaria control is high and was estimated to be about US$1.66 billion in 2011 and US$1.84 billion in 2012, with an estimated US$5.1 billion more needed every year between 2011 and 2020 to achieve universal access to malaria interventions (World Malaria Report, 2012). This means that the cost keeps rising, thus making malaria a very serious problem with high economic implications affecting almost all segments of the society.

In the current study, transportation cost to and from hospital for ill household members was highest in Nyando (a flood prone region), compared to the other regions. Poor road networks occasioned by flood waters and the geographical location of Nyando region – being close to Kisumu city in western Kenya, could have been the cause of the high transportation cost since in most cases, urban and rural transportation costs differ. Consistent with the current findings, studies show that change in climate compromises access to crucial health services among the affected people, particularly where infrastructure is poor and the population at risk has limited economic resources (World Bank, 2010). Study findings showed that households from Bomet and Bondo regions were likely to spend much less in transportation than all other regions, though Bondo (a relatively dry region) had a relatively higher disease frequency. This implies that aridity of the region did not necessarily affect the road infrastructure hence the cost of transportation remained low. However, it can also be argued that in the drought prone regions, the dusty roads may trigger respiratory diseases and coughs leading to increased

cases of respiratory tract infections among the local communities as also reported by Stanke et al. (2013) in their systematic review of the evidence of health effects of droughts. The current study results suggest that floods can have significant effect on transportation both directly through cutting off sections of the road and indirectly by forcing people to travel to far off areas to access health care services which then increases the transportation cost.

Apart from transportation cost, other direct cost of illness include: cost of food and medication cost all of which depend on the duration of the illness. The indirect cost of illness often estimated through the human capital approach that considers the value of lost productivity as a result of illness, and which are not out-of-pocket payment included time lost traveling to and from hospital and time lost waiting at the hospital. These costs affect both the patient and the caretaker which drives up the total cost of illness for households. This is because the value of time lost is assumed to be equal to the earnings that household members could have made in the absence of the illness. Indeed, other similar studies in their conclusions stressed the importance of including caretaking costs when determining diseases such as malaria's economic impacts, arguing that significant productivity is lost when for instance women – who comprise a large proportion of the production base at the household level also comprise the majority of those who take care of the sick household members (Cai and Kalb, 2006).

As already mentioned, in the current study, it was established that the overall cost of illness was highest in Budalang'i (a flood prone region) and lowest in Bomet (a region with relatively good weather). More precisely, the cost of medication, transportation, travel and waiting time, food and essential items and overall cost of time wasted due to illness were all highest in Budalang'i region and lowest in Bomet region, probably because of the high disease frequency per household recorded in Budalang'i region compared to the other regions. The process of nursing patients by a household member has financial implications to the affected household because, both the sick and the caregiver lose on productive time, which then translates to much higher economic losses in terms of lost opportunity and time, that could otherwise have been used to generate income for the household.

5 Conclusions

Results from this study showed that annual impact of climate induced diseases on communities' economic wellbeing was related to the frequency of the diseases in regions of different climatic conditions. The expenditures on diseases can be reduced if households are economically empowered and encouraged to avoid residing in highly vulnerable areas such as flood plains and drought prone regions which calls for government sponsored resettlement programmes. This study provides important information to LVB communities presently benefiting from moderate climate scenarios but which are likely to experience more extreme climatic events due to global warming.

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Competing interests

The authors declare that there are no conflict of interests.

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