

Full Length Research Paper

Climate Change, Food Security, and Health Outcomes in Tanzania's Southern Highlands: A Multidisciplinary Analysis

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Tanzania like many African countries is highly vulnerable to global environmental change, particularly climate change. The impacts of particular concern are related to food production, human health and water resources. Agricultural production, which is essential to ensure food security, is weather-dependent, which has occasionally subjected the country to food shortage and insecurity in years with low rainfall. Food security varies spatially and temporally depending on rainfall patterns and other multiple stress factors such as soil conditions, types of crops grown, socio-economic and cultural factors. The southern highlands of Tanzania which are the grain basket for the country are highly vulnerable to impacts of global change, especially decrease in the amounts of rainfall. In some parts, extreme events (for example, floods) have destroyed infrastructure hence affecting food distribution and access by the affected communities. Environmental change has also impacted on human health in various parts of Tanzania. The rise in mean temperatures is an important factor for increased incidences of malaria in the highlands that were traditionally free from malaria. Long-term climate records for the southern highlands of Tanzania confirm that the climate of the region is changing. Temperatures have steadily increased over the last forty to fifty years, and are closely associated with increasing prevalence of malaria and other health risks as confirmed by existing hospital records.

Key words: Food security, human health, climate change, environmental change, multiple stress factors, southern highlands of Tanzania, multidisciplinary approaches.

INTRODUCTION

Like many other parts of Tanzania, the southern highlands (Figure 1) are vulnerable to climate change. This paper highlights on the impacts of environmental change, particularly climate change, on food security and human health¹. Particular concerns are on agricultural production (crop and livestock production), which is an essential component of food security. To a large extent, agricultural production in the southern highlands of Tanzania is weather-dependent, which subjects the area to occasional food shortage and insecurity especially in years with extreme climatic events. In some parts,

extreme events (for example, floods) have destroyed infrastructure hence affecting food distribution and access by the affected communities. Increasing temperature associated with environmental change has been a cause of various health risks, such as increased incidences of malaria in the southern and other highlands of Tanzania (Kangalawe, 2009; Yanda et al., 2006).

This paper is based on studies undertaken in the southern highlands of Tanzania to assess the impacts of environmental change on people's livelihoods, food security, health and associated community adaptations. Environmental change, particularly climate change, is a challenge to both sustainable livelihood and economic development. The adverse impacts of climate change are now evident in many parts of the world, particularly in the developing countries, including United Republic of

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Figure 1. Map of Tanzania showing the southern highlands (shaded) with district boundaries.

Tanzania (URT, 2009). This is especially true where changes in rainfall and temperature patterns threaten sustainable development goals related to poverty reduction, water, food security, health, education and biodiversity management (URT, 2009).

According to the fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC, 2007), warming of the global system is unequivocal. The report predicts that progression of global warming will increase the frequency of extreme weather events such as heavy floods and droughts, and increase health hazards through infectious diseases. It may also lead to food crisis resulting from depletion of water resources. Many developing countries particularly in Africa are regarded as being vulnerable to the adverse impacts of climate change because of factors such as widespread poverty, recurrent droughts, inequitable land distribution, and overdependence on rainfed agriculture (IPCC, 2001, 2007). For Tanzania, the adverse impacts of climate

change are already vivid in almost all sectors of the economy (URT, 2009), including agriculture and health. Thus strategic actions are required to address climate change impacts on agriculture and other key economic sectors (URT, 2008a).

Both climatic and environmental changes have resulted in declining agricultural productivity, deterioration of water quality and quantity and loss of biodiversity. These have serious implications on the livelihoods of the people and the environment (Hulme, 1996). While climate change is a global phenomenon, its negative impacts are more severely felt by poor people and poor countries. They are more vulnerable because of their high dependence on natural resources, and their limited capacity to cope and adapt with climate variability and extremes (McCarthy et al., 2001; World Bank, 2005). In addition, poor communities are not only located in high-risk areas, but the lack of economic and social resources mean they are ill-equipped to adjust to the long-term impacts of

Table 1. List of selected districts, health facilities and village's involved in the study.

District	Ward	Health facility	Nearby village
Chunya	Chokaa	District Hospital (Kibaoni)	Kibaoni
	Mbuyuni	Mbuyuni Health Centre	Chang'ombe
	Mkwajuni	Mwambani DDH	Mkwajuni
Mbeya Rural	Ikumbi	District Hospital (Ifisi)	Ikumbi
	Ilembo	Ilembo Health Centre	Ilembo
	Inyala	Inyala Health Centre	Inyala
Mbozi	Vwawa	District Hospital (Vwawa)	Vwawa
	Nyimbili	District Hospital (Vwawa)	Nyimbili
	Igamba	Mbozi Mission DDH	Mbozi
	Ivuna	Mbozi Mission DDH	Ntungwa
Rungwe	Malinyo/Mpuguso	District Hospital (Tukuyu)	Mpuguso
	Ikuti	Ikuti Health Centre	Ikuti
	Kinyala	Igogwe Hospital	Isumba

changing climate.

In Tanzania, the impact of climate change is increasingly becoming evident in various sectors, such as health, agriculture, forestry and wildlife. Among the evidences in the health sector is the increased incidences of highland malaria, for example, in places like Mbeya (Kangalawe, 2009) and Kagera (Yanda et al., 2006). The similarity in the long-term temperature and malaria trends confirm the association between climate change and prevalence of highland malaria. Thus with increasing temperatures the risk of highland malaria also increases (URT, 2009). Other sectors such as livestock keeping are also impacted. For example, occurrence of droughts has been more frequent during the last few decades causing shortage of pastures and prompting long distance migrations among livestock keepers searching for pastures and water in the southern highlands (Mbonile et al., 1997; Kangalawe and Liwenga, 2004; Kangalawe et al., 2007). The impacts of climate changes are also evident in the islands of Zanzibar, where some historical ruins in Ras Mkumbuu peninsular have been submerged as a result of sea level rise (URT, 2009). Overall these experiences call for concerted efforts to increase community awareness of climate change and enhance their adaptive capacities.

METHODOLOGY

This paper is based on studies undertaken in Mbeya Region between 2007 and 2009. It involved four main methodological approaches, namely focus group discussions, interviews, field observations and secondary data collection. The interviews involved consultations with key informants, including agricultural and health officers at regional and district levels, selected health centres and interviews with households in villages surrounding the

health centres using a structured questionnaire.

Consultations were first made with the Mbeya Regional Administrative Secretary (RAS) and the Mbeya Regional Medical Officer (RMO) to introduce the study and obtain permission for carrying out the study in the selected districts and identifying representative health facilities that could be visited in the sampled districts. Two to three health facilities were selected from each of the selected districts. These included respective district hospitals and two other health centres. At all these health facilities a questionnaire was filled by the medical or nursing officer in charge of the facility. A random sample of 56 households was also selected for interviews from villages surrounding the health facilities (Table

1) to capture local perceptions, perspectives and experiences related to climate change and health in their respective areas. Apart from climatic change, household interviews also entailed collection of information on other stress factors with impact on local community livelihoods, food security and human health.

Human health data particularly for malaria outpatients, inpatients and deaths were collected from records available at health facilities. The data on malaria collected from the selected health facilities, included outpatient, inpatient and deaths for <5 and 5+ years of age. Data was collected for as long period as it was available, the major sources being the MTUHA (Mfumo wa Taarifa za Uendeshaji wa Huduma za Afya, literally meaning *record system for health services*) records for each health facility. Despite the challenge of record keeping in many parts of Africa, MTUHA has ensured that available records are well organized and were considered adequate for the study. Additional information was obtained from various reports available at district and regional level, and from literature. Field observation was undertaken in the study sites to capture possible evidence of changes that could have occurred as a result of changing climate, for example changes in stream flow.

Data from focus group discussion and key informant interviews were triangulated during the discussions. Data from household interviews was processed and analysed using the statistical package for social science (SPSS). The sustainable livelihood approach (DFID, 1999) was used as an analytical tool to understand the adaptive capacities. The sustainable livelihood approach provided a means of analysis of livelihood strategies and community vulnerability to external shocks and stresses. The approach was also used to assess adaptive capability of different

Table 2. Percentage responses on local understanding of climate in four districts in the southern highlands of Tanzania.

Local understanding of climate	Chunya	Mbeya Rural	Mbozi	Rungwe	Average
Climate as rainfall	100	89.5	50	95.2	83.7
Climate as temperature	100	89.5	50	95.2	83.7
Outbreak of human diseases	64.3	42.1	100	61.9	67.1
Climate as drought	78.6	52.6	50	61.9	60.8
Climate as floods	78.6	42.1	50	42.9	53.4
Climate as wind	92.9	36.8	0	61.9	47.9
Climate as humidity (dryness of the air)	64.3	26.3	0	66.7	39.3

socio-economic groups in the respective villages based on household livelihood assets. Malaria data from hospital records was processed and analysed using excel computer package to establish patterns on malaria incidences and prevalence.

RESULTS AND DISCUSSION

Local perceptions and indicators of climate change

Local perceptions of changing climate

Global change may be perceived differently by various communities. Thus while addressing the concepts of changing climate at the community level; it is important to establish the local understanding of the concept "climate". Interviews with various stakeholders at the village level showed that there is a growing concern that climate change and variability is already occurring. Table 2 presents findings from interviews in selected districts in the southern highlands of Tanzania. It shows that people understand climate, among others as rainfall, temperature, drought, floods, wind and humidity (Kangalawe, 2009). The concept "climate change" was associated with variability in weather conditions such as rainfall inconsistency and unpredictability over years. The variability was related to increased seasonality of rainfall which affects the agricultural calendar and hence the local livelihoods.

Rainfall and temperature were ranked highest among the aspects mentioned to indicate the local understanding of climate, followed by drought, floods, wind and humidity. Concerns about drought were raised more in Chunya district, perhaps owing to the relatively low amounts of average annual rainfall usually received in the area compared to the other three districts. Other aspects were mentioned by smaller proportions of respondents, indicating that they are not commonly used to reflect local understanding of climate change.

Responses to the inquiry on rainfall situation during the last 30 to 40 years showed a general concern that in all the eleven villages studied rainfall has been decreasing, as expressed by 82% of respondents. The decrease in rainfall was also associated with the disappearance of

short rains that used to be received around September, delayed and fluctuations in the onset of heavy rains (Kangalawe, 2009). Very few reported an increase in rainfall. This was locally associated with extreme events such as El Niño that took place some ten years ago (1997/1998). Long term rainfall records for Mbeya seem to support this latter observation (Figure 2).

Documentary records indicate that the climate of the southern highlands is generally tropical with marked seasonal and altitudinal temperature variations and sharply defined dry and rainy seasons. The rains normally start in October and go through to May followed by a dry and cold spell between June and September (URT, 2003). However, the pattern has become more unpredictable in recent years. Similar observations have also been reported elsewhere in Tanzania and East Africa in general (Yanda et al., 2006; Wandiga et al., 2006).

Regarding temperature conditions, majority of the respondents claimed that temperature has increased over last 10 to 30 years, with their areas becoming much warmer (Kangalawe, 2009; Liwenga et al., 2009). The observations from the local communities seem to be supported by meteorological data for Mbeya (Figure 3), which shows that both the mean maximum and mean minimum temperatures for February increased steadily since 1955 (Mpeta, 2009). February falls within the rainy season that, according to local people, is a period with more incidences of malaria. The combined effect of warmer temperatures during the season and the availability of ample breeding sites for mosquitoes make the communities in the area vulnerable to malaria if appropriate adaptation measures are not undertaken. In places like Rungwe, the temperature increase was reported to have been associated with a decline in frost incidences that used to be experienced in the past (Liwenga et al., 2009).

Local indicators of the perceived changing climate

Table 3 presents the local indicators of climate change used by communities in villages involved in the assessment of the impacts of climate change on human

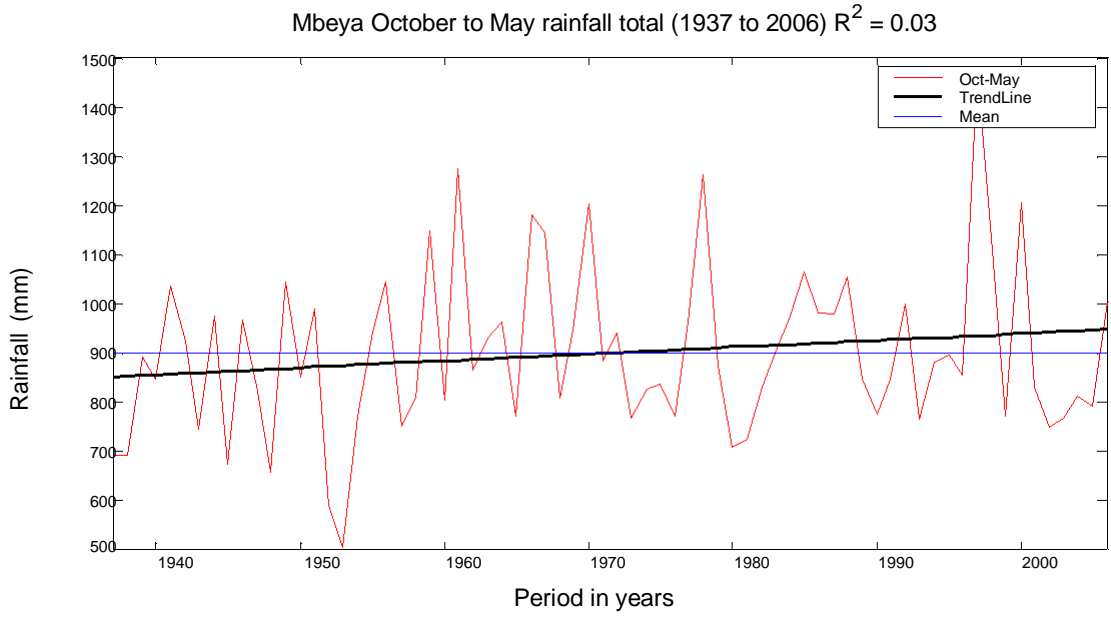


Figure 2. October-May rainfall in Mbeya - 1940-2008. Source : Mpeta (2009).

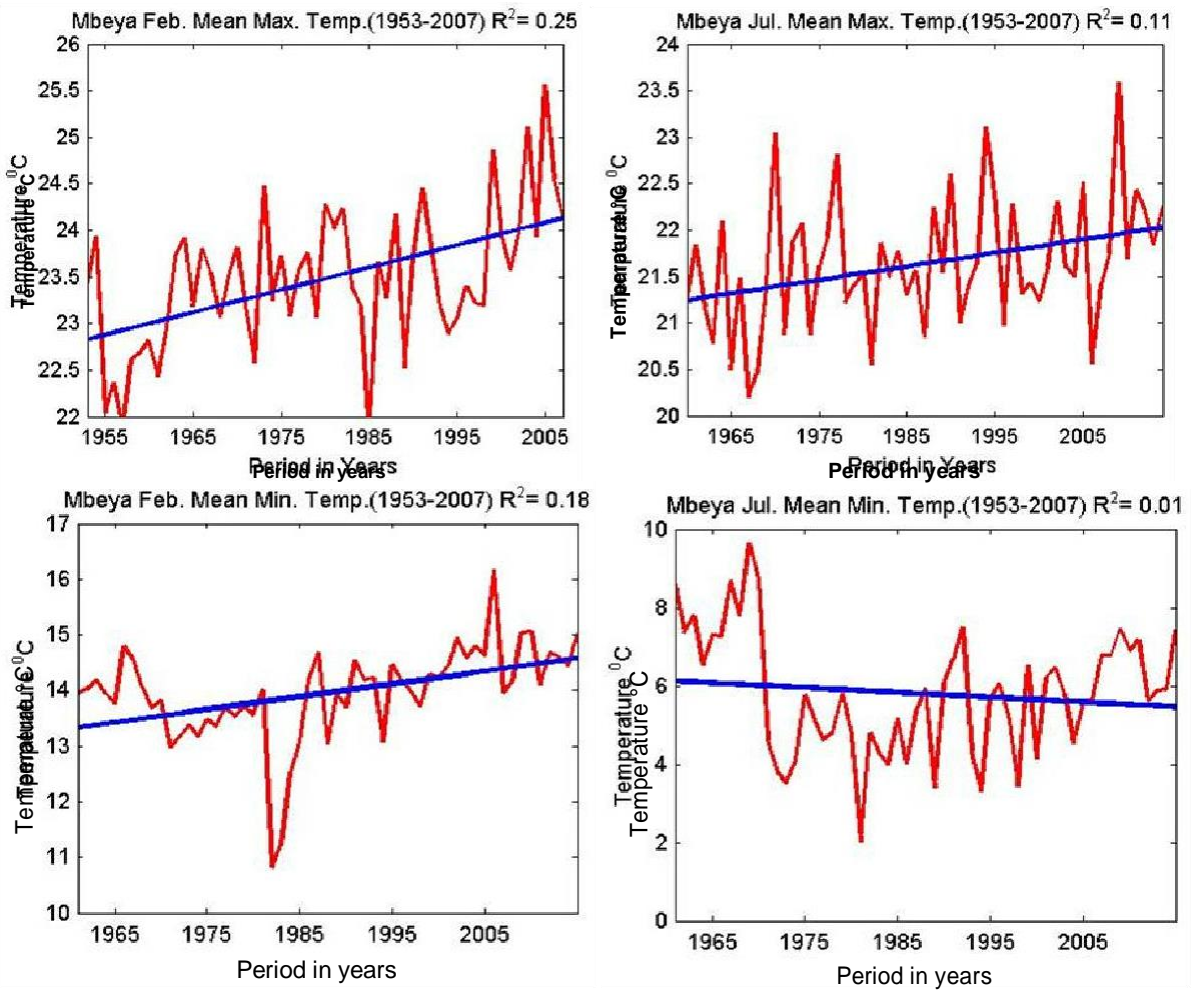


Figure 3. Long-term temperature record for Mbeya meteorological station. Source: Mpeta (2009).

Table 3. Percentage responses on local indicators of climate change in selected parts of Mbeya Region.

Indicator of climate change	Chunya	Mbeya Rural	Mbozi	Rungwe	Total
Increasing temperatures	85.7	89.5	100	85.7	90.2
Shortened growing seasons	85.7	78.9	100	95.2	90.0
Rainfall coming late in the seasons	78.6	73.7	100	66.7	79.8
Recurrent food shortage	85.7	63.2	100	52.4	75.3
Rainfall coming too early in the seasons	71.4	47.4	100	66.7	71.4
Increased incidences of drought	100	63.2	50	66.7	70.0
Outbreak of other human diseases	64.3	42.1	100	61.9	67.1
Outbreak of malaria	50.0	26.3	100	38.1	53.6
Increased rainfall amounts	71.4	36.8	50.0	47.6	51.5
Decreasing crop productivity	71.4	26.3	50.0	33.3	45.3
Increasing crop productivity	78.6	52.6	0	38.1	42.3
Decrease in the number of livestock kept	50.0	31.6	0	33.3	28.7
Outbreak of livestock diseases	50.0	26.3	0	33.3	27.4
Outbreak of plant diseases	42.9	5.3	0	33.3	20.4

health in the southern highlands of Tanzania (Kangalawe, 2009; URT, 2009). The diversity of indicators shows that perhaps no single indicator may be sufficient to explain a climatic phenomenon among the rural communities. Increasing temperatures; shortened growing seasons; late coming of rains in the seasons, recurrent food shortage, rainfall coming too early in the seasons, and increased incidences of drought emerged as the major indicators of climate change, as indicated by the large proportions of respondents reporting them (Table 3). It may appear surprising that both late and early rains were reported as indicators of climate change. This may explain the fluctuations that are experienced over the years, where in some seasons rains start earlier than expected while in others rains start late in the season.

Outbreak of human diseases is among the top ten local indicators of climate change as expressed by 67.1% of the respondents. The diseases that were reported to be associated with seasonal variations of climate include diarrhoeal diseases, which were reported to be more prevalent during the rainy season; and respiratory infections that were claimed to be more common during the cool months. Outbreak and increased incidences of malaria was reported by 53.6% of respondents, indicating a growing awareness of the relationship between the climate change phenomena and prevalence of mosquitoes and malaria.

Some of the local indicators of climate change may however be difficult to ascertain because of the complementarities that exist between climate phenomena and other stress factors. For example decrease/increase in crop productivity may be a function of several factors, including climatic, edaphic factors and agronomic practices. It may therefore be difficult to isolate the single impact of climate change. However, it is worth noting that local communities recognise the relationship between climate change and agricultural production.

Environmental change impacts on livelihoods and food security

Livelihoods of the majority of people living in rural areas of Tanzania depend on agriculture and other natural resources, particularly forest products (URT, 1998). In many sub-Saharan African countries, smallholder agriculture underpins most rural livelihoods and national economies, and worsening poverty and increasing food insecurity is closely linked to low and/or declining levels of agricultural productivity. Already there are reports that agricultural production and food security (including access to food) in many African countries are likely to be severely compromised by climate change and climate variability (Boko et al., 2007). However, as reported by Sen (1981) food insecurity may occur not because there is not enough food, but because people do not have access to enough food. The Tanzania's National Food Security Policy (URT, 2008b) also recognizes food availability, accessibility and utilization as three major pillars of food security. Improved food security leads to improved human capital and higher wages in the labour market. Food security is therefore a development issue that must be streamlined in the development agenda to ensure a healthy and productive nation (URT, 2008b). The rest parts of this paper analyses how environmental change, particularly climate change, has impacted on various sectors and its consequences on food security.

Decline in agricultural productivity (crops and livestock)

Tanzania's economy depends heavily on agriculture, which accounts for almost half of GDP, provides 85% of exports, and employs 80% of the work force (URT, 2008a). Agriculture is highly vulnerable to climate

Table 4. Impacts of climate change on agriculture (crops and livestock).

Agriculture	Livestock
Unpredicted rainfall will lead to uncertainty in cropping patterns	Favourable condition for ticks, snail, blood-sucking insects and pests outbreaks
Areas with less rainfall will lose water through evapotranspiration and require irrigation	Increased east coast fever and rift valley fever
Region with increase rainfall will experience nutrient leaching, soil erosion and water logging	Eruption of new pest and diseases
The incidence of pests and diseases will rise on areas with increased rainfall	Reduced productivity (draught power, milk, and meat) as increased carbon dioxide reduced protein available from vegetation
Prolonged dry spells may extend beyond normal patterns	Livestock deaths due to heat waves
Decline in maize yields by 33% overall	Shrink the rangelands and shortage of pastures
Cotton yields expected to fall in some areas, rise in others	Shortage of water
Shifts in agro-ecological zones	
Increased weed competition with crops for moisture, nutrients and light	

Source: Compiled from URT (2003, 2007) and Ehrhart and Twena (2006).

variability and long-term climate change, which could in many parts of the country result in food shortages, higher food prices and lower domestic revenues; and climate change will only aggravate falling harvests (Devereux and Edward, 2004). In Tanzania, for example, famine resulting from either floods or drought has become increasingly common since the mid-1990s, undermining food security (URT, 2003). In addition, increased rainfall could lead to nutrient leaching, loss of topsoil and water logging, all of which will seriously affect agricultural production. Increased incidence of crop pests and diseases is also expected due to higher temperatures and rainfall. This is likely to lead to farmers using more agrochemicals and disease resistant varieties, thus increasing production costs (Orindi and Murray, 2005).

According to URT (2007), climate change is expected to shrink the rangelands which are particularly important for livestock keeping communities. This shrinkage will be more aggravated by the fact that about 60% of the total rangeland areas in the country are infested by tsetse fly making it unsuitable for livestock pastures and human settlements (URT, 2007). Shrinkage of rangelands is likely to exacerbate conflicts between livestock keepers and crop farmers, thereby affecting the livelihoods of both groups. This has been among the reasons for livestock keepers in the northern parts of the country shifting their herds towards southern Tanzania in search for pastures (Mbonile et al., 1997; URT, 2003, 2007; Kangalawe et al.,

2007). The overall impacts of changing climate on the agricultural sector are summarised in Table 4.

Increased risk of food shortage and famine

Droughts and floods result in crop damages and failure (Kangalawe and Liwenga, 2005), and in combination with other stress factors lead to chronic food shortages. Although most rural farming communities are aware of climate variability and have risk reduction methods for example, multi-cropping, increasing crop diversity (Kangalawe, 2001, 2003; Kangalawe et al., 2005), the traditional rain-fed subsistence agriculture is extremely vulnerable to changing climatic patterns through shifts in growing season conditions. The rainfall pattern is no longer predictable. There have been recurrent droughts in recent years including those in 1994/1995 and 2005/2006, which triggered food shortage and a severe power crisis (Mwandosya, 2006). Since most rural communities rely on their agricultural produce for food and for income generation, poverty is directly coupled to agricultural production. However, neither at household nor at the community level can people adequately cope with climate change-induced extreme variability.

According to McCarthy et al. (2001) climate change will negatively affect agricultural production and therefore worsen food security, mainly through increased

extremes, its influence on land use and temporal and spatial shifts in water availability. Also as a result of increasing water stress and land degradation, other land use options, such as inland fisheries will be rendered more vulnerable to episodic drought and habitat destruction.

Impact of climate change/variability on food security

Experiences from selected sites in Rungwe district in the southern highlands of Tanzania, namely Idweli (in the highland zone), Mibula (in the middle zone) and Busisya (in the lowland zone) indicate that agriculture is the major livelihood activity that has been impacted by climate change. Although there are very few incidences of severe food insecurity in the area, climate change and variability have some negative impacts on the local economies (Liwenga et al., 2009). Such impacts are manifested in terms of increased costs of agrochemicals required to control crop pests, whose severity was associated with increasing seasonality of rainfall and increasing temperatures. Communities in the middle lands, where the staple foods are bananas and maize, reported for instance that food insecurity implies inadequate availability of bananas since the crop can be consumed directly or easily sold to generate income. The incomes obtained could further be used to purchase other food items such as maize. The productivity of bananas was reported to vary with prevailing climatic conditions.

Lesser important crops such as bambaranuts, cassava, cocoyam and sweet potatoes were reported to have helped in overcoming food shortage and insecurity. However, the acreage of these crops was reported to be declining as the land they used to be grown has increasingly been taken for commercial crops like tea and bananas production. According to Liwenga et al. (2009) crop diversity is high in the midlands zone and this has helped the respective communities to ensure food security. However, the increasing replacement of farmlands for crops such as cassava and yams by more commercial non-food crops like tea may negatively impact on food security in the long run. This is a basically non-climatic stress factor impacting on food security situation of the area. Similar experiences were also reported in other parts of the southern highlands where commercial crops like tea are grown (Kangalawe and Liwenga, 2007).

In 2008 the Ministry of Agriculture, Food Security and Cooperatives conducted a study to examine the strategies for addressing negative effects of climate change in food insecure areas of Tanzania (URT, 2008b). The objective of this study was to identify and enhance adaptive strategies for addressing negative effects of climate change in areas with recurrent food shortage consistent with the Ministry's goal towards sustainable food security in the country. Among the sites included in

the study were Mufindi and Mbarali districts (in Iringa and Mbeya region respectively) in the southern highlands of Tanzania. That assessment examined various aspects of food security, including what food shortage actually meant, experiences of food shortages and associated causes, and how households dealt with food shortages.

Findings from that study indicated that maize was the main staple in all districts in the southern highlands. These results indicated specialization of respondents in only few staple foods, which has implications in relation to food security, particularly in case of crop failures. Many respondents (65.6%) in that study associated "food shortage" with shortages of main food staples and particularly shortage of food from own farms, while others associated food shortage with unavailability of food in the market and reduction in number of meals per day (15 and 43.1%, respectively). Such variability in how the communities perceived food security may be an important consideration when addressing food security issues at local levels. The findings from household interviews indicated that there are several causes of food shortages and insecurity, ranging from natural to socio-economic factors. However, the main causes of food shortages were reported to be drought, floods, strong winds and excessive rainfall, all being influenced by climate change. Other significant causes included increased incidences of crop pests and diseases, low soil fertility, lack of labour, weeds, lack of agricultural inputs, small farm sizes, destructive birds and use of local varieties. The latter are among the non-climatic stressors impacting on local food security.

Responses on how households addressed food shortages indicated buying food, selling livestock to buy food, work for food, reducing amount of food eaten, eating unusual foods, borrowing food, getting relief food, reducing number of meals, migrating to other areas and assistance from relatives. Buying of food appeared to be the most prominent way of dealing with food shortages, which implies the need for alternative income generating activities to provide the required cash. While most of the southern highlands are food secure, with more than 70% of community members having sufficient food for the households throughout the year, there have been occasions of food shortage. Such occasions were reported to be addressed in various ways, including reducing the number of meals per day. About 70% reported to take between 2 to 4 meals a day, while only about 30% reported to usually have one meal per day (Maro et al., 2008). The number of meals could however, be influenced by several other factors. The ones mentioned during field survey included distances to crop fields and poverty. During the growing seasons when most of the household members are busy with farm work, the number of meals could be reduced because there is limited time for people to spend in the homesteads preparing meals. Thus farmers whose crop fields are located long distances from their homesteads were

reported to take fewer meals.

Destruction of infrastructures also hampers food access and availability. Floods have occasionally destroyed hectares of croplands as well as harvested produce and houses. Transportation infrastructure, such as roads and railways, and water systems may also be at risk from impacts of climate change. Already some parts remain impassable until the flood water subsides. For instance, the El Niño rains of 1997/1998 disrupted the transport system, washing away some roads and bridges and damaging parts of the railway network thereby hampering crop and livestock haulage from main production to consumption areas. Consequently, this caused sharp consumer price increases that limited food access to market dependent consumers. This had considerable impacts on the food security situation.

Environmental change and human health risks

Human health risks associated with environmental change

Health is one of the key sectors that are affected by environmental change, particularly changing climate. This manifests itself through increase of average temperature leading to among others, widespread malaria in highland areas. It is very likely that climate change will alter the ecology of some diseases in Africa and consequently the spatial and temporal transmission of such diseases (cf. Tonnang et al., 2010). For instance, higher peak flows contribute to floods which adversely affect human settlements and health. More frequent floods destroy infrastructure, buildings and belongings in the floodplains. Moreover, warming, flooding and increased rainfall increase the spread and incidence of vector-borne diseases such as malaria. Droughts impact settlements, requiring more time for water collection and resulting in reduced water use. This impairs hygiene and contributes to the spreading of contagious diseases such as cholera.

Among the various vector-borne diseases malaria is a major public health concern in Tanzania, especially among pregnant women and children under five (COWI et al., 2007). It accounts for 16.7% of all reported deaths in the country and 12% of under-fives, and is one of the leading causes of morbidity (URT, 2003). About 95% of the Tanzania's population is reported to be at risk for malaria (Mboera et al., 2007). Already the disease causes between 70,000 and 125,000 deaths annually, and accounts for about 19% of the health expenditure (De Savigny et al., 2004). Reported malaria cases for the year 2003 mounted to 10.7 million and the actual numbers of malaria cases are considered to be much higher since the majority of cases in Tanzania are not reported (WHO and UNICEF, 2005).

The link between climate and malaria distribution has long been established. Sustained transmission depends

on favourable conditions for both vector and parasite (Githeko et al., 2000; Tonnang et al., 2010). The effect of temperature on the malaria parasite and vector survival is particularly important. The study by Kangalawe (2009) conducted in Mbeya region in the southern highlands of Tanzania to assess the local impacts of climate change on highland malaria demonstrated clear association between temperature trends and malaria incidences. Other diseases also increasing with climate change include cholera, dysentery and respiratory diseases.

Malaria was mentioned by all respondents in the districts consulted (Table 5). Other important diseases were diarrhoeal diseases, respiratory diseases (mainly the acute respiratory infections), HIV/AIDS and tuberculosis. A follow up inquiry on whether malaria was among the most prevalent diseases in the area again confirmed that the disease is prevalent, and was a concern of majority (85.9%) of respondents; and that majority of the respondents (88%) had once suffered from malaria (Table 5).

Malaria is locally perceived as a recent phenomenon in the southern highlands of Tanzania, with more incidences being reported over the past 10 to 30 years, suggesting that environmental conditions have changed over that period in favour of the malaria vector and parasites. Further, there is a general concern among communities in this area that malaria is a very severe disease, which points to the low immunity inherent in highland communities not historically exposed to malaria. Many respondents in the survey reported that historically malaria was not a common phenomenon in their areas, except in Chunya District which has since been relatively warmer compared to the other three districts. Findings presented in Table 6 confirm that in the 1960s there were very few incidences of malaria in most parts of the southern highlands, and the trends have been increasing with time.

The locally perceived trends regarding prevalence of malaria in the studied areas is also supported by diagnostic records from nearby health facilities (Figure 4). Although it was difficult to obtain long-term data from all the health facilities (data from other health facilities was from 1994), available malaria data indicates a generally increasing trend. Long-term data on malaria cases found at Igogwe Hospital in Rungwe district attests that malaria has steadily increased since the 1960s, especially for the inpatients (Figure 4). Even when taking into account the factor of increasing population, the same increasing pattern of malaria inpatients can be discerned (Figure 5). Although there had been fluctuations over the years (Figures 4 and 5), the numbers of patients hospitalised have generally increased. The peaks in number of malaria cases coincided with climatic events such as El Niño, and warmer temperatures associated with droughts, for example, between 2002 and 2005. The number of deaths between 1994 and 2007 also shows a generally increasing trend for almost all the health

Table 5. Percentage responses on common diseases and frequency of having malaria.

Common diseases in the area	Chunya	Mbeya Rural	Mbozi	Rungwe	Total
Malaria	100	100	100	100	100
Diarrhoeal diseases	92.9	84.2	100	71.4	87.1
Respiratory diseases	64.3	73.7	100	61.9	75.0
HIV/AIDS	50	26.3	50	47.6	43.5
Tuberculosis	46.2	15.8	50	23.8	34.0
Presence and frequency of having malaria					
Presence of malaria/mosquitoes					
Is malaria among the most prevalent diseases in the area?	100	57.9	100	85.7	85.9
Are there mosquitoes in the area?	100	89.5	100	90.5	95.0
Have you ever contracted malaria?	92.9	68.4	100	90.5	88.0
Frequency of having malaria					
Occasionally	28.6	57.1	100	71.4	64.3
Regularly	35.7	14.2	0	19.1	17.3
Rarely	28.6	21.4	0	9.5	14.9
Do not know	7.1	7.2	0	0	3.6

Table 6. Percent response on the history of malaria incidence in selected districts in the southern highlands of Tanzania.

Malaria situation over different periods	Chunya	Mbeya Rural	Mbozi	Rungwe	Total
Since 1960s					
No malaria	7.1	31.6	0	19	14.4
Few incidences of malaria	50.0	31.6	100	57.1	59.7
Many incidences malaria	14.3	5.3	0	4.8	6.1
Do not know	28.6	31.6	0	19	19.8
Total	100	100	100	100	100
Since the 1970s					
No malaria	7.1	21.1	0	4.8	8.3
Malaria increased	64.4	47.3	100	61.9	68.4
Malaria decreased	7.1	0	0	4.8	3.0
No change in malaria incidences	7.1	10.5	0	19	9.2
Do not know	14.3	21.1	0	9.5	11.2
Total	100	100	100	100	100.0
The last ten years 1990-2000s					
No malaria	14.3	73.7	0	14.3	25.6
Malaria increased	78.6	15.8	100	71.4	66.5
Malaria decreased	7.1	10.5	0	9.5	6.8
No change in malaria incidences	0	0	0	4.8	1.2
Do not know	100	100	100	100	100

facilities consulted (Figure 6).

The numbers of outpatients at Igogwe Hospital have greatly fluctuated over the last forty years, with peaks between 1985 and 1989, 1996 and 1998, and between 2002 and 2005. These peaks of malaria cases coincided with periods with warmer temperatures (Figure 3). This

confirms the association between increasing temperatures and increased risk of malaria. The latter therefore indicates that with global warming, and thus climate change, such highland areas may face increased risk of highland malaria. And given the fact that highland communities have lower natural immunity to malaria

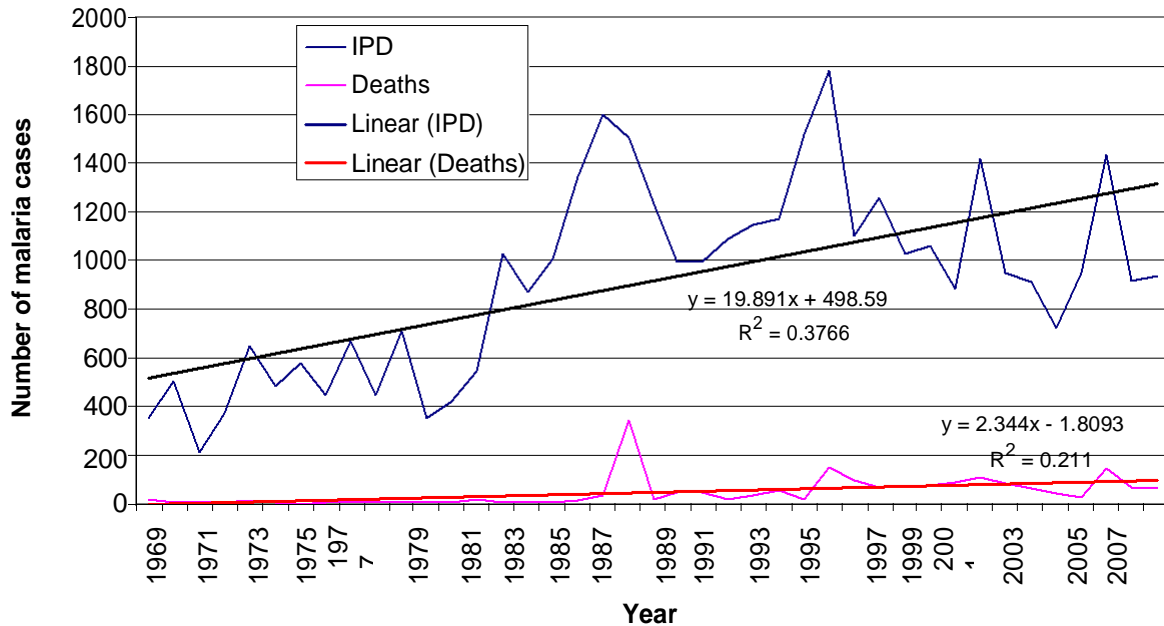


Figure 4. Long-term malaria trends from Igogwe Hospital records. Source: Compiled from Hospital Annual Reports (1969-1993) and MTUHA records (1994 to 2007).

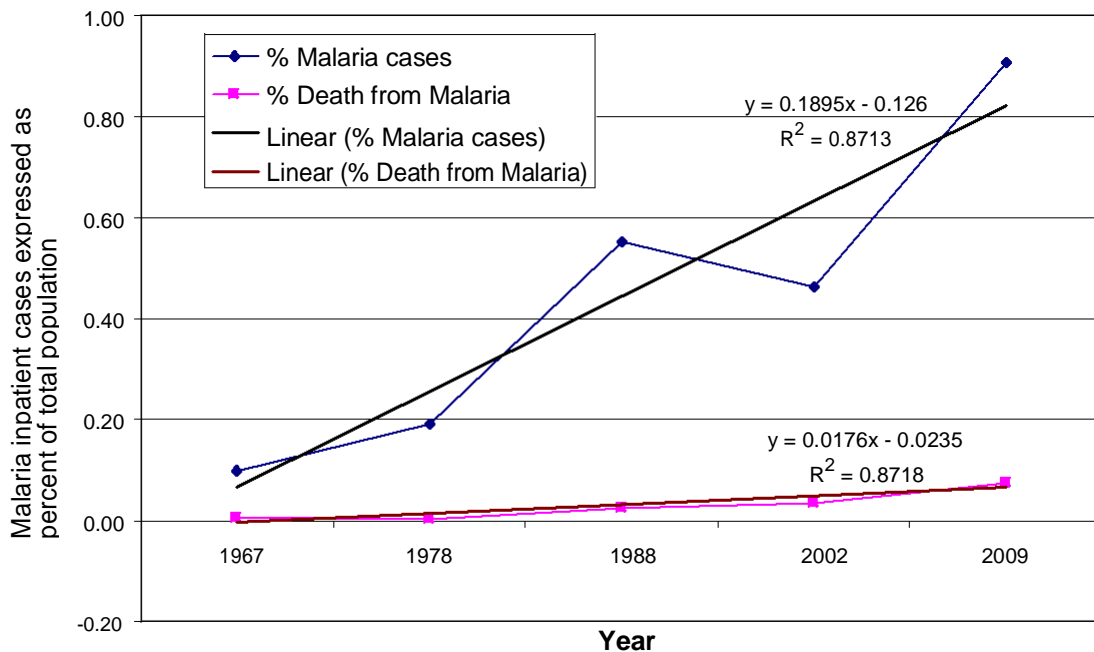


Figure 5. Long-term malaria trends from Igogwe Hospital records expressed as percent of total Rungwe District Population. Source: Computed from Hospital Annual Reports (1969-1993) and MTUHA records (1994 to 2007).

because of not having been exposed to malaria parasites, the impact of climate change will be greater compared to similar situations in the traditionally warmer lowlands (Yanda et al., 2006; Kangalawe, 2009). However, proper health and climate record keeping is

necessary to facilitate understanding and projection of future trends.

An inquiry on the link between human disease and the perceived climate change revealed that majority of the people recognised such linkage (Figure 7). Malaria,

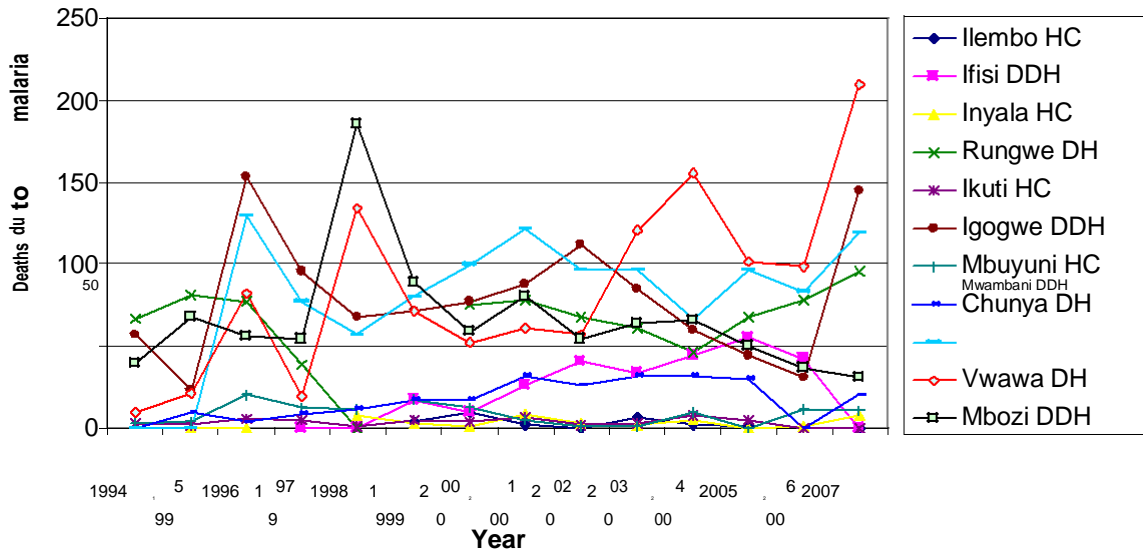


Figure 6. Deaths due to malaria in selected health facilities in Mbeya Region. Source: Compiled from MTUHA records 1994 to 2007.

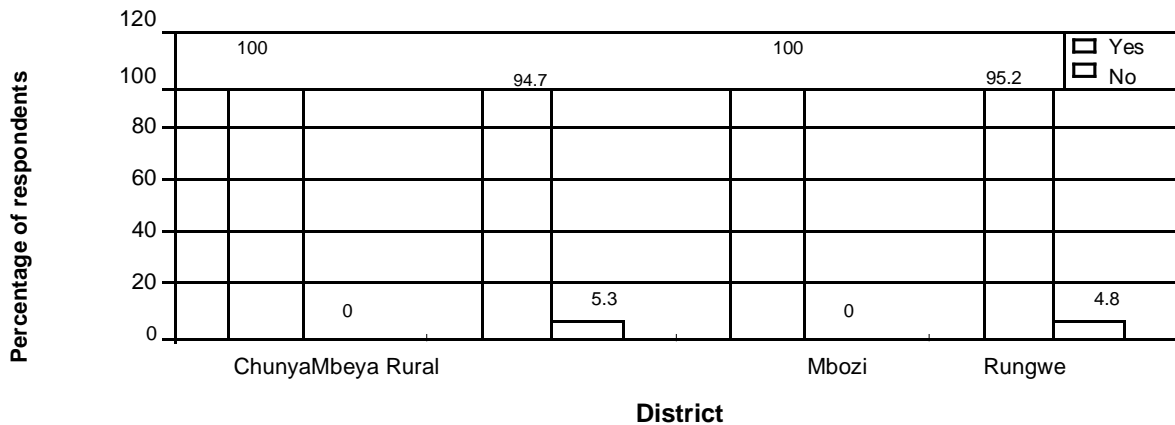


Figure 7. Responses on the link between climate change and malaria in Mbeya region.

diarrhoeal and respiratory diseases were linked to climate change in that they are influenced by seasonal fluctuations of weather factors such as increasing/decreasing amounts of rainfall or temperature. Responses from household and key informant interviews indicated that in Mbeya malaria is most prevalent during the rainy season, as reported by about 77% of respondents (Table 7), locally attributed to presence of mosquito breeding sites in most areas. This period is also much warmer compared to the cold months like June to August

The responses by some respondents that malaria has become a common phenomenon during other times of the year indicates that generally mosquitoes and associated malaria have found a suitable habit in an area that would traditionally be devoid of malaria without climate change. Traditionally, malaria transmission has

been limited in the highlands because of their low temperatures, which deter mosquitoes and malaria parasites. However, with a rise in global temperatures this trend is changing (Githeko et al., 2000; Wandiga et al., 2006). It was noted in some villages, such as Ilembu in Mbeya Rural district that although there were still no mosquitoes in the area because of the very cold climate, there were many clinical malaria cases. The explanation given was that those who got malaria were bitten by mosquitoes when they travelled outside the village on short-term basis, and returned back to the village with the parasites. Given their low natural immunity they succumb easily to malaria. This shows that apart from climate change mobility could be a compounding stress factor for the prevalence of malaria in some areas (Kangalawe, 2009).

Diarrhoeal diseases were also reported to be most

Table 7. Percentage responses on time of the year when malaria is most prevalent in selected districts in the southern highlands.

Time of the year/season	Chunya	Mbeya Rural	Mbozi	Rungwe	Total
Rainy season (November to May)	82.4	61.1	100.0	63.6	76.8
Dry season (June to October)	17.6	5.6	0.0	27.4	12.6
All times	0.0	33.3	0.0	9.0	10.6
Total	100	100	100	100	100.0

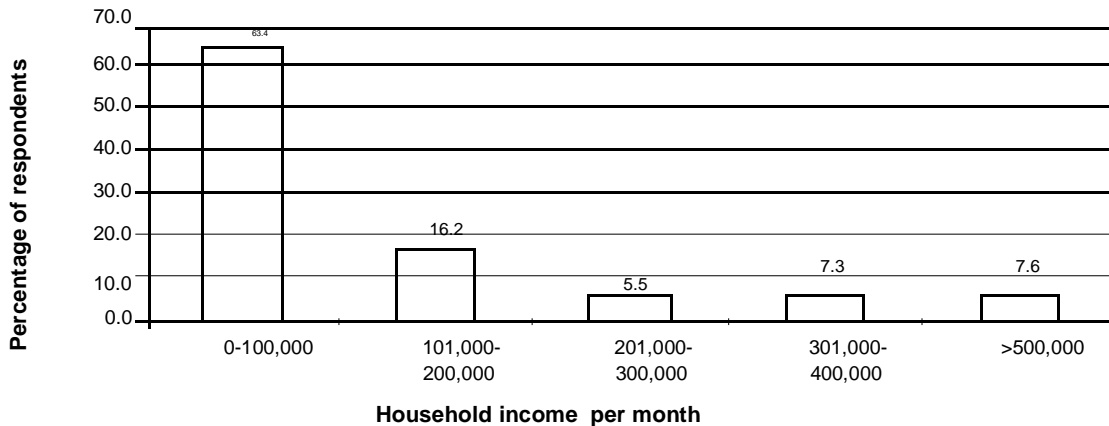


Figure 8. Average household monthly income (shillings) in selected villages in Mbeya region.

prevalent during the rainy season, mainly between October and May. This is a generally wet period for most parts of southern highlands of Tanzania. Respiratory diseases were reported to be most prevalent during the cooler months, especially from June to September. Community's expressions of periods with more disease incidences were also supported by hospital records in all the eleven health facilities visited as part of the assessments of the impacts of climate change on human health in Mbeya region (Kangalawe, 2009).

Impacts of malaria on household economy and local livelihoods

Many of the respondents who reported to have had malaria or patients suffering from malaria indicated that they had to pay for treatments at the nearby health facility or to buy medication from pharmaceutical shops (Kangalawe, 2009). The low incomes (Figure 8) among most community members may indicate their limited capacity to pay for medical treatment² from the health facilities available in the area. Such low incomes may as well indicate inability to meet various costs related to

² There was a considerable variation between households regarding experiences with costs for malaria treatment. The costs were reported to range between 500 and 30,000/= Tanzanian shillings, with a mean value of 10,225/=. The upper and lowest extremes are values for patients hospitalized and for outpatient respectively.

climate change adaptations, especially with increased prevalence of highland malaria.

There was a majority concern that the amount they have to pay for malaria treatment is very high and many of them could not afford. This was one of the reasons why in case of a household member getting malaria the household may have to sell livestock or food crops to get cash for malaria treatment. Selling food crops and livestock may have negative impacts on the household food security especially where overselling becomes a problem. As such some households did not afford modern medicine, opting for herbal medicines, as expressed by 17.9% of respondents. This may have some negative consequences on their livelihoods.

A Multidisciplinary approach to evaluate the impact of climate change and other stress factors

Assessment of non-climate stress factors affecting livelihoods

A stress factor in this case is considered as any factor or combination of factors; be it environmental, socio-economical, health related or political that has negative impacts on the natural resource base and livelihoods of the local communities. Table 8 presents examples of non-climate stress factors related to agricultural production, natural resource base and local livelihoods in

Table 8. Examples of non-climatic stress factors in Mbozi District.

Rank	Ntugwa village	Nyimbili village
1	Health related factors (HIV/AIDS infections; malaria)	Health related factors (HIV/AIDS infections; malaria)
2	Crops and livestock diseases/pests	Declining soil fertility
3	Shortage of agricultural inputs	Shortage of agricultural inputs
4	Shortage of experts	Poor road infrastructure
5	Water management problem in farmlands	Low prices of agricultural produce
6	Declining soil fertility	Inadequate livestock facilities
7	Crimes e.g. stealing food stuffs in fields	Youth out migration
8	Water logging during the rainy seasons	Lack of capital
9	Poor roads and other transport infrastructure	Lack of clean and safe water

Source: Liwenga et al. (2007b).

some parts of the southern highlands of Tanzania. The factors have been ranked based on locally perceived importance.

Health related factors were ranked high, particularly malaria. According to respondents in the study areas even when climatic factors and soil fertility are good enough for agricultural production, good human health remains of paramount necessity for effective management of the farms. A healthy person can undertake various livelihood activities more successfully compared to a less healthy one, even when the climate is favourable. Further, human diseases reduce the labour force, making the undertaking of various livelihood activities by the household rather difficult (Liwenga et al., 2007b; Kangalawe, 2009).

Other common stress factors include declining soil fertility, which was attributed to continuous cultivation without adequate nutrient replacement, which has resulted in declining agricultural productivity. Declining soil fertility was further linked to shortage of agricultural inputs such as fertilizers, improved seeds, pesticides and herbicides. It was reported in Nyimbili that the problem is further compounded by land scarcity that limited agricultural expansion. Nyimbili village is surrounded by protected natural forests, which cannot be exploited for agriculture. With increasing population growth shifting cultivation practices have also declined and fallow periods shortened due to increasing land scarcity (Liwenga et al., 2007b). A combination of these situations compounds the negative impacts of climate change and subsequently threatens the food security situation of the area.

Lack of capital and poor road infrastructure were also reported to be a serious stress factors in many parts of the southern highlands. Out migration of youth from the villages was regarded as an important factor affecting agricultural production and, consequently, food security. Youths were reported to migrate to urban and peri-urban areas of Mbeya town looking for alternative livelihoods. This was reported to be a stress factor limiting the attainment of food security because it reduces labour force at household level thereby reducing sizes of

cultivated farms, and consequently low crop production.

Lack of clean and safe water was considered to be another stress factor due to the fact that in many parts existing water sources such as springs are shared between humans and livestock. In this case, water pollution was reported to be a problem, which could be a cause for various human health risks, such as diarrhoeal diseases. Villages located in lowlands and dominated by clay soils often suffer from water logging during the rainy seasons. This was reported to cause damage to rainfed crops, particularly maize and sorghum, thereby affecting the local people in terms of income as well as food security. This was a particular concern in Ntungwa village located within the Lake Rukwa basin.

Another stress factor that impacts the food security situation in many parts of the southern highlands is crop trade. It was reported by communities in Mbozi District, for instance, that crop trade is responsible for food insecurity, the way it happened in 2006 when most of the humid highland areas of the district reported food shortage due to overselling of food crops. This shortage was due to higher prices offered for food crops especially by traders from neighbouring countries (Liwenga et al., 2007b). The areas that were most affected were those easily accessed by the major roads. Thus an area traditionally with favourable climate for agricultural production faced occasional food insecurity because of the influence of market forces. Thus, climatic and non-climatic stress factors may complement or compound the impacts of each other. An already stressed socio-economic environment becomes more vulnerable to environmental change like climate change and variability compared to a less stressed environment under the same level of exposure to risks of climate change and variability.

Using multidisciplinary approaches in assessing impacts of climate change and other stress factors

Thorough understanding of the impacts of climate change and other stress factors related to food security and



Figure 9. Using participatory approaches in assessing the impacts of climate change and other stress factors in Ntungwa village, Mbozi – brainstorming (left) and matrix scoring (right).

human health need a multidisciplinary approach. This may be reflected in the assessment tools used, mainly considering the field experiences and ability of the people to comprehend the different tools. Some of the tools used are discussed here.

Field experiences in the southern highlands indicated that for establishing overviews on patterns and impacts of climate change and variability participatory approaches (Chambers, 1992; Mikkelsen, 1995), such as brainstorming could be used, as they facilitate participants to contribute in the discussions (Figure 9). Timelines and key informant interviews are among the other tools that could be effectively used in establishing global change patterns at the local level.

Identification of other stress factors and the magnitude of their impacts on the natural resource base and livelihoods can successfully be undertaken at community level using matrix scoring (Figure 9). Field experience has shown that such an exercise makes participants more excited and eager to participate. Wealth ranking has proven to be another very helpful tool in examining the levels of vulnerability to environmental change and other stress factors in the southern highlands of Tanzania (Kangalawe and Liwenga, 2007; Liwenga et al., 2007a,b). This approach, which determines the endowment of livelihood assets by respective households, is particularly useful in social stratification that influences adaptation and vulnerability to various stress factors such as climate change. Wealth ranking may also provide explanations to questions of why and how certain groups are more vulnerable or most adaptive than others in the same community, for example, as indicated by sizes of farms and number of livestock owned, ownership of food or cash crops, and level of food security of a particular household, among others.

Despite the effectiveness of these tools in assessing the impacts of climate change and other stress factors, these tools need to be integrated as they complement

each other. Nevertheless, field experience has shown that participatory assessments of climate change do contribute to the quick understanding of the patterns of climate variability, the impacts, and adaptive capacities, as well as other stress factors impacting on the livelihood of rural communities. However, for more quantitative analysis such tools need to be complemented by some traditional approaches like household surveys and modelling.

Conclusions

Like many other parts of the country the southern highlands of Tanzania are vulnerable to environmental change, particularly climate change. Such vulnerability is reflected in various impacts of environmental change on, among others, food security and human health. Agricultural production, which is an essential component of food security, is largely rainfed. This subjects the area to occasional food shortage especially in years with extreme climatic events such as floods and droughts. Droughts have become more recurrent, while floods have often destroyed infrastructure and affecting food distribution and access by many communities. While food security and/or insecurity varies spatially and temporarily depending on rainfall patterns, other stress factors such as soil conditions, socio-economic, cultural factors and access have often influenced food security in the southern highlands of Tanzania and globally.

Environmental change has also had significant impacts on human health in various parts of the country. The rise in global temperatures has been a factor for increased incidences of highland malaria in the southern highlands, areas that were traditionally free from mosquitoes and malaria. Other climate-related health risks have also increased, for example, diarrhoeal and respiratory diseases. Increased health risks due to environmental

change are of particular concern as they impact on the population, including reducing the labour force in agricultural production and other sectors of the economy. Thus sound adaptation mechanisms are needed to address the consequence of climate change on agricultural production, food insecurity and health. While addressing global change impacts on food security and human health it is also important to consider the multiple, and often interdependent, stress factors that affect the community livelihoods, especially in the rural areas.

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