Analysing Vulnerabilities of local communities to flood disasters in the Lower Rufiji Floodplain, Tanzania

Johnstone M. Andrea[24] *Richard Y.M. Kangalawe*[25]

Abstract

Climate change scenario shows that areas with bimodal rainfall pattern and major river basins including the Rufiji basin are anticipated to receive an increase of rainfall intensity by 5% to 45%, with a decrease of raining seasons. This incident is expected to upsurge the frequency and magnitude of extreme flood events and cause serious devastations to vulnerable communities. This paper examined the progression of factors causing community vulnerability to flood disasters as basis for developing appropriate flood risk reduction strategies. Data collection methods involved household survey, focus group discussions, in-depth interviews, remote sensing and hydrological analysis. The household survey and hydrological data were analysed using Statistical Packages for Social Science and Trend Analysis software. Data from focus group discussion and interviews were triangulated with community during participatory discussions. Results showed high degree of community vulnerability to flood impacts extending from geographical, social, economic, political and environmental factors. The catchment delineation model showed that the community is geographically located in flood hazardous areas because the river networks flow into the study area. Also, severity of flood impacts was locally related by the recent influx of cattle in the area which has contributed to land degradation, increased runoff and siltation of the Rufiji river. Furthermore, lack of access to social services such as education, health, water and sanitation facilities were found to largely reduce socio-economic abilities while illuminating underlying vulnerabilities of study communities to flood impacts. The findings suggested combining underlying and immediate factors in reducing future community vulnerability to flood disasters.

Keywords: Climate change; Vulnerability; Flood disaster; Community vulnerability; Floodplain, Rufiji.

Introduction

Flood related disasters are reported to increase in frequency and intensity in the 21st century as a result of climate change (Few, 2003; Parry et al., 2007).

[24] Assistant Lecturerer, Geography Department, College of Social sciences, University of Dar es Salaam

[25] Professor, Institute of Resource Assessment, University of Dar es Salaam

Globally, extreme flood events have negatively impacted hundred thousands of people, majority of them from poor communities (Mulugeta et al., 2007). Over recent decades, some parts of Tanzania have been impacted by extreme rainfall events and river flows, with unusual floods that have caused population displacement, widespread destruction of infrastructure, crops, and loss of human lives and properties (Kangalawe, 2012; Kangalawe et al., 2011; URT, 2008). The impacts of climate change hazards such as floods have been greatly unproportional across communities and individuals (Kangalawe, 2017). The poor have felt much deleterious consequences because of few resources, high degree of vulnerability and low adaptive capacities to cope with impacts of the hazards (Kangalawe, 2017; Mwakalila, 2013). A number of literature show that climate change has intensified climatic hazards and disasters and thus adversely impacting infrastructure, properties and livelihoods of different communities (Mulugeta et al., 2007; Parry et al., 2007; URT, 2008). Also, the climate change scenario has shown that the major river basins such as the Rufiji basin are anticipated to receive an increase of rainfall intensity by 5% to 45% while decreasing of wet seasons (Meena et al., 2009; URT, 2007). This incident of increase in rainfall intensity over short periods of time is likely to increase the occurrence and magnitude of extreme flood events and therefore cause serious destructions to vulnerable communities. However, Wisner et al. (2004) conveys a different scenario that the number of natural hazards including floods have not considerably increased in the past decades but the number of global disasters have apparently increased. Increasing number of disasters in terms of the value of losses and number of fatalities is connected to social, economic, political and cultural factors that increase people's vulnerability (Wisner et al., 2004). Studies show that human actions such as population increase, poor policies and decisions, unequal resource allocations among communities from local to global scales increases susceptibility of populations to the impacts of the natural hazards (Bankoff&Hilhorst, 2013). Even if the flood hazards have not essentially increased in frequency or intensity, the increased people's vulnerable conditions such as habitations on the flood hazardous areas, dangerous buildings, lack of skills and trainings and fragile livelihoods, and low adaptive capacities to cope with impacts perpetuates the increase in disasters (Blaikie, et al., 1994).

This paper provides a deeper analysis for better understanding of the underlying vulnerability to climatic hazards and social factors in explaining the current and future flood disasters to the study communities. To aid this study, two theoretical approaches; the "Pressure Model" and "Political Ecology" have been used as the guiding models for analysis. The political ecology approach was used to explain the relationship that exist between community members and their environment and provides an account on how the social, economic, political and cultural forces influence their vulnerability to disasters (Oliver-Smith, 2013).The pressure model provides explanation of the creation of people's vulnerability into three sets of interconnectedness that function in the progressive manner (Figure 1), starting with the underlying causes that feed into dynamic pressure and ultimately cause unsafe conditions (Bankoff&Hilhorst, 2013). When these sets of progressive vulnerability meet with a hazard event at a particular time and space cause a disaster (Blaikie et al., 1994; Wisner, et al., 2004; Hambati, 2013).

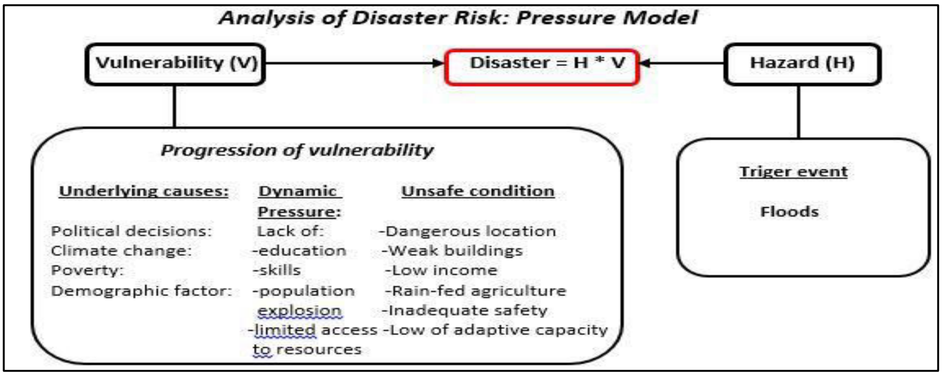

Figure 1, Pressure model of vulnerability progression and disaster risk.
(Modified from Hambati, 2013).

Methodology

This study was conducted in the Lower Rufiji Floodplain (LRF), in the coastal zone of Tanzania. Five villages were selected for the study namely, Chumbi 'B', Chumbi 'C', Mbunjumvuleni, MkongoKusini and Mloka. The selection of the study villages considered the coverage of the main three zones of the LRF which include; the western valley, the central and the eastern floodplains (Hamerlynck,et al., 2010). Mloka village represents the western floodplain zone, MkongoKusini and Mbunjumvuleni represent the central zone, Chumbi 'B' and Chumbi 'C' represent the eastern zone (Figure 2). The data were collected by using a combination of methods, comprising of focus group discussions (FGD), key informant interviews, household survey and documentary search to facilitate the acquisition of secondary data from various sources. The FGD was used to collect information on the general background of climate change and variability, flooding history, impacts and various local community ingenuity in reducing adverse impacts in the LRF. This method was conducted for each village in order to capture general and specific data for each of the study villages. Knowledgeable people within the villages and wards were recruited to participate in FGDs. The key informant interviews were administered at district, wards and village level. At district level, the health and sanitation officer, the environmental officer, agricultural officer and the water engineer were interviewed. At ward and village levels the local leaders and elders were recruited for interviews. Also household surveys were conducted using structured questionnaire. The sample size (n) of 312 households was derived from total households (N) of 1,411 by using sample size equation developed by (Israel, 1992) as presented in equation 1.

$$\boldsymbol{n} = \frac{\boldsymbol{N}}{\boldsymbol{1 + N(e)^2}} \dots\dots\dots\dots\dots (\boldsymbol{Equation\ 1})$$

The determination of the household sample size was based on the confidence interval of ±5% in order to ensure accuracy of the sample estimates (Israel, 1992). The secondary data collected from different offices such as the Rufiji district planning office, the Rufiji district environment health and sanitation office, Tanzania Meteorological Agency, GIS laboratory of the Institute of Resources Assessment and National Bureau of Statistics used to supplement the primary data. The data were analysed using Statistical Package for Social Sciences version 20, trend software statistical analysis, the Crunch model and the political ecology approach. The crunch model used as an analytical tool to understand the causes, effects and degree of vulnerability as well as adaptive capacities of the community to flood impacts. The political ecology approach helped to analyse and discuss on how the physical environment and human actions influence or reduce vulnerability to flood disasters.

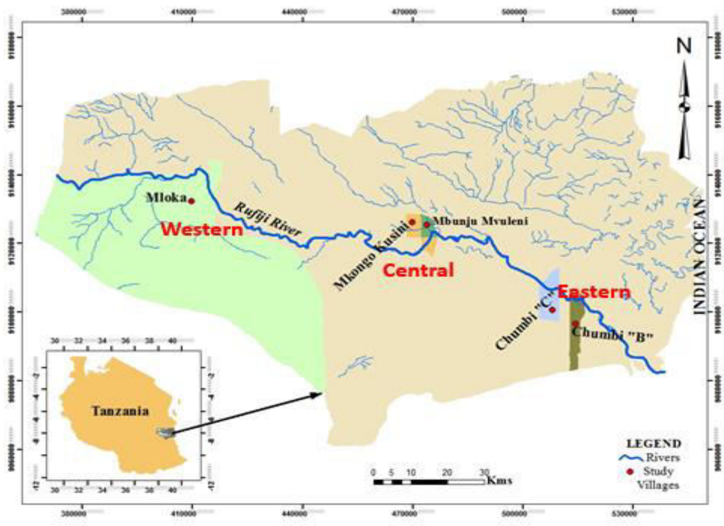

Figure 2. Map of the Rufiji floodplain showing the location of the study areas.
Source: (NBS, 2002).

Results and discussion

Geomorphology and flooding risk

The catchment delineation and analysis of the Digital Elevation Model by using ArcGIS and Arc SWAT indicated that the LRF is situated in the low laying area in which rivers and streams from highlands pour their water and cause frequent floods during the wet season. The outputs from the catchment delineation showed that most of the rivers and stream which cause flooding originated from outside the study area. The elevations of the entire Rufiji basin and the flow directions of rivers and streams showed a considerable evidence that the geomorphological structure of the study area is located in a flood hazardous areas. The area is located in lower elevations above the sea level compared to other parts of the Rufiji basin. The rainfall and run-off which take place within the Rufiji basin boundary are likely to cause flooding over the LRF area (Figure 3).

The findings from the river catchment delineation and GIS analysis were supported by perceptions of respondents from the household surveys. It was revealed by 65.7% of the respondents that flooding incidences in the LRF was mostly connected with amount of rainfall and run-off conditions in areas mainly outside the Rufiji district. Similar observations were reported by (Hamerlynck et al., 2010; Havnevik, 1993; IRA, 2014) that the Rufiji basin catchment touches various districts from different administrative regions of the country in which rainfall and run-off occurring within the basin have been greatly contributing to flooding in the lower parts of the basin, which was involved in this study.

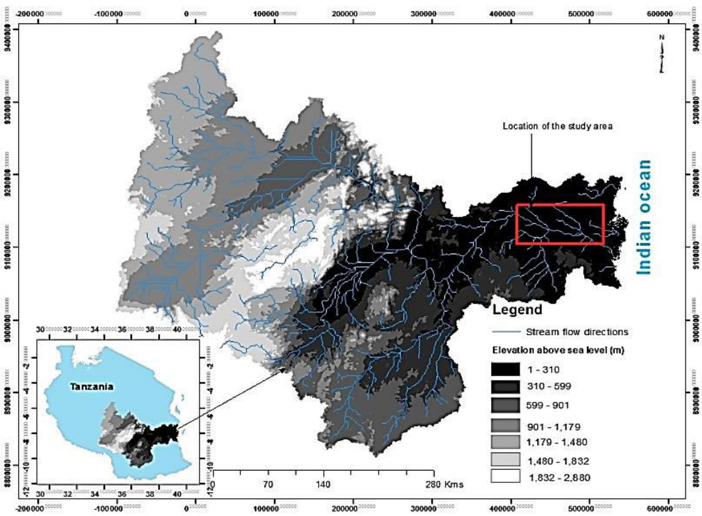

Figure 3. Catchment delineation of the Rufiji River Basin showing rivers and streams flow and directions.
Source: (Field survey 2016).

Flooding trends

The historical trends of flood events and impacts over the LRF was traced back since 1920's (Havnevik, 1993). In order to establish disaster trends a linear regression statistical analysis was used to understand changes in the maximum flood heights (in metres) over time. For the available flooding records (1926 – 1977) (Havnevik, 1993), the findings suggested substantial positive relationship between flood heights and time with R2 = 0.5131. The flood events indicated that flood heights had been substantially increasing at annual rate of 0.07m (Figure 4). The years of highest flooding peaks (1962, 1969, 1972 and 1974) were associated with extreme annual rainfall over 1000mm. For the 1949 and 1953 indicated the lowest flooding peaks and were interrelated to severe drought and low annual rainfall between 500mm to 650mm (Havnevik, 1993). Although the time series of flooding data for the rest of the period from 1978 to recent years could not be traced, available evidence shows that flood disasters have been on the rise.

The findings from other studies (Few, 2003; Parry et al., 2007) show that climatic disasters including floods have been increasing in trends and severity in the past decades and also (Zhou, Leng, & Huang, 2018) expected more increase for the coming years. This also concurs with the climate change scenario that areas with bimodal rainfall pattern will experience more increase of rainfall intensity in the coming years with a decrease of wet season (Ebi, 2008; Omambia&Gu, 2010; URT, 2007; Watkiss et al., 2011). Such situation will exacerbate flood disasters to the vulnerable communities living in the flood hazardous areas such as floodplains and lowland areas (Watkiss et al., 2011). Likewise, a study by (Kangalawe &Liwenga, 2005) in the Kilombero valley, Tanzania found that extreme climatic events including floods have largely increasing in frequency and contributed to regular damage of crops and triggering chronic food shortages to the affected communities. This concern was also claimed by respondents during FGD's and interviews conducted as part of the present study that years of extreme flooding incidences have been occurring more frequently in recent years causing serious damage of crops for households undertaking farming in the flooding areas. Moreover, the household survey indicated that 55.4% of the respondents had experienced at least one extreme flood disaster event within four years, 23.7% showed between five to nine years, and 8.7% claimed that flooding events occurred after every ten years. Available flooding records (1926 – 1977) indicate at least one extreme flood disaster occurs in the average of four years, which supports the local knowledge of flood events indicated above. The findings above confirm that the study community is within the flood prone areas. As shown in Figure 5, flooding that resulted into a disastrous event had a minimum depth of 4m. However, only 13 disastrous events were recorded while 31 floods which reached the height of 4m or higher were reported within 1926 to 1977. With this result, it is most likely that for the flooding events with the size of 4m or larger but not reported as disastrous, might have stricken the area before farmers planting crops or after harvesting food crops in which less impacts were felt. As noted by Wisner et al. (2004) a natural hazard stricken on a particular environment can not cause a disaster until meets with vulnerability (i.e crops in farms). The flood frequency analysis method (USGS, 1982) was applied to determine flooding probability based on the time series flood data from 1926 to 1977 of the Lower Rufiji River Basin. Results revealed out that the Annual Exceedance Probability (AEP) of flooding with the size of 4m or larger is 31% chance of occurrence in a 100 years with the Average Recurrent Interval (ARI) of 3 years. With this analysis it means that the probability of flooding occurrence in any given year is 1 in 3 years. However, the findings from 12.2% of the respondents and discussions from FGD and interviews pointed out that the recent past years flooding behaviour have largely changed its predictability compared with the past decades. This observation could be associated with climate change that has impacted various places particularly in the past thirty years.

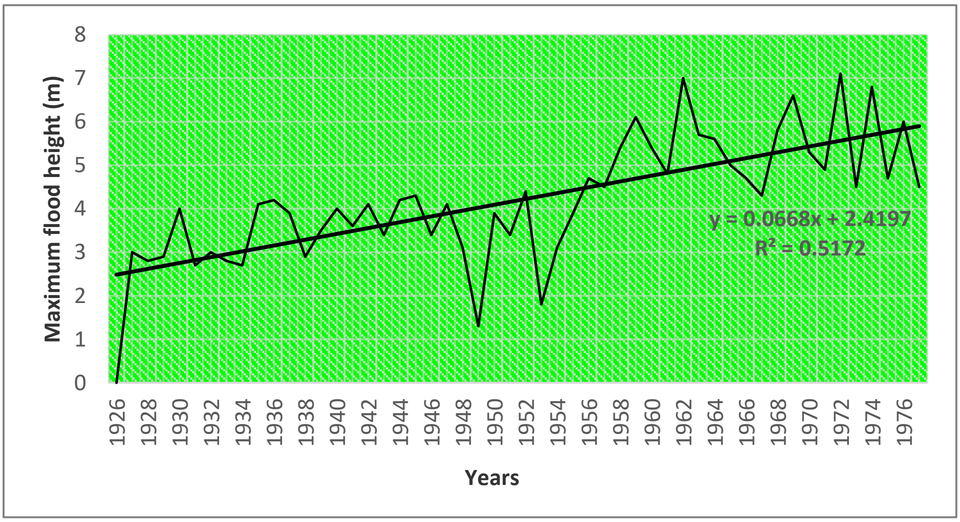

Figure 5. Relationship between maximum flood height and time
Source: Modified from (Havnevik, 1993).

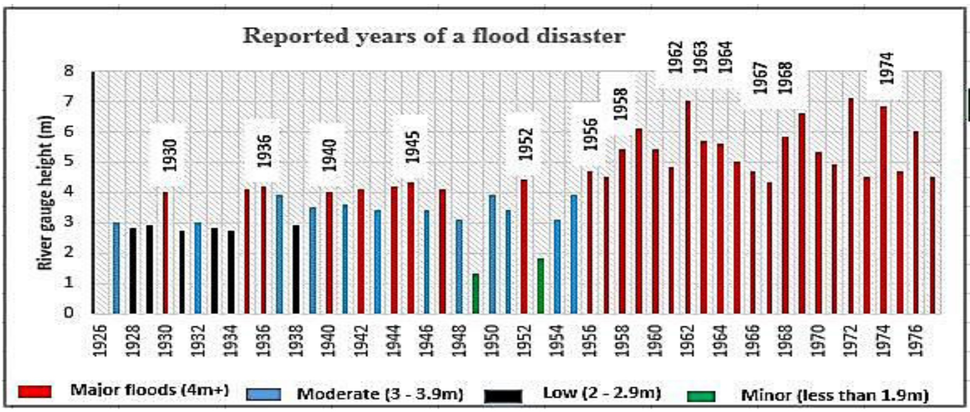

Figure 5. Annual maximum flood height and years of disaster events (1926 – 1977).
Source: Modified from (Havnevik, 1993).

Progression of vulnerability to flood disasters

Effects of cattle influx

Cattle influx was reported as the major factor contributing land degradation on the study area. During the FGD with key informants it was revealed that the ongoing rapid land degradation caused by huge in-migration of cattle from Sukuma, Maasai, Nyamwezi and Mang'ati ethnic groups from the north-central parts of Tanzania has contributed to the increased flood disaster incidences in the LRF. It was claimed by respondents that the rapid increases of herds of cattle have greatly caused soil erosion which perpetuates siltation of the river waterway and therefore contribute to overflow of the river. The finding from this study concur with a study by (Kangalawe, 2017) in the southern highlands of Tanzania, where it was found that environmental degradation contributes to frequent flooding in the lowland areas, associated with increased runoff in highlands and siltation on river channels. The data on cattle population change in Rufiji district (URT, 2014) correlate with respondents' perceptions, which suggests a rapid increase of cattle in the study area. The available data showed that within a period of ten years the number of cattle increased from 3,503 to 106,734 in 2002/2003 and 2011/2012 respectively (Figure 6) (URT, 2014). This makes an increase of over 103,231 cattle, which is equivalent to 2946.9% within a period of ten years. This has caused an enormous pressure on the environment.

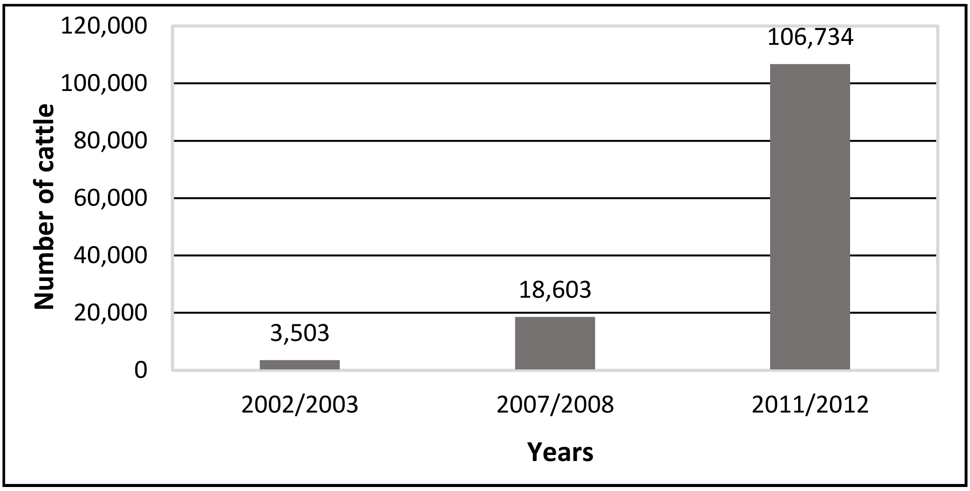

Figure 6. Trends of cattle influx in the Rufiji district from 2002/2003 – 2011/2012. Source: (URT, 2014).

A part from land degradation it was also indicated that the influx of cattle in the study villages have caused chaos by damaging crops in the farms and thus propagating frequent farmers and herders conflicts. Crop destructions by cattle were perceived by the respondents as having more serious potential impacts on food production than climatic hazards. Fighting between farmers and herders were reported by respondents as being common and more frequent in Rufiji district in recent years compared to the past. Farmers and herders conflicts, frequent destruction of crops and farms by cattle and regular extreme flooding were together reported as being causes for reduced food production. Insufficient production of food was reported impeding their local capacities to withstand to current and future climate change stresses such as floods and droughts because their main livelihood depends of farming. The above observations demonstrate that the vulnerability of the local communities in the LRF are not only induced by climatic factors but also compounded by non-climatic stresses associated with resource use conflicts.

The explanation of the reasons for cattle influx in Rufiji and their influences on flooding and community's livelihoods consist of a series of factors ranging from underlying to immediate. Conducting interviews with the pastoralists to understand the reasons for migration to Rufiji district were not successful. This was due to the reason that during data collection period the pastoralists found with high tension as were instructed by the district government to evacuate straightaway with their herds of cattle from the district. Such situation intricate undertaking interviews with the pastoralists. However, the findings by (Mwamfupe, 2015) observed that the root cause of pastoralists and cattle migration and conflicts between herders and farmers was the lack of security of land tenure to smallholder farmers and livestock keepers. Smallholder farmers and herders hold and use un-surveyed lands that are easy for alienation and acquisition and encroachment (Mwamfupe, 2015). Also the study by (Mwasha, 2016), revealed that pastoral migration to parts of the Rufiji river basin was due to lack of pastures, water and grazing lands in native areas, which is exacerbated by climate change. Climate change stresses such as prolonged droughts have greatly caused the lack of water and pastures for cattle in central and northern parts of Tanzania and therefore forced pastoralists with their herds migrate to Rufiji basin and other areas with better opportunities seeking pastures and water (Mwasha, 2016).

Lack of alternative cultivation area and vulnerability

It has been indicated that in 2012 crop cultivation employed about 75% of the adult population in Rufiji district (URT, 2014). The findings from the survey for the current study showed that 97.1% of the households were undertaking cultivation activities on the flood hazardous areas. About 84.2% of the respondents who were cultivating on the flood hazardous areas revealed that the main reason for undertaking farming activities on the area was the availability of natural fertility resulting from alluvial materials deposited by frequent floods. Other reasons for cultivating on the flooding areas as mentioned by the rest of respondents were; lack of alternative land for cultivation (7.9%), availability of soil moisture and water (6.9%) and have knowledge to live with floods (1%). The study also examined the availability of agricultural inputs from the government to farmers, such as fertilizers and improved seeds and pesticides. It was found that only 9% of the sampled households had received fertilizers and seeds from the government for the past cultivation seasons following the study. Out of these, 26 households complained that agricultural inputs were not timely provided and were insufficient. For example, the agricultural census conducted by the Rufiji District Council in the year 2010/2011 and 2011/2012 indicated that only 5.5% and 5.8% of the required tonnes of seeds were distributed to farmers respectively (URT, 2014). These findings show that lack of inputs is likely to influence local farmers to undertake crop production in the flooding areas where there is natural fertility. A study by (Hamerlynck et al., 2010) supports the current study findings in that the floodplain areas attract farmers for cultivation because of fertile soils resulted from alluvial materials brought by floods and prolonged soil moisture. However, it is argued by (Sandberg, 2004) that flood plains are extreme cases of risky environment which illuminates serious damage of farms and crops of farmers during great floods. This is comparable to findings from FGD and interviews which showed that in years of great floods crops in farms are severely damaged and farmers suffer from food shortage and cannot sustain their lives without food reliefs from the government. Other community members were reported to embark on other livelihood options such as charcoal making, intensive fishing and poaching in the nearby Selous game reserve and other protected areas within and adjacent areas.

Population increase and vulnerability

It was revealed from the study that population increase has exerted pressure on land through cultivation, settlement and forest degradation for different purposes. It was revealed during the FGD that the demands of land for cultivation for example, has recently increased and some places which were reserved in the past like the river banks are now encroached for cultivation. During the discussions on 18 November 2016, Mr. B. Hassani stated that,

"In the past the river bank was not cultivated but now most of the parts are already under cultivation because the number of people has significantly increased in this village".

The population increase has largely contributed to increased runoff and siltation which has reduced the depth and capacity of the river channel to accommodate floods. Overflows of river was reported being common especially during the rainy season and thus causing frequent floods to farming areas. Survey findings indicated 41% of the households had established permanent settlements within the flood hazardous areas because of increased demands of establishing new homes. Similarly, results from interviews revealed that the flood impacts are becoming more serious as a result of increased people's habitations in the flooding areas. The population of the Rufiji district has shown significant growth since 1978 to 2012 censuses which implies the need for more land for cultivation and settlement, as well as other natural resources extraction. Available data show that the number of people has increased from 135,542 in 1978 to 217,274 in 2012 which is equal to 60.3% change within three decades (URT, 2014). The findings coincide with the study by (Huppert & Sparks, 2006) which observed that the susceptibility of the people to natural disasters is becoming more frequent, largely as a consequence of population increase. Likewise (Bankoff&Hilhorst, 2013) indicated that human actions including population growth from local to global scales lead to the deprived populations into habitations to areas prone to natural hazards.

Community domestic water sources and sanitation facilities

Water supply and sanitation is one of the indicators which determine the susceptibility of communities to impacts of flooding. The protected water sources (tape water and deep closed well) and improved sanitation facilities reduce vulnerability of the victims to impacts of flooding. Unprotected water sources (boreholes, open wells, surface water from (rivers, ponds and springs) and unimproved sanitation facilities such as open defecation and traditional pit latrines increase vulnerability of the victims to the secondary impacts of flooding such as waterborne infections. The findings from the study revealed unsatisfactory conditions of the sources of water for domestic use and sanitation facilities. About 62.5% of the respondent households largely depended on unprotected sources of water for drinking whilst the rest had an access to the protected water sources. However, the study villages showed significant variations about their main sources of water for drinking. In MkongoKusini village, for example, all households sampled (100%) were fetching water for domestic use from the protected sources, corresponding proportions for Mloka was 54.9%. On the contrary all the sampled households from Mbunjumvuleni and Chumbi 'B' villages were relying on unimproved water sources which were susceptible to waterborne diseases especially during the flooding period. In Chumbi 'C' 11.6% only of the households sampled within this village reported fetching water from improved water sources. This implies that the vulnerabilities of the community members with respect to impacts of flooding on water sources varied among villages. Chumbi 'B' and Mbunjumvuleni for example, were more vulnerable than any other village sampled in this study because of high dependency on fragile water sources with little water treatment practices. Contrasting the MkongoKusini was found least vulnerable as all the sampled households were fetching water from improved sources which are less prone to flood contaminations. Results from $\chi 2$ test found that communities living in flooding areas were more vulnerable because they were depending much on unimproved sources of water for domestic use. The Chi-square value obtained is 100.095a, $P = 0.000$ ($P<0.05$). Also the study examined water treatment practices among community members to understand cleanness and safeness of water for drinking. Water from unimproved sources can be boiled or treated and become safe for drinking and other domestic uses. Unfortunately the study community were found with low water boiling behaviours where only 23.7% claimed to boil water for drinking. Even these respondents were not boiling the water all the time. Likewise the results on sanitation situation found that 94.2% of the households were using unimproved form of toilets, of which 78.5% were using traditional pit latrines and 15.7% open defecation. It has been observed by (Batterman et al., 2009) that insanitary water related diseases such as diarrhoea was one of the major cause of illness and death in Africa. (Schriewer et al., 2015) showed that in most cases faecal contaminations and poor cleanness of sanitation facilities and environmental surroundings become more severe during flooding. (Chanda Shimi, Ara Parvin, Biswas, & Shaw, 2010) also reported that unprotected water sources become more vulnerable for contamination during flooding especially when there is insanitary defecation facilities. Studies conducted in Bangladesh, South America, and Peru by the (Islam et al., 2007) concurred with the current study findings that flooding increase risk of water-borne diseases on open surface water arising from the contaminated drinking water and inadequate water treatment practices among communities. Likewise, (Wisner et al. 2004) showed a rapid growth in the prevalence of malaria and yellow fever that may turn into acute cases in the stagnant water after flooding.

Road networks and accessibility

Effective roads which are accessible all the time promote economic benefits through access to services such as markets, health facilities, education and mobility of people whilst lack of good and accessible roads hinders economic and social opportunities. The findings from this study showed that 71.3% of all the roads in the district are earth roads which are not effective during the rainy season (URT, 2014). The results from the FGDs conducted in the study villages revealed that most of the roads are inaccessible during the rainy season and becoming worse in the flooding periods.

Inaccessibility of roads especially during rainy seasons and flood periods has been a hindrance to availability of various social services, including access to education. For example, it was reported during the interview at Kipoka Primary School that the attendance rates of school children usually become critically low during the flood periods. This was also evidenced by the attendance rates data collected at the school comparing flooding and non-flooding periods. It was found that the non-flooding periods in October and November 2015 indicated high attendance rates of 83.9% and 78.0% compared to 29.5% and 19.5% for the flooding period in February and March 2016 respectively. The attendance for April 2016 was not available as it was reported that the school was closed because of extremely low attendances of the school children. Likewise, the school attendance data collected from Chumbi Primary School for October and November 2015 in the non-flooding period revealed relatively high attendance rates of 86.7% and 87.6% compared to 79.3% and 82.9% for February and March in the flooding period. The main reason for such poor attendance at Kipoka Primary School was inaccessibility of roads to enable the school children to move from their homes to school. The area is dominated by earth roads and traditional bridges which are extremely vulnerable to impacts of floods. For Chumbi Primary School the attendance rates during the flooding period (February and March) indicated low decrease compared to Kipoka. This is due to the fact that the school is along the main road from Dar es Salaam to Mtwara which is excellently accessible throughout the year. It was claimed by the school head that most of the pupils used this road to go to school except for some pupils whose homes were not connected to this road. These pupils failed to attend school during flooding period. Generally the assessments of school attendance rates during flooding and non-flooding periods from two different primary schools, provides an indication that extreme flooding in the study area may deny access to education among the school children.

Political decisions and community vulnerability

The political decisions of resettlement programme and creation of Ujamaa villages in the early 1970's explains the current vulnerability of local communities in Rufiji floodplain areas (Sandberg, 1974). Most of the places where new villages were formed were reported to be dry and unproductive for farming activities compared with their old villages which were located in the floodplain, and currently not politically recognized. As a result most of the community members return back to their politically unrecognised old villages (floodplain) for cultivation. Previous studies found that communities who refused to move to Ujamaa villages and those who went back to floodplain areas after the villagisationprogramme had for long time been denied social services from the government (Beymer-Farris & Bassett, 2012; Sandberg, 1974). The social services such as schools, health facilities, water and sanitation facilities and road services are not provided to these communities because of occupying in the flood prone areas banned by the government. Also, it was commonly revealed by respondents during interviews and FGD that lacking of the public services have been done deliberately to punish communities living in the flooding areas. The household survey for example, found that 64.5% of the households which were using water from unimproved sources (boreholes, open wells and rivers/streams) were found living in the flooding areas. Contrary to that all households reported using tap water (improved source) as their main source for drinking was found in the then Ujamaa villages which were formed during the resettlement and villagisationprogramme. The study found that households that lived in the flooding areas were more likely to suffer from waterborne diseases because majority depended on unimproved water sources.

Similarly, community access to health services for those residing in the flooding areas was reported to be unsatisfactory. For instance, 81% of the respondents who claimed walking above one hour to reach the nearest health facility were from the flooding areas while 98.9% of the respondents who were likely to walk within 30 minutes to the nearest facility were living in villages formed during villagisationprogramme in high ground areas. This means that communities residing on floodplain areas do not have closer access to health facilities compared to their counterparts in the high ground areas. Most of the local leaders in interview claimed that regardless the severity of flood impacts and the eruption of waterborne diseases such as diarrhoea, typhoid and vomiting, the lack of health facility within their areas and poor road accessibility worsen the sufferings among the community members. Parallel to education access, the villages which show higher percentages of households living in flooding areas indicated relatively higher percentages of respondents who have never been enrolled to formal education. For example, Chumbi B indicated the highest 94.1% of the households living in the flooding areas and the highest 70.6% of respondents had never enrolled to formal education. Similarly, Chumbi C which indicated 60.3% of households living in the flooding areas, revealed the second highest non-enrolment with 50% of respondents reporting to have never enrolled to formal education. Other study villages indicated relatively low percentages of households living in the flooding areas and also indicated low percentages of respondents who had never been enrolled to school. The deliberate non-establishment of education services, health facilities, improved water and sanitation facilities and good roads increase vulnerability of the community members and reduce their socio-economic capacity to withstand with impacts of flood disasters.

Conclusion

"The explanation of vulnerability to flood disasters have been directly restricted to the immediate factors including geo-physical configuration of the area, settlement and cultivation in the flood hazardous areas" this study moved beyond these explanations by bringing in the underlying factors. Unlike previous studies, the study analysed both immediate and underlying factors in explaining vulnerabilities of the community to impacts of the current and future extreme flooding. The analysis has found that the causes of community vulnerability to flooding are connected to geographical, environmental changes, political, economic and demographic factors. For example, increased flooding incidences due to siltation of the river channel, is associated with persistence drought in the central and northern parts of the country that has perpetuated migration of pastoralists to the lower Rufiji basin in searching for pastures and water. Also, it has been found that lack of education services, health facilities, improved water facilities, sanitation facilities and accessible road networks to the floodplain communities are associated to political decisions since the Villigasation Programme in the early 1970's in Tanzania. Furthermore, the increased demand of agricultural lands which drives farmers to flood hazardous areas is also due to rapid population increase in the area. The study therefore, has evidenced that vulnerabilities of the study community to impacts of extreme flooding involve a chain of factors ranging from distant (root) to immediate. Thus, unless these chain of factors are addressed the orthodox practices of dealing with immediate factors in flood disaster responses such as provision of relief food and impracticable prohibition of communities' habitation in the floodplain areas may not provide a long term and sustainable solution of reducing community vulnerability to flood impacts.

Acknowledgement
This paper is a part of a PhD study by the first author under the sponsorship of the Norwegian Programme for Capacity Development in Higher Education and Research for Development (NORHED). The sponsorship was available through the Centre for Climate Change Studies at the University of Dar es Salaam.

References

Bankoff, G., & Hilhorst, D. (2013). "Introduction: mapping vulnerability". In G. F. a. D. H. Greg Bankoff (Ed.), Mapping Vulnerability (pp. 20-28): Routledge.

Batterman, S., Eisenberg, J., Hardin, R., Kruk, M. E., Lemos, M. C., Michalak, A. M., Watkins, C. (2009). Sustainable control of water-related infectious diseases: a review and proposal for interdisciplinary health-based systems research. *Environmental Health Perspectives, 117(7), 10 - 23.*

Beymer-Farris, B. A., & Bassett, T. J. (2012). The REDD menace: Resurgent protectionism in Tanzania's mangrove forests. *Global Environmental Change, 22(2), 332-341.*

Blaikie, P., Cannon, T., Davis, I., & Wisner, B. (1994). *At Risk: Natural Hazards, People's vulnerability and Disasters:* Routledge, London and New York.

Chanda Shimi, A., Ara Parvin, G., Biswas, C., & Shaw, R. (2010). Impact and adaptation to flood: A focus on water supply, sanitation and health problems of rural community in Bangladesh. Disaster Prevention and Management: *An International Journal, 19(3), 298-313.*

Ebi, K. L. (2008). Adaptation costs for climate change-related cases of diarrhoeal disease, malnutrition, and malaria in 2030. *Globalization and health, 4(1), 9 - 22.*

Few, R. (2003). Flooding, vulnerability and coping strategies: local responses to a global threat. *Progress in Development Studies, 3(1), 43-58.*

Hambati, H. (2013). Weathering the storm: disaster risk and vulnerability assessment of informal settlements in Mwanza city, Tanzania. *International Journal of Environmental Studies, 70(6), 919-939.*

Hamerlynck, O., Duvail, S. p., Hoag, H., Yanda, P., & Paul, J.-L. (2010). The large-scale irrigation potential of the lower Rufiji floodplain: Reality or persistent myth. Shared waters, shared opportunities: *Hydropolitics in East Africa, 219-234.*

Havnevik, K. J. (1993). *Tanzania: the limits to development from above*, Nordic Africa Institute.

Huppert, H. E., & Sparks, R. S. J. (2006). Extreme natural hazards: population growth, globalization and environmental change. Philosophical Transactions of the Royal Society of London: *Mathematical, Physical and Engineering Sciences, 364(1845), 1875-1888.*

Institute of Resources Assessment. (2014). Milestone 1.4: Mapping Report.

Islam, S., Brooks, A., Kabir, M., Jahid, I., Shafiqul Islam, M., Goswami, D., . . .Luby, S. (2007). Faecal contamination of drinking water sources of Dhaka city during the 2004 flood in Bangladesh and use of disinfectants for water treatment. *Journal of applied microbiology, 103(1), 80-87.*

Israel, G. D. (1992). Determining sample size.

Kangalawe, R.Y.M, Mwakalila, S. & Masolwa, P. (2011). Climate change impacts, local knowledge and coping strategies in the great Ruaha river catchment area, Tanzania. *Natural Resources, 2(4), 212-223.*

Kangalawe, R. Y. M. (2012). Food security and health in the southern highlands of Tanzania: A multidisciplinary approach to evaluate the impact of climate change and other stress factors. *African Journal of Environmental Science and Technology, 6(1), 50-66.*

Kangalawe, R. Y. M. (2017). Climate change impacts on water resource management and community livelihoods in the southern highlands of Tanzania. *Climate and Development, 9(3), 191-201.*

Kangalawe, R. Y. M., &Liwenga, E. T. (2005). Livelihoods in the wetlands of Kilombero Valley in Tanzania: Opportunities and challenges to integrated water resource management. *Physics and Chemistry of the Earth, Parts A/B/C, 30(11-16), 968-975.*

Meena, H.E., Mwakifamba, S., Lugenja, M., Mella, E., Sharif, Z., O'Keefe, P., O'Keefe, M., Stephenson, M., Mascaernhas, A., Gadema, Z., & O'Keefe, P. (2009). "The Tanzanian Adaptation Program" In Devisscher, T., O'Brien, G., O'Keefe, P., &Tellam, I. (ed.). *The Adaptation Continuum: Groundwork for the future* (pp 275-296). Leusden, ETC Foundation.

Mulugeta, G., Durrheim, R., Ayonghe, S., Daby, D., Dube, O. P., Gudyanga, F., & Lucio, F. (2007). ICSU ROA Science plan to address natural and human-induced environmental hazards and disasters in sub-Saharan Africa. International Council for Science, Pretoria.

Mwakalila, S. (2013). Climate change impacts and adaptation strategies in Kilimanjaro transect in Tanzania. *Environmental Science and Water Resources, 3(1), 7-14.*

Mwamfupe, D. (2015). Persistence of farmer-herder conflicts in Tanzania. *International Journal of Scientific and Research Publications, 5(2), 1-8.*

Mwasha, D. I. (2016). Farmer-pastoralist conflict in KilosaDisrtict, Tanzania: a climate change orientation. (Master dissertation, Sokoine University of Agriculture).

NBS (Cartographer). (2002). 2002 Population and Housing Census:Tanzania map shepefile

Oliver-Smith, A. (2013). "Theorizing vulnerability in a globalized world: a political ecological perspective". In G. F. a. D. H. Greg Bankoff (Ed.), *Mapping Vulnerability: Disasters, Development and People* (pp. 29-43). London: Routledge.

Omambia, C. S., &Gu, Y. (2010). The cost of climate change in Tanzania: impacts and adaptations. *Journal of American Science, 6(3), 182-196.*

Parry, M., Parry, M. L., Canziani, O., Palutikof, J., Van der Linden, P., & Hanson, C. (2007). *Climate change 2007-impacts, adaptation and* *vulnerability: Working group II contribution to the fourth assessment report of the IPCC (Vol. 4):* Cambridge University Press.

Sandberg, A. (1974). *Socio-economic survey of lower rufiji floodplain: Rufiji Delta agricultural system,* BRALUP Research Paper(34).

Sandberg, A. (2004). Institutional challenges to robustness of flood plain agricultural systems. Paper presented at the Third Penannual Workshop on the Workshop Conference, Indiana University.

Schriewer, A., Odagiri, M., Wuertz, S., Misra, P. R., Panigrahi, P., Clasen, T., & Jenkins, M. W. (2015). Human and animal fecal contamination of community water sources, stored drinking water and hands in rural India measured with validated microbial source tracking assays. *The American journal of tropical medicine and hygiene, 93(3), 509-516.*

United Republic of Tanzania. (2007). National adaptation programme of action (NAPA): Dar es Salaam: Vice President's Office, Division of Environment.

United Republic of Tanzania. (2008). *State of the Environment Report*, The Vice President's Office, Division of Environment,Dar es Salaam.

United Republic of Tanzania. (2014). The Rufiji District Socio-economic Profile. Rufiji District council.

USGS. (1982). Interagency Advisory Committee on Water Data: Guidelines for determining flood flow frequency. *Bulletin B, 17, 17-19.*

Watkiss, P., Downing, T., Dyszynski, J., Pye, S., Savage, M., Goodwin, J., . . . Lynn, S. (2011). *The economics of climate change in the United Republic of Tanzania*.

Wisner, B., Blaikie, P., Cannon, T., Davis, I. (2004). *At risk: natural hazards, people's vulnerability and disasters*, Routledge, London & New York:

Zhou, Q., Leng, G., & Huang, M. (2018). Impacts of future climate change on urban flood volumes in Hohhot in northern China: benefits of climate change mitigation and adaptations. *Hydrology and Earth System Sciences, 22(1), 305-316.*