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Full Length Research Paper

Climate change risk on agriculture and response strategies by small holder farmers in Lake Victoria Basin, Tanzania

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Lake Victoria Basin (LVB) forms an important ecosystem which to a large extent maintains the flow of the River Nile waters, and supports agricultural activities in the region. Climate change is among major challenging factors to communities that depend on agriculture for their livelihood in the basin including Tanzania. This study investigated the current status of climate change in particular temperature and rainfall and their implication on people's lives and potential adaptations required. A combination of methods was used including trend analysis of both temperature and rainfall data and risk assessment. Social economic data and communities perceptions on climate issues were obtained through literature review, discussion with key respondents, and household (HH) survey to 10% of total number of HH in selected case study village followed with Focus Group Discussion (FDG) and a stakeholder's discussion meeting. Results showed that out of 21 and 30 years, from 1979 to 2008 and from 1985 to 2011 for Mwanza and Magu stations, only 11 and 10 years respectively had chances of receiving rainfall less than 400 mm during rainfall season. The risk of having seasonal rainfall less than 400 mm in 30 and 21 years time was found to be 40% for Mwanza and 47% for Magu. In both cases much observed were increased rainfalls showing climate change. In this case the risk was categorized as moderate. Although climate change risk in the basin is characterized to be moderate, communities are now experiencing negative impacts on agricultural and water sectors such as increased crop pests and diseases, change in rainfall seasonality and drying of water sources of which all affects both crops and livestock production. Although there are adaptations in place these need to be strengthened through capacity building of the local existing innovation systems.

Key words: Agriculture, adaptation, climate change, Lake Victoria, impacts.

INTRODUCTION

Agricultural producers, in particular smallholder farmers in developing countries, are facing unprecedented challenges including climate change impacts in the 21st century leading to declining crop and livestock production (IPCC, 1995; Nelson and Stathers, 2009; Majule et al., 2013). It is estimated that 9.2 billion people are to be fed by 2050 of which 8 billion will be in developing countries and this might be a challenging issue if effective measures to enhance production are not put in place. On the other hand, considering the increasing scarcity of land and water as well as climate change impacts, productivity gains will have to be the main source of growth in agriculture and the primary means to satisfy increasing demand for food and other agricultural products.

In many Sub Saharan Africa (SSA) countries, poverty and food insecurity are linked to low agricultural productivity which accelerating climate change (CC) threatens to worsen (Butt et al., 2005; Müllera et al., 2011). A key challenge for decision makers is to understand the context and strategies of farmers and other stakeholders in agriculture for adapting to CC. Agriculture in SSA and Tanzania in particular is facing enormous challenges, including how to increase yields, replenish nutrients in depleted soils and also to adapt climate change and variability impacts (Garrity et al., 2010). Rapid population growth rates, poverty and inequality exacerbate problems caused by climatic changes to most developing countries.

LVB is found in the Eastern part of SSA and is shared with Tanzania, Kenya and Uganda and people living within the basin have developed a wide range of livelihood activities which are interlinked. The basin is among potential basins in Africa and it forms parts of the upper Nile Basin which extends to Egypt through Sudan (EAC, 2005). Over time LVB has maintained a wide range of livelihoods which is agricultural based with pockets of fishing activities particularly in areas near the Lake and in rivers which feed the Lake. Diverse farming environments and complexities associated with peoples' livelihoods in LVB have faced a number of socio and environmental challenges such as demographic pressure, land and water degradation as well as climate change, and associated impacts of measures to address such challenges are highly needed for sustainability of the basin (Tolo et al., 2012). Recent studies in the basin have shown that agricultural sector in the basin is vulnerable to climate change and this is due to a number of factors including poverty, existence of poor farming technologies and poor social infrastructures (Woodward et al., 1998; Brooks et al., 2005).

Despite climate change and variability challenges reported in areas adjacent to LVB (Muzo, 2012; Kaijage, 2012) the area is not potentials for both socio-economic and environmental development. Kangalawe et al. (2008) clearly identify that climate change in the country is a reality and the most vulnerable sector is agriculture. A number of studies conducted have shown that climate change and associated impacts are not uniform and also vulnerability and adaptation potential varies accordingly and depends on a number of factors including endowment of both physical and social capital (Woodward et al., 1998; Brooks et al., 2005). Furthermore it is generally accepted that adaptation potential of most communities is still low and thus capacity building particularly in the agriculture sector is highly needed in order to reduce loss and damage associated with climate change. On the other hand most data on temperature trends clearly shows that in most areas for example of Tanzania temperature has been increasing over decades in various orders but rainfall has been showing varied patterns (NAPA, 2007). This therefore has revealed different impacts and adaptation strategies to both social and natural systems (Bohle et al., 1994; Majule et al., 2013). It is on this basis that this study investigated trends of both temperature and rainfall in LVB over time to establish climatic risks and examined communities' perceptions on climate change and current existing adaptation strategies.

MATERIALS AND METHODS

Description of the study areas

This study was conducted in the LVB focusing more on the Tanzanian part (Figure 1). The LVB has a surface area of about 69,000 km^2 collectively owned by three countries namely Kenya (6%), Uganda (43%), and Tanzania (51%). Additionally, the catchment of the principal affluent river, the Kagera, runs through the countries of Rwanda and Burundi (World Bank, 2005; Tolo et al., 2012). The Nile river outflow is an extremely important freshwater resource for the Nile Basin countries including Uganda, Sudan and Egypt. Over the past three decades or so, the basin has come under increasing and considerable pressure from a variety of interlinked human activities such as degradation of its catchment and wetlands, over-fishing, species introductions, industrial pollution, eutrophication, sedimentation and climate change (Majule, 2008; Tolo et al., 2012).

Analysis of climate change risks

The climate pattern in the LVB to a large extent reflects that of Eastern Africa as a whole with short season from October, November and December (OND); and relatively warm and long season from March, April and May (MAM); and two dry seasons (Yanda et al., 2006). Furthermore, the Lake is also facing the problem of declining water level believed to be associated with climate change.

In order to establish climate change risks analysis for LVB, climatic trend analysis was done. Parameters, rainfall data was obtained from two main meteorological stations namely Mwanza and Magu. Also Temperature data for trend analysis was obtained from Mwanza station only. The data was checked for quality using single mass curve and found of good quality. Any missing data was replaced by the long term average of the specific station. This study preformed 30 year time slice annual climatology analysis for Mwanza station and ten year time slice climatology analysis for Magu. The aim was to capture inter-annual and inter-decadal signals for climate change risks. Due to data availability Mwanza station

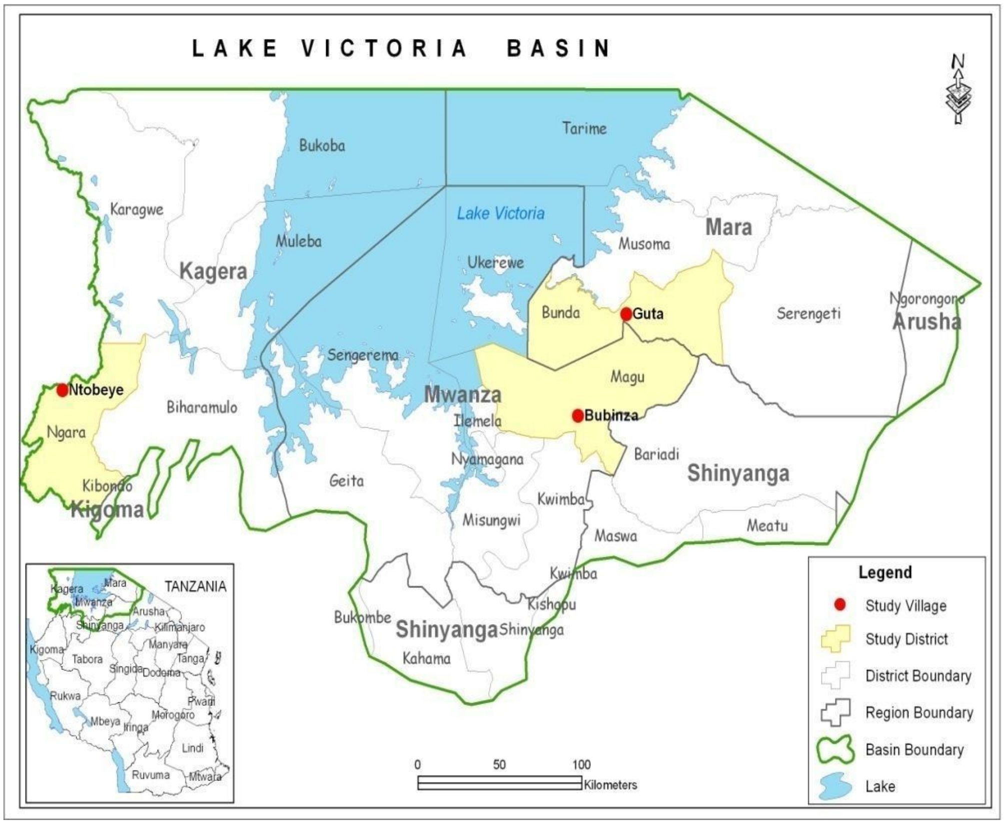


Figure 1. Location of the study sites within Lake Victoria Basin.

used longer climate dataset, 30-year time slice average analysis and Magu station used 10 year average time slice analysis. Seasonal rainfall data (MAM season) for the two stations from 1979 to 2008 was extracted from long term daily data using Instant statistical tool. Annual and seasonal rainfall trend analysis was determined using the same tool for both stations.

In order to understand below normal seasonal total rainfall risks, line graph of seasonal rainfall frequencies from 1985-2011 for both stations was plotted against seasonal total rainfall. This study used rainfall mode type of the central tendency (average) to study signals for climate change risks. Mode is the value that has got the highest frequency on the occurrences of seasonal rainfall and is more representative type of average. MS Excel plotting tool was used to determine rainfall frequencies for both stations. The 400 mm is chosen for this study as a measure of the central tendency and more representative long term average seasonal rainfall total for 30-year average. This study compared how many seasons have got rainfall total greater or less than 400 mm for the purpose of determine seasons with total rainfall less than the long-term average. The risk was categorized subjectively as higher, normal or lower depending on the highest frequency seasonal rainfall whether was below, normal or above normal. If the highest frequency on the occurrence of seasonal rainfall total falls was below normal, it categorized as higher risks and if it falls above normal it categorized also as higher risks. Annual maximum and minimum temperature anomaly was determined using Instant tool. The aim was to capture signals for changes in climate in the study site. Due to climate data scarcity, only temperature analysis was done in Mwanza only.

Socioeconomic analysis

In this study both secondary and primary data were collected using different standard methodologies (Table 1). Secondary data was obtained through detailed review of various publications including journal papers, books and book chapters, various dissertations and theses published by postgraduate students. Primary data were collected through discussion with key respondents, focus group discussion (FDG) and household interviews following procedures used by Lema and Majule (2009) and Tolo et al. (2012). Various forms of checklists were designed and used to gather information in three representative villages strategically selected to represent various parts of the basin in Mara, Mwanza and Kagera regions found in the LVB (Figure 1). Sample size per

Table 1. A summary of samples taken per village in the basin.

Data collection methods	Study village			Total
	Mara	Mwanza	Kagera	
	Guta B	Rubinza	Ntobeye	
Household survey	48	51	-	99
Focus Group Discussion	15	20	15	50
Discussion with key respondents	6	6	6	18
Transect walk	10	10	10	30
Totals	79	87	31	197

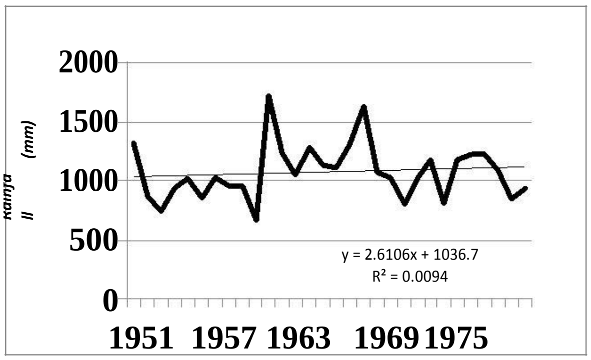


Figure 2. Annual Rainfall (Mwanza 1951-1980).

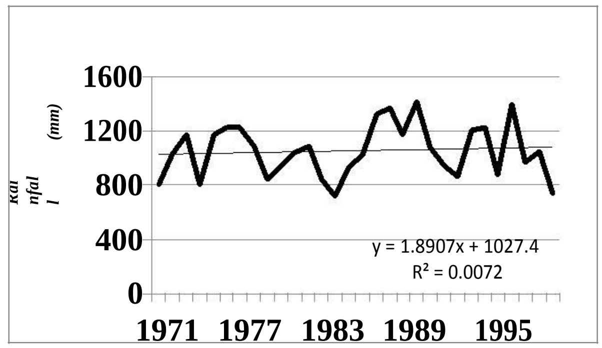


Figure 4. Annual rainfall (Mwanza 1971-2000).

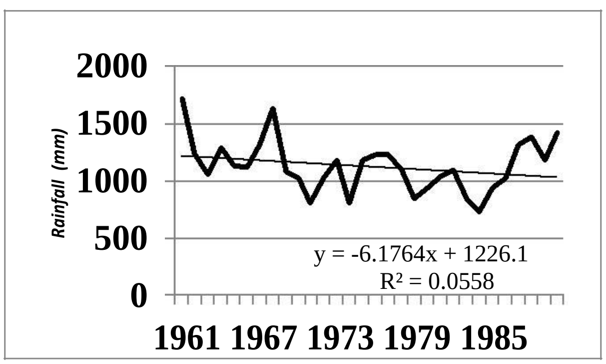


Figure 3. Annual Rainfall (Mwanza 1961-1990).

method used and villages involved in this study are shown in Table 1.

In general the methods used included key informant interviews on climate change issues including historical rainfall and temperature patterns, focus group discussion (FGD) with at total number of 50 participants from 3 villages (Table 1) particularly on climate change impacts, vulnerability and adaptations. On the other hand historical mapping of different climate related events over the past years that could be remembered was also acquired through FGD. Finally direct field observations through transect walks was done to confirm impacts and adaptations strategies and methods used that were easily mentioned by communities. The approaches used are quite similar to those used by Yanda et al. (2005) and Kangalawe et al. (2005). A local agricultural innovation system was constructed by adopting the approach followed by Majule et al. (2013).

RESULTS AND DISCUSION

Climate change risk analysis

Annual rainfall trends for Mwanza

During the climate analysis the annual total rainfall for a 30-year time slice for the periods of 1950-2010, 1951-1980, 1971-2000 and 1981-2010 respectively showed changes in their trends, not statistically significant (Figures 2 to 5 respectively). Figures 2, 4 and 5 had increasing trends while Figure 3 had decreasing trend. The overall annual rainfall trend analysis for Mwanza showed increasing trend not statistically significant.

The trend analysis of annual rainfall for the period 1951-2011 could reveal that, from the past five decades, the annual normal rainfall pattern for Mwanza has been altered with signals of changing rainfall trends as measured by the sign of the regression equation.

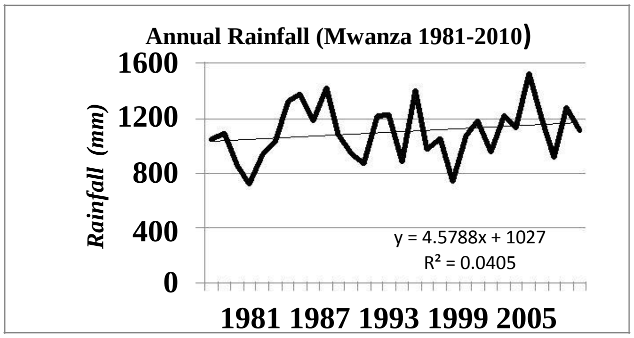


Figure 5. Annual rainfall (Mwanza 1981-2010).

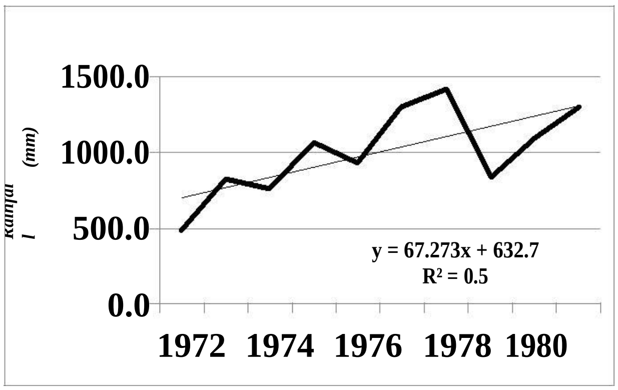


Figure 6. Annual rainfall (Magu, 1972-1981).

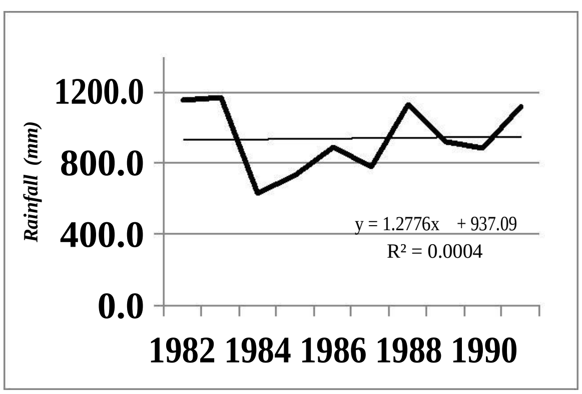


Figure 7. Annual rainfall (Magu 1982-1991).

Annual rainfall trends for Magu

The analysis of annual rainfall total for Magu from 1972 to 2001 showed varied rainfall trends, not statistically significant. For the decadal time slice, from 1972 to 1981, the annual rainfall total had increasing trend, statistically

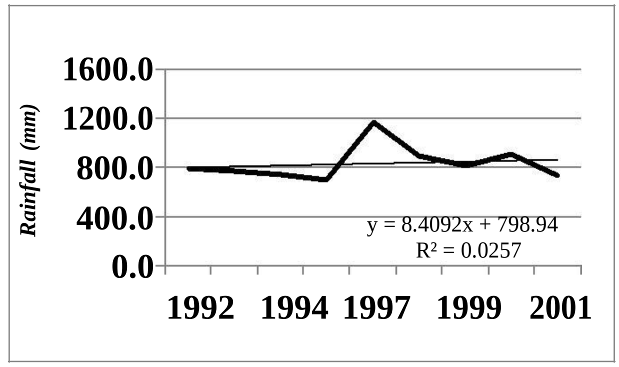


Figure 8. Annual rainfall (Magu 1992-2001).

significant (Figure 6), followed by increased trends from 1982- 1991 and 1992-2001, not statistically significant (Figures 7 and 8 respectively).

In general, results analysis above concluded that the normal rainfall pattern of Magu has been altered with overall increasing trend not statistically significant.

Seasonal rainfall histogram risk analysis

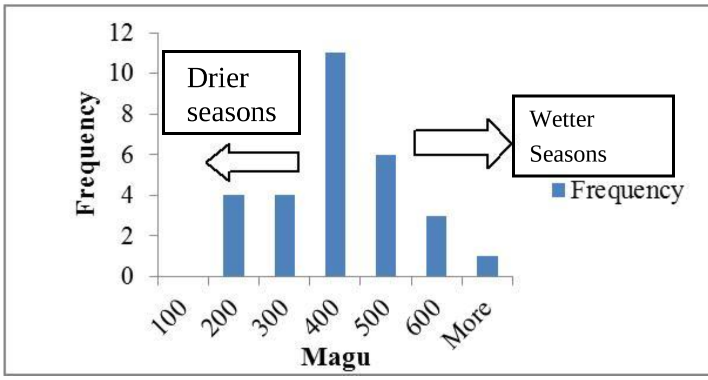
The seasonal rainfall total histogram for Magu showed that out of 30 years 1972-2001, eight years could receive seasonal total rainfall less than the long-term average (400 mm) relatively higher drought risks (Figure 12), and for Mwanza, 20 years out of 30 years could receive rainfall below long term average, relatively higher drought risk (Figure 10).

Relatively draught risk can be seen for both stations. For Magu areas, extreme conditions with seasonal rainfall greater than normal are likely to dominate, and drier seasons are likely to dominate in both locations.

Temperature anomaly trends

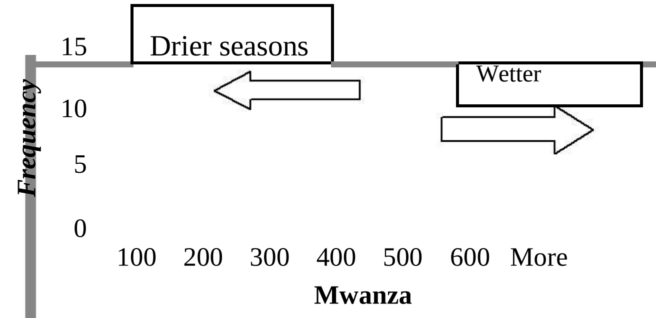
During the analysis of temperature data for Mwanza station, five years moving average temperature anomaly was done to determine signals for changes in climate. For the analysis of annual maximum and minimum temperature anomaly, varied temperature trends were observed. Maximum temperature anomaly showed increasing trend, not statistically significant (Figure 11) and minimum temperature anomaly showed decreasing trend not statistically significant (Figure 12). Signals for changes in climate in terms of increased maximum temperature anomaly may cause varied risks for some crops during crop development.

In general, relatively varied signals for climate change risks observed in the analysis of annual total rainfall, seasonal total rainfall, seasonal total rainfall distribution



Bin	Frequency
100	0
200	4
300	4
400	12
Total	30

Figure 12. Histogram of seasonal rainfall frequency for Magu 1972-2001.



Bin	Frequency
100	1
200	10
300	9
400	7
500	3
600	0
More	0
Total	30

Figure 10. Histogram of seasonal rainfall frequency for Mwanza 1972 to 2001.

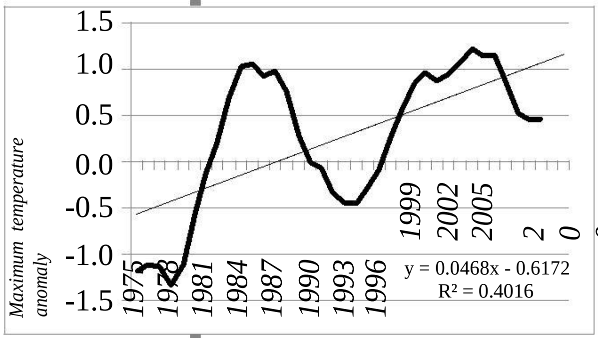


Figure 11. Maximum temperature anomaly for Mwanza.

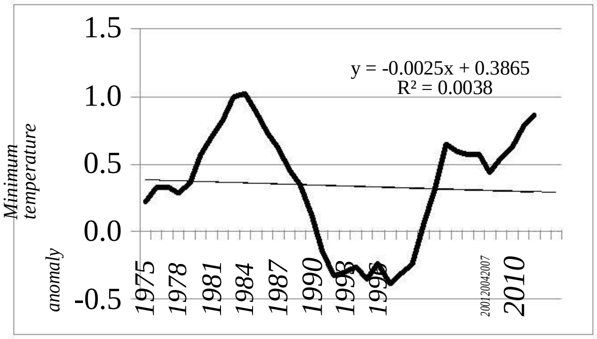


Figure 9. Minimum temperature anomaly for Mwanza.

(frequency) and annual temperature anomaly. Response strategies should be oriented to minimize impacts associated with observed climatic risks.

Communities perceptions of climate change and major climatic events

Based on historical events associated with climate change as well as with temperature and rainfall data presented in Climate change risk analysis Section, there is significant awareness on climate change and associated impacts by most communities in the basin. The study through consultations revealed that 91,100 and 100% of households in case study villages are able to describe climate change and associated impacts based on the historical events that can be remembered. Accordingly most of the changes associated with climate

Table 2. Major climatic extreme events and their impacts on livelihood and responses.

Years	Extreme events	Impacts	Coping and adaptation
1984	Excessive rainfall	Death of people, Hunger and cholera incidences	Received maize called 'yanga' from Local Government
1992	Extreme drought	Hunger due to crop failure, death of people and animals	Temporally migration for searching food and permanent migration
1997	Excessive rainfall, whirlwind	Houses unroofed, fields inundated, hunger and death, more cholera incidences	Temporally migration for searching food, fishing and the Government rebuild houses and provided medicine for cholera
1998	Excessive rainfall	Death of animals, hunger people restricted to move out of the village, more cholera incidences	Government provided medicine for cholera treatment,
2001	Excessive drought	Death of animals, hunger and increase of food prices.	Government provided food, temporally migration for searching food, selling livestock and cultivating sweet potatoes on the lake banks
2004	Drought and hailstorms	Crop damage and hunger	Temporally migration for searching food irrigation farming, sweet potatoes cultivation
2006	Drought	Death of animals and hunger	Out migration for searching food; food relief, planting sweet potatoes (yellow variety)
2007	Drought	Hunger, animals death	Temporal out migration, food relief from the government
2009	Drought	Death of animals and hunger	Government provided relief food and temporally out migration for searching food
2010	Drought	Death of livestock and hunger	Fishing and temporally migration for searching food
2011	Drought and inundation	Hunger	Fishing, temporally migration for searching food,

Source: Field Data, 2011.

are reported to have historically happened long time ago estimated to be more that 40 according to FGD. With time it was reported that more changes and impacts associated with climate change are now being observed. Similar observations have been reported by Muzo (2012) and Kaijage (2012).

In this study through FDG and discussion with key informants associated with field observation climate change and its impacts can be traced back by the analysis of climate related historical events over years as shown in Table 2. In general extreme events, their impacts and related coping and adaptation strategies are clearly associated with climate change.

In general (Table 2), the number of climate change impacts including drought are common in recent years unlike extreme rainfall in the past in the LVB. Copping and adaptation are common strategies to support and strengthen community livelihoods in the basin. These in common have been able to strengthen communities' capacity to reduce climate change impacts to a large extent by reducing loss and damage their livelihood. New varieties of crops introduced in the area such new type of sweat potato (yellow fledged) significantly tends improve livelihood in terms of food security and income. One

Table 3. Perception on climate change impacts on major crops in the LVB.

Climatic factor	Specific changes	Major impacts on major crops (*maize, paddy, sweet potatoes)*
Rainfall	-Rainfall in most cases has decreased -Rainfall becoming more unpredictable -Rainfall come late in November unlike in September in the past and ends in early in March or April) -Short rain duration (maximum 3 months) -Few incidences of heavy rains which is damaging	-Significant reduction in crop yields -Increased number of birds particularly *qualea qualea* to attack paddy rice in farms -Disappearance of early introduced maize varieties such as hybrids -Reduced farm sizes to grow maize due to high climate risk -Expansion of sweet potatoes farming -Introduction of more drought tolerable maize and rice varieties -Introduction yellow/orange sweet potatoes
Temperature	-Generally it has been increasing -High temperature starts early, as soon as rain ends (June) and extends for a longer period	-Significant reduction in crop yields due to soil drying and hardening -Problem with birds -Disappearance of early introduced or traditional varieties of all three major crops -Decreased yield of high breed maize variety which required high rainfall
Wind	-Wind speed has increased -Wind is becoming more common even during the rainy season	-Increased damage to standing crops -Enhanced wind erosion

Source: Field Data, 2011.

interesting issue to note with regards to existence of excessive rainfall in the past years is the incidence of cholera which has been associated with high rainfall in the basin (see Platz, 2002). The findings are in broad agreement with existing literature which suggests that cholera incidence in East Africa can be traced back in 18th century as reported by Christie (1876). Findings clearly show that the basin is becoming warmer and dryer and this could have serious implications on community livelihoods. Indirect impact of climate change in the basin has been reported by Tonnang et al. (2010) to include increased malaria incidences which indirectly affect human productivity and efficiency.

Impacts on major crops

A number of agricultural crops are grown in the basin including rice, maize, sweet potatoes, cassava, sorghum and cowpea. Cash crops in the basin include cotton in Mwanza and Shinyanga parts of the basin, coffee in Kagera and some parts of Mara regions. These and they all form a part of communities' livelihoods in particular food and income in terms of food and income generation. The production of such crops is challenged by a number of factors including climate change impacts. Table 3 presents findings on perception on climate change impacts on major crops in the LVB.

Based on the impacts reported in Table 3, potential copping and adaptation strategies indentified in the basin are listed in Box 1 and they do not vary very much to those reported by Majule (2008) for other basins in East Africa. Adaptations are not static and communities have been able to implement a number of strategies as copping or adaptation. Box 1 presents a summary of major changes that have taken place in agriculture sector to reduce climate change risk in the LVB.

Among major challenges for improving resilience of the small farmers' agricultural production and livelihoods include the lack of reliable weather information that could

- ✓ Planting methods have changed as people are following recommendations based on research such as planting on time, follow line spacing,
- ✓ Increased knowledge on the use of inputs such as appropriate seeds, and fertilizers
- ✓ Improved the processing of crops to various products such as cassava and changed the marketing strategy in terms of packing
- ✓ Communities have developed interest to know more about climate issues
- ✓ New crops are now emerging particular sunflower which is processed locally to get cooking oil
- ✓ Increased number of NGO's dealing with agriculture issues
- ✓ Increased service delivery to the farmers by extension department through District Agricultural Development Planning units
- ✓ Increased seeking of weather information

Box 1. Major coping and adaptation strategies to climate change in the LVB.

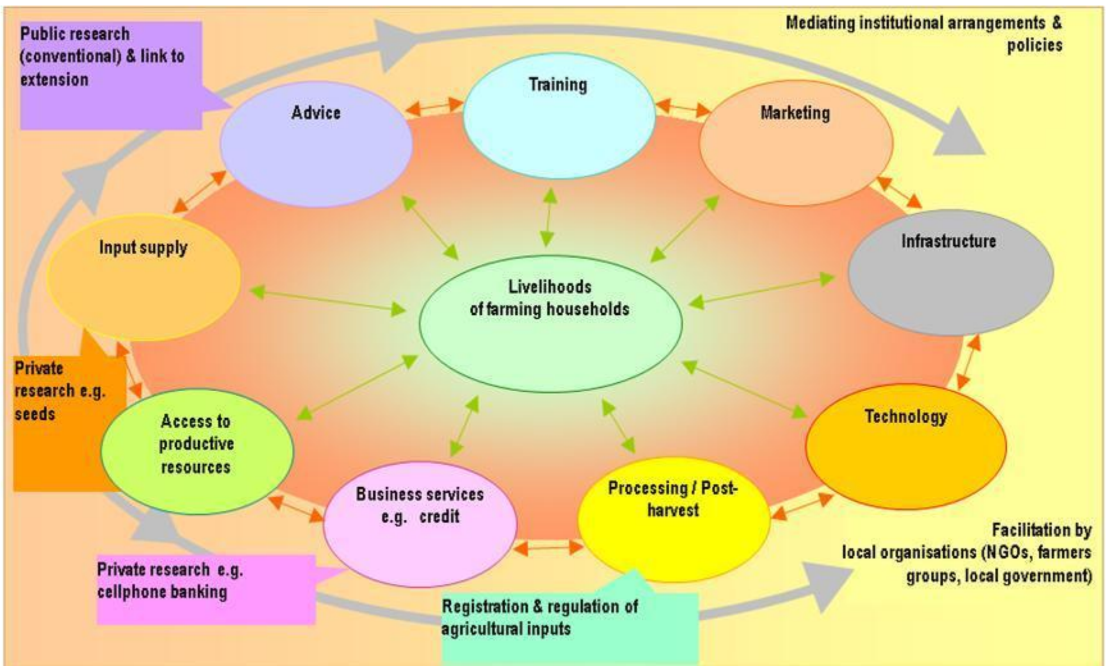


Figure 13. Local agricultural innovation systems common in LVB (Adopted from Majule et al., 2013).

help to effectively plan agricultural activities. Also some of crop seeds provided were not drought tolerant, hence the need for more drought resistant and high yielding crop varieties that could enhance local food security. However, in order to ensure that all resource management practices sustain community livelihoods in the basin sustainable livelihood approach needs to be adopted.

Intimated agricultural innovations for adaptation

An Innovation System (IS) (Figure 13) is a 'network of organizations, enterprises and individuals focused on bringing new products, new processes and new forms of organization into economic use, together with the institutions and policies that affect their behavior and performance'. This study has revealed that local innovation systems do exists in the basin but they are still relatively very weak to address effectively the challenges associated with climate change in the LVB. Various NGO's, private sectors, media, stockiest, extension and farmer groups are working separately and therefore there is not enough room to share information that would otherwise strengthen farmers' capacity to adapt to climate change.

In management of the LVB and strengthening adaptive

Table 4. Assessment of strengths, weaknesses and threats for existing and proposed adaptations in the Basin.

S/N	Proposed adaptation per sector	Potential strength	Potential weaknesses
	Agriculture		
1	i. Promote rice production	-Rain water harvesting -Improve food and income securities -Alternative crops	-Lack of appropriate technologies
	i. Abandon cotton production	-Increase production of other crops	-Reduced income, loss of jobs
	i. Irrigation farming	-Increase crop yields, employment, new innovation	-Poor infrastructures
	v. Formation of adaptation groups	-Sharing of innovations, enhance learning,	-Lack of commitments, focus
	v. Planting early maturing crops	-Escape droughts, increase yields,	-Attack by pests, taste and lack of preference
	Livestock strategies		
2	i) Reduce number of livestock	-Increase productivity	-Religious and taboos
	ii) Improve livestock production	-Reduce conflicts on land, increased productivity	-Lack of landuse plans and sources of breeds
	iii) Control tick born disease by dipping	-Reduce livestock deaths and improve quality of products	-Infrastructure and management
	iv) Introduce improved livestock breeds	-Reduce management costs and increase productivity	-Source of breeds and management issues
	Non-farm strategies		
3	i) Train and encourage people to become more entrepreneurships	-Reduce climate risks and vulnerability	-Shift from agriculture
	ii) Promote fishing eg beach management units	-Reduce climate risk, increase income, job creation	-Lack of technology and interest
	iii) Control local brew making	-Food and income securities	None
	Use of natural resources		
4	i) Implement restrictive by laws on use	-Conservation of natural resources and ecosystems	-Illegal use of natural resources
	ii) Education on natural resources managements	-Sustainable use of natural resources -Poverty alleviation	-none
	iii) Control illegal charcoal making	-Climate change mitigation, forest protection,	-Leakage
	iv) Promote tree planting	-Income generation and climate change mitigation	-Introduction of aliens species

capacity of small farmers to the impacts of climate change, different agricultural innovations have been suggested based on field work and a stakeholder workshop. A framework for strengthening capacity of local agricultural innovation system to adapt to climate change is presented in Figure 13. Main issues to be considered which are also applicable to other similar basins include;

i) Improvement of income generating activities;
ii) Adoption of relevant technology;
iii) Improve marketing services for agricultural crops;
iv) Improve social infrastructure such as roads, storage facilities and crop processing and
v) Maintain a very strong link among various partners in the local innovation framework.

Identified technologies, services and interventions for improving agricultural production in the basin include adoption of irrigation farming, supply of irrigation facilities, and introduction of drought resistant crops. Other strategies were control of the hippopotami that affect crop production around the Lake, expansion of fields and the use of ridging. On the other hand different adaptation option or opportunities identified for the basin are summarized in Table 4 and their strength and weaknesses and threats are also indicated in the same Table.

Conclusion

The LVB like many other parts in Africa is also equally impacted by climate change and chances are that temperature will continue to raise and the area will continue to have years with rainfall less than 400 mm per year meaning that the basin will in the future become more arid. This is likely to affect the fresh ecosystem of the Lake Victoria which is found in the basin. Existing coping and adaptation strategies of the majority of communities are not sufficient to counter the impacts of climate change due to poverty, lack of technology and limited access of information on how best to adapt particularly in agricultural and water sectors. Diversification of income generating activities is needed at a community level in order to improve the economic base, instead of concentrating on a few activities such as subsistence farming and livestock keeping. Capacity building through research and training of various stakeholders is strongly recommended so as to strengthen local agricultural innovation systems that exist in the LVB.

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REFERENCES

Bohle HG, Downing TE, Watts MJ (1994). Climate Change and Social Vulnerability. Global Environ., Change. 4(1): 37–48.

Brooks N, Adger WN, Kelly PM (2005). The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation. Global Environ. Change 15 : 151 -163

Butt A, McCarl BA, Angerer J, Dyke PT, Stuth JW (2005) The economic and Food Security implications of Climate Change. Climate Change 68 :355-378

Chrstie J (1876). Cholera Epidemics in East Africa. McMillan and Company, London.

EAC (2005). The vision strategy framework for Management and Development of Lake Victoria Basin. Published by the East African Community Secretariat, Arusha. ISBN: 9987-666-60-4.

IPCC (1995) Climate change: A report of the intergovernmental panel on climate change. IPCC Report, Geneva.

Kaijage HR (2012) Impact of Climate Change on Groundwater Dynamics in Nzega District, Tanzania: Triangulation of Indigenous Knowledge and Empirical Method Scenario Analytical Approach. M.Sc Dissertation, University of Dar es Salaam, Dar es Salaam, Tanzania.

Kangalawe RYM, Liwenga ET, Kabumbuli R, Walingo MK (2008). Livelihood Diversification and Implications on Poverty and Environment in the Lake Victoria Basin. Afr. J. Environ. Sci. Technol., 2 (10): 272-281.

Lema MA, Majule AE (2009). Impacts of Climate Change, variability and adaptation strategies on Agriculture in semi arid areas of Tanzania: The Case of Manyoni District in Singida Regio, Tanzania. Afr. J. Environ. Sci. Technol., 3 (7). 206-218

Majule AE (2008). Climate Change and Variability: Impacts on Agriculture and Water Resource and Implications for livelihoods in Selected Basins. Towards Climate Change Adaptation. InWEnt-Internationale Weiterbildung und Entwicklung gGmbH (publisher). ISBN: 978-3-939394-28-0

Majule AE, Stathers T, Lamboll R, Liwenga ET, Cosmo Ngongondo, Kalanda-Joshua M (2013). Enhancing capacities of individuals, institutions and organizations to adapt to climate change in agricultural sector using innovation system approaches in Tanzania and Malawi. World J. Agric. Sci. 1 (6), 220-231, Available online at http://wsrjournals.org/journal/wjas ISSN 2329-9312©2013 World Science Research Journals

Majule AE, Kauzeni AS, Mujwahuzi M (2013). Exploring Opportunities for Climate Change Adaptation in semi arid areas of Tanzania*:* A case of Nzega District in Tabora Region, Afr. J. Sci. Technol., 7(8): 758-769.

Müllera C, Cramera W, Harea WL, Lotze-Campen H (2011). Climate change risks for African agriculture. PNAS 108, 11:4313–4315

Muzo N (2012). Climate Change and its Impacts on Agricultural Land use Practices in Selected Viilages of Nzega District, Tanzania. MSc. Dissertation. MSc. Dissertation, Dar es Salaam University Press.

Nelson V, Stathers T (2009) Resilience, Power, Culture and Climate and New Research Directions: A case

Study from Semi-Arid Tanzania. Gender Dev. J., 17 (4) : 81-94

Platz J (2002). Human disease indicator for the effect of recent global climate change. Proc. Acad. Sci. USA. 99:12506-12508

Tolo CU, Majule AE, Perfect J (2012). Changing Trends of Natural Resources Degradation in Kagera Basin: Case Study of Kagera Sub-Basin, Uganda. Natural Resour., 2012, 3, 95-106 doi:10.4236/nr.2012.33014 Published Online September 2012 (http://www.SciRP.org/journal/nr)

Tonnang HEZ, Kangalawe RYM, Yanda PZ (2010). Predicting and mapping malaria under climate change scenarios: The potential redistribution of malaria vectors in Africa. Malaria J. 2010, 9: 111. [MS ID.1152724815331868]

Yanda PZ, Kangalawe RYM, Sigalla RJ (2006). Climatic and socio-economic influences on malaria and cholera risks in the Lake Victoria Region of Tanzania. ICIFAI J. Environ. Econ., 4(3): 44-70