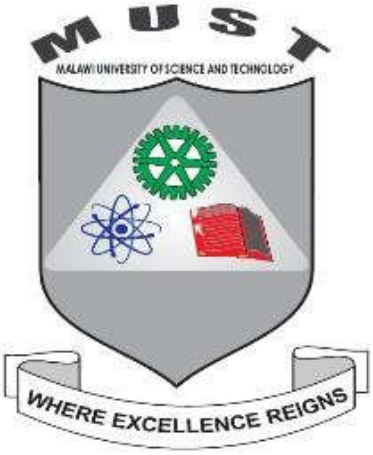


VULNERABILITY ASSESSMENT OF FLOODS IN HOST REGIONS: A CASE STUDY OF T/A MAKHWIRA IN CHIKWAWA DISTRICT

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Dissertation submitted to Ndata School of Climate and Earth Sciences of the Malawi University of Science and Technology in partial fulfillment of the requirements for the Bachelor of Science degree in Disaster Risk Management

July 2021

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DECLARATION

I Allan Milanzi declare that this work is my own and that it has never been submitted to Ndata School of Climate and Earth Sciences or any other institution for academic purposes. All information sources used in this paper have been properly acknowledged.

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ABSTRACT

Contrary to the nature of occurrence of floods in local authorities of Malawi like Chikwawa, floods have a social and economic face and should also be understood as a socio-economic disaster other than natural disasters only. A study was carried out in two villages of T/A Makhwira in Chikwawa, Malawi, to understand the levels and extent of socio-economic vulnerability people to floods in the lower shire. Assessment of the vulnerabilities of people in the area was critically reviewed with pressure and release model (PAR), GIS & statistical analysis. Data was collected from the communities through interviews, a questionnaire & a desk study using the fifth Household integrated survey [IHS5] & Malawi housing and population census 2018 complemented by geospatial analysis. It was found out that the socio-economic vulnerability is high in the study area, affecting a large segment of the population due to vulnerability conditions such as exposure to the flood zone, Poverty, poor settlements/poor housing, and reliance on rain-fed agriculture as their elite source of income. Those with a low score of access to resources (financial, human, material, physical & technical) and near to flood risk zone were more vulnerable.

ACKNOWLEDGEMENTS

I would like to thank GOD Almighty for the grace during my studies in Malawi university of science and technology. He is the master planner for my studies at the campus.

My sincere thanks go to my supervisor, Mr. V Katonda for guidance, encouragement, and suggestions to achieve this study. I extend my sincere thanks also to Miss Namanja, Mr. Nkhoma & Mr. Asima for guidance and suggestions through this work. To Mr. Lackson for untiringly sharing his expertise in Arc GIS and Remote Sensing. This sincere gratitude has also been extended to all lecturers and the entire staff of the Department of climate science, Malawi university of science and technology for their support during my studies.

Finally, I extend my sincere thanks to my parents, MR and Mrs. Mambo, and all my relatives for their love and support.

GOD ALMIGHTY BLESSES YOU ALL!!!

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ABBREVIATIONS/ ACRONYMS

DPR Act- Disaster Preparedness and Relief Act

T/A – Traditional Authority

PDNA- Post Disaster Needs & Assessment

IPCC- The Intergovernmental Panel for Climate Change

GIS- Geographical Information system

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1. CHAPTER 1: INTRODUCTION

1.1 background

Malawi is highly vulnerable to the impacts of extreme weather events given its location along the great African Rift Valley, rapid population growth, unsustainable urbanization, climate variability and change, and environmental degradation(Hazarika et al., 2018). Floods are among the most frequent and costly weather events in terms of human and economic losses(Niang et al., 2015). Over several years the people of Malawi have been facing hazards from the floods caused by the torrential and heavy rains which have persisted in the country(Inozemtsev & Lopes, 2017). Bursting the river's banks, affecting a lot of people and causing substantial financial worth of damage to households and infrastructures. From the 29 affected districts, the most vulnerable and worst hit are Chikwawa, Nsanje, Phalombe, and Zomba(Inozemtsev & Lopes, 2017). The reason for these hazards to merge in such times are due to the climate change which is increasing the intensity/ magnitude and occurrence of flood events. Over the past five decades, Malawi has experienced more than 19 major flood. With these events increasing in frequency, magnitude and scope over the years which had a significant impact on people's lives, livelihoods and socioeconomic infrastructure in the affected areas such as Agriculture, Health, Housing, Infrastructures and Education etc. This push a large number of people into poverty and food insecurity (Niang et al., 2015). The Intergovernmental Panel for Climate Change's (IPCC) Fifth Assessment Report (AR5) has identified Malawi as a country at high risk to the adverse effects of climate change and it is experiencing challenges in adapting to the changes (Niang et al., 2015)

Flood risk arises due to the combination of the flood hazard, Vulnerability conditions, and insufficient capacity(Wisner et al., 2014). flood risk comprises different types of potential losses which are often difficult to quantify. Nevertheless, with knowledge of the prevailing hazards and the patterns of population and socio-economic development, disaster risks can be assessed and mapped, in broad terms at least (Heylin, 1986). Flood disasters unfold in varying geographic, political, socioeconomic, and cultural contexts and people's ability to respond, cope with or adapt reflects unevenly distributed patterns of vulnerability structured by access to and control over resources, the extent of diversified livelihood strategies, physical location or personal endowments and access to information and communication systems (Mtembenuzeni & Kushe, 2018). Some of the losses caused by flood events cannot be prevented but there are ways in which these losses can be reduced. Reducing flood risk can be done by restricting the hazard or vulnerability. Reducing flood hazards is usually very difficult or even impossible. Reducing Vulnerability is easier to influence by strengthening human response, planning, and protective capabilities(Wisner et al., 2014). A study was conducted in T/A Makhwira in Chikwawa district to assess the Level of socio and economic vulnerability of people to floods in the study area. The Lower Shire Valley has been one of the most affected parts of the country, owing to its geographical conditions and the preparedness of its local population. The high recurrence of floods in the Lower Shire Valley poses a low safety level in Chikwawa floodplains. The problem of floods in Chikwawa has been there for a couple of years, and this has a major impact on the livelihood of the communities. While relief aid is paramount to reduce the effects of floods adopted by many stakeholders on the local population of the study area, equally important is to address the deep causes of floods, unsafe conditions and enable local communities to be well prepared. There is therefore an urgent need to provide a reliable solution to the occurrence of flooding in the process of flood risk management.

1.2 problem statement

The recurring floods have contributed to the greatest concentration of flood-risk hotspots in Sub-Saharan Africa (Niekerk & Nemakonde, 2017). Malawi is one of the developing countries in Sub-Saharan Africa whose economy and livelihoods have been greatly affected by flood occurrences.

Malawi established enabling structures and Frameworks such as district contingency plans, DRM policies, etc. to assist the implementation of disaster risk management programs from village level to national level (Affairs, 2013). The structures are guided by the Disaster Preparedness and Relief Act of 1991 (DPR Act 1991) that was developed after the 1991 phalombe floods to provides the legal and institutional framework for addressing disaster in Malawi (Malawi Government, 1991). Before that, hazard, emergency, and disaster management in Malawi have been "ad hoc" thus very reactive not proactive. Disaster risk management practices have, therefore, evolved from a largely top-down relief and response approach to a more inter-sectoral risk management approach. DRM activities such as mitigation, preparedness, response, and recovery require assessing socio-economic conditions and vulnerability factors that determine the impact of a disaster to be taken into account for their effective success. The aim is to identify who and what will be affected, why will the identified groups be affected, and who will need assistance in case of an event. However, Malawi still remains a disaster country because of its poor disaster management and governance since it uses outdated DRM instruments and established structures to manage dynamic events such as annual floods which are becoming more devastating in terms of their occurrence, magnitude, and severity. There is, therefore, a need to conduct vulnerability assessments of floods yearly to provide a real and accurate data on elements at risk, who are vulnerable to flood risk, reasons why they are vulnerable, and damage and losses incurred in the process. The results will improve the efficiency of humanitarian aid in vulnerable areas, update plans, standard operating procedures, frameworks, and policies which are mainstreamed to alleviate all the problems that may arise due to disasters.

The study aimed at providing the probability for different groups of people in the society, Housing, and agricultural activities to be in or exceeding a certain damage state under a given flood hazard intensity, to ana0lyse dynamic causes of socioeconomic vulnerability, and provide additional empirical evidence of what explains socio-economic vulnerability to floods in Malawi, a case study application in T/A Makhwira. The study will quantify and compare the rate of vulnerability on specified elements at risk such as the elderly, women, children, and old & people with disabilities.

1.3 Research Hypothesis

Floods in Chikwawa will reoccur and shall continue to affect the livelihoods, property, agriculture, and the surrounding environment in Chikwawa. Therefore, there is a need for effective flood risk management for Chikwawa District to reduce the impact of reoccurring floods.

1.4 Main & Specific Objectives

The study aimed at investigating the socio-economic vulnerability of floods in T/A Makhwira. Specifically, the research had the objectives outlined below;

1. To assess flood impacts on housing and agriculture
2. To assess causative factors of Vulnerability to floods in the Study Area
3. To Analyze social vulnerable groups to floods
4. To assess the extent of socio-economic vulnerability of the study area.

1.5 Research questions

The following questions seek to reach the objectives of this study.

1. What losses and damages do the Agricultural and Housing sectors experience as a result of floods?
2. Why is T/A Makhwira vulnerable to the damaging impacts of floods?
3. Who is more vulnerable to floods in the area?

4. What is the level of vulnerability based on the social-economic condition of the people in the study area?

1.6 Significance of The Study

Flooding events that occur in Malawi cause huge economic, social, and infrastructural damages. Such events demand the development of contingency plans, institutional and legal frameworks, and arrangements for timely monitoring, governance, and management of flood events. In absence of the correct understanding of vulnerability to floods, people will keep on suffering from floods without adequate and proper ways to address the risk and inefficient use of resources since it will be used to implement programs with wrong disaster information (Mtembenuzeni & Kushe, 2018). The study will produce an exposure map, vulnerability curve, and Damage and loss trends which will visualize and compare elements risk and how floods affect them socially and economically. A copy documented finding will be shared to Chikwawa district council to be used as baseline data in decision-making and implementation of DRM activities to optimize the use of mobilized resources, build resilience, and increase the coping capacity of people in the study area.

2. CHAPTER 2: LITERATURE REVIEW

The literature review is composed of three main parts namely Floods, Vulnerability, and Pressure and release model.

2.1 Floods

A flood is a natural hazard that is defined as the overflow of a large amount of water beyond its normal limits, especially over what is normally dry land(Affairs, 2015.) There are many types of floods are; Coastal flooding which often occurs in coastal areas which bear brunt of severe storms, River flooding which is one of the most common types of inland flooding occurring when a water body exceeds its capacity, flash flooding, groundwater flooding, and drains and sewer flooding. Floods affect both individuals and communities and have social, economic, and environmental consequences. The probability of flood occurrence is computed from the frequency analysis of a given flood event(Thesis, n.d.).

According to Post Disaster Needs Assessment (PDNA) report, in 2015 Malawi experienced floods that affected approximately 1.1 million people, displaced 230 thousand people, and killed 106 people (Government of Malawi, 2015). The three major sectors affected by the flood included agriculture covering 47% of the total damage and loss, transport 35%, and 18% for sanitation and water (Government of Malawi, 2015). Some of the damage and loss figure estimates indicated in the 2015 PDNA report included 523, 347 houses, 1220.53 km roads, 183 Bridges, 15 hydrological stations, and 4 Dams (Government of Malawi, 2015).

The government of Malawi thus declared 15 of 28 districts of the country's flood-prone areas. The major impact of the flood is in the Southern region of the country (Government of Malawi, 2015). The Southern region is the key agricultural region in Malawi (Government of Malawi, 2015). The lakeshore plains and lower shire valley are the most vulnerable area in the region. During the 2015 floods, Blantyre, Nsanje, and Chikwawa districts in the lower shire valley had the highest damage (in terms of infrastructure, agriculture, and property) with percentage losses of 16.4, 16.4, and 14.3

respectively, and floods erode agricultural land causing smallholder farmers to produce low yields (Government of Malawi, 2015). Among the three districts, Chikwawa (4892 km2 of Shire Basin) is rated the most vulnerable district because of the high exposure to climate variability and soil degradation that influences the occurrence of riverine floods (Adeloye, et al., 2015).

The flood that occurred in Chikwawa in January 2015 is regarded as 1 in 500 years (Department of Disaster Management Affairs, 2015). One in 500 years means that there is one probability of occurrence of the flood event to happen 500 years. The floodplains and the floodways are flood-prone areas that are vulnerable or most likely to floods (Els, 2011). The floodplains are all areas covered with water surrounding the river during floods. There is no absolute boundary for floodplain since it varies in size depending on the level of water that floods (Els, 2011). During floods, those areas with high flow velocity, deep water levels, and debris flow can be associated with floodways (Els, 2011).

According to the Government of Malawi, Malawi 2019 Floods Post Disaster Needs Assessment (PDNA), 2019, during the first week of March, some districts in Malawi were affected by experienced one of the worst strong winds, heavy rains, and floods induced by Tropical Cyclone Idai10 (one of the worst storms in its history) that formed in the Mozambican channel and moved into Malawi during its formative stage. Chikwawa was among the districts heavily affected by floods. The losses and damages recorded by the report indicated an increase of impacts from the 2019 event as compared with the 2015 flood event. This entails that flood events are dynamic and their magnitude and severity are increasing over time.

2.2 Vulnerability

The concept of vulnerability originated from the social sciences, it originated from buildings & structures at risk, and how these were damaged by hazards, due to physical forces exerted by ground motion, wind, water, etc. The damage was rated on a scale of zero (no damage) to one total damage. A vulnerability has no universal definition. Experts from various disciplines use the concept and define vulnerability, which leads to diverse measuring methods to serve their purpose and interests.

Approaches to defining vulnerability vary among the disciplines because of the various components of risk, household response, and welfare outcome (Kumar & Ph, 2014). In the field of Disaster Risk Reduction (DRR), the (UNISDR, 2009) defines vulnerability as the conditions determined by physical, social, economic, and environmental factors or processes, which increase the susceptibility of an individual, a community, assets, or systems to the impacts of hazards. This definition is very applicable to this study since it is considered as a resource and circumstance that influences effective risk management, which is in line with the objective of this study. Other authors, like Wisner, et al. (2004) relate the vulnerability of a system or a community only to its capacity to anticipate, cope with, resist and recover from the impact of a hazard. Based on the various views on vulnerability shown above, flood vulnerability in the current study is viewed as the degree of experienced flood harms under certain conditions of exposure, susceptibility, and resilience factors within the human-environment system.

The IPCC (2001) distinguishes three indicators for vulnerability to environmental hazards: exposure, sensitivity, and adaptive capacity. Exposure refers to People, property, systems, or other elements present in hazard zones that are thereby subject to potential losses (UNISDR, 2009). Measures of exposure can include the number of people or types of assets in an area. These can be combined with the specific vulnerability of the exposed elements to any particular hazard to estimate the quantitative risks associated with that hazard in the area of interest. Adaptive capacity describes the ability of a system to cope with climatic extremes (Ludeña et al., 2015).

Adaptive capacity depends on physical resources, access to technology and information, varieties of infrastructure, institutional capability, and the distribution of resources. Indicators for adaptive capacity compose economic capability, physical infrastructure, social capital, and institutional capacity, etc.(Ludeña et al., 2015). The degree of a system's sensitivity to hazards depends not only on geographic conditions but also on socio-economic factors such as population and infrastructure. Indicators of sensitivity can encompass geographical conditions, land use, demographic characteristics, and industrial structure such as dependency on agriculture and extent of industrial diversification (Ludeña et al., 2015).

2.3 Pressure and Release Model (Par)

The basis for the PAR idea is that a disaster is the intersection of two opposing forces: those processes generating vulnerability on one side, and the natural hazard event (or sometimes a slowly unfolding natural process) on the other. The image resembles a nutcracker, with increasing pressure on people arising from either side, from their vulnerability and the impact (and severity) of the hazard for those people. The 'release' idea is incorporated to conceptualize the reduction of disaster: to relieve the pressure, the vulnerability has to be reduced (Wisner et al., 2014). PAL Model helps to understand the complexity of vulnerability and how the risk of disasters can be reduced (Wisner et al., 2014). It is a tool for showing how disasters occur when natural hazards affect vulnerable people. Their vulnerability is rooted in social processes and underlying causes, which may be quite remote from the disaster event itself. The model shows that vulnerability (pressure), which is rooted in socio-economic and political processes, has to be addressed (released) to reduce the risk of disaster. The model begins from the premise that a disaster happens only when a hazard affects vulnerability.

A natural phenomenon by itself is not a disaster similarly, a population may be vulnerable for many years, yet without a trigger event, there is no disaster. Vulnerability is not a situation that just happens. Most often, it develops as a progression. The "progression of vulnerability" explains the interrelationships

between different elements that cause vulnerability. Three layers of social processes that because vulnerability are underlying/root causes, dynamic pressures & unsafe conditions. Vulnerability is associated with these conditions at progressive levels: *Root causes*, which can be, for example, limited access to power, structures, or resources; correlated with political ideologies or economic systems. *Dynamic pressures are* represented, for example, by demographic or social changes in time and space (e.g., rapid population decrease, rapid, and urbanization, lack of local institutions, appropriate skills, or training). The last condition is *unsafe conditions* posed by the physical environment (e.g. unprotected buildings and infrastructure, dangerous slopes) or socio-economic context (e.g. lack of local institutions, the prevalence of endemic diseases) (*(PDF) The Concept of Vulnerability and Resilience*, n.d.) While the Disaster Pressure Model explains vulnerability processes, the Disaster Release Model is the way to understand risk reduction processes. The aim is to release the "pressure" between hazards and vulnerabilities to reduce disaster risk. Hazards should be mitigated to reduce their intensity, thus affect vulnerable people less, Vulnerability should be reduced at different levels, Disaster Risk Reduction activities should be undertaken to turn "unsafe conditions" into "safer conditions", Dynamic pressures should be be reduced and Underlying causes should be reduced.

3. CHAPTER 3: METHODOLOGY

3.1 Study design

This study is descriptive cross-section research and employs both quantitative and qualitative approaches to understand in-depth the social and economic vulnerability of floods in the area under study.

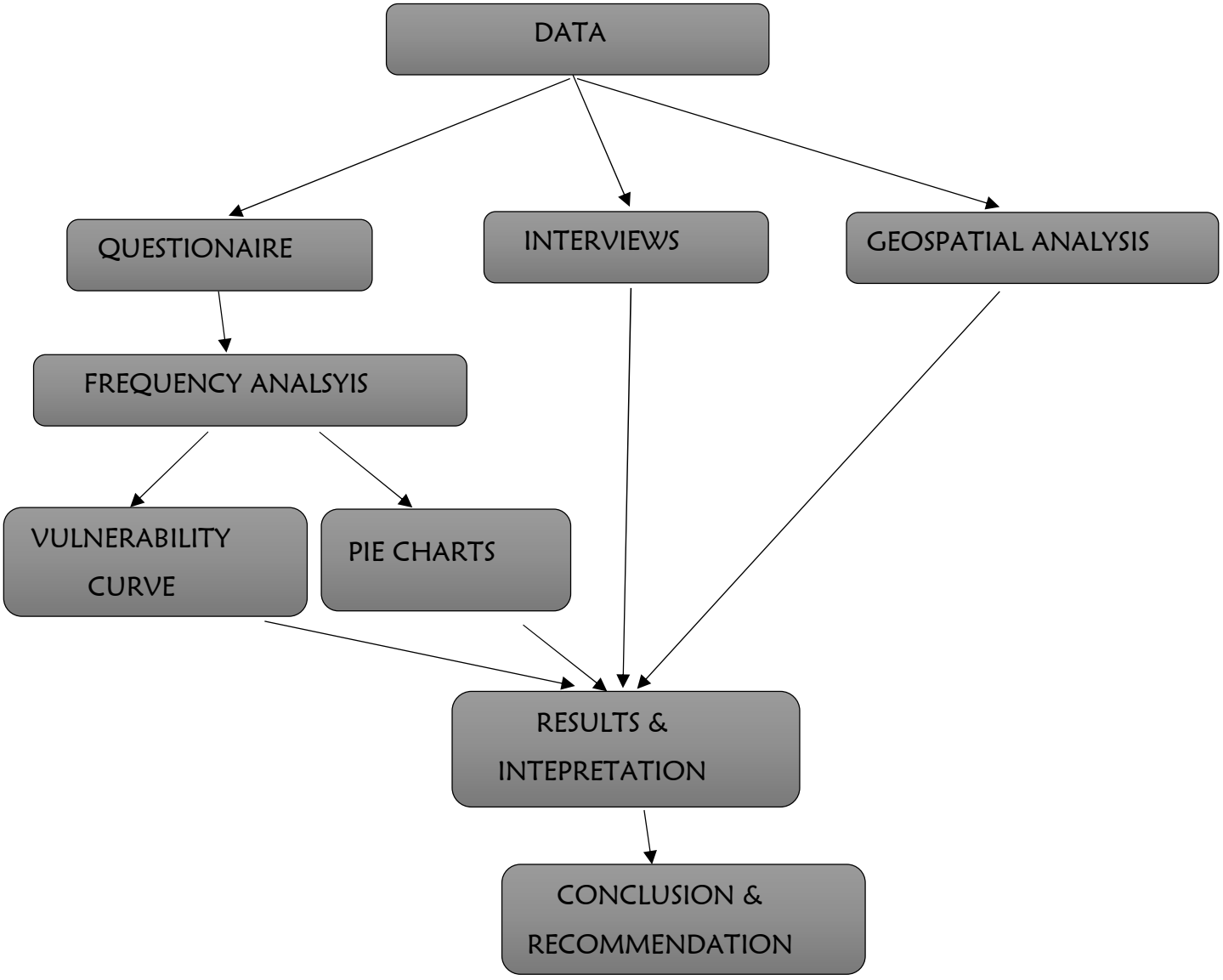


Figure 1: An approach for vulnerability assessment in the area

3.2 Research Materials and Methods

Data collection methods include Desk analysis with the help of remote sensings (satellite images) such as Landsat image and Digital elevation model, ArcGIS Software for spatial analysis and processing, and corresponding land and property maps to be complemented by a field trip which will use a semi-structured questionnaire with primary participants in the affected areas and general observation. Key informant interviews will also be used with the village heads and other key stakeholders. Audio will be recorded for key informant interviews.

3.3 The Area of Study & Population

The study was conducted in Chikwawa district, the southern region of Malawi, specifically in T/A Makhwira whose population is 79,933 (Office, 2006). Chikwawa is one of the poorest and prone to floods districts in the country. The study area has been purposively chosen since it is hit by floods almost every rainy season, annually. Most of the people in the area are farmers and their daily livelihood depends on rain-fed season agriculture due to good fertile soil that attracts people to the cultivation of crops without applying inorganic fertilizer although the crops are always washed away by flooding water during the rainy season (Mtembenuzeni & Kushe, 2018). Poverty, lack of land due to rapid population growth has encouraged many households to be established in marginalized areas that are prone to flooding. There is a lack of economic diversification, low employment opportunity, and low access to social services, making people, property, and the environment to be susceptible socially and economically to flood risk. The study was conducted in two random villages of the traditional authority namely; Zing'ando & Mtembo. The study targets to get information from only those residents aged 20 above in the area who had experienced and survived flood event(s).

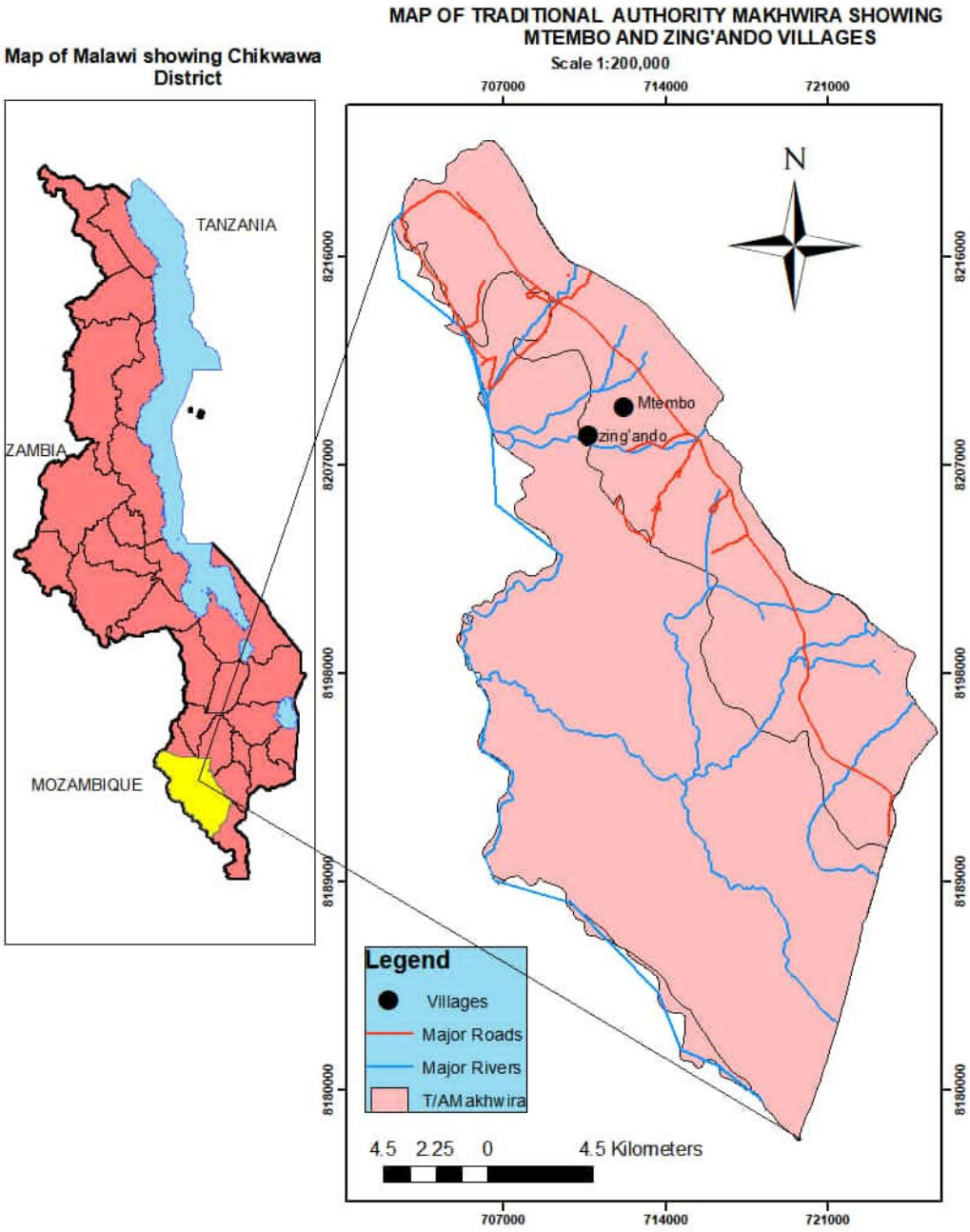


Figure 2. Map of T/A Makhwira, Chikwawa District (the study area).

3.4 Sampling Selection and Size

Due to the high population of the area, households will be selected using random systematic methods to get the information required. Village heads will be selected purposively based on the household's primary participants come from. To come up with a sample size whose results will represent the total population, below is the formula on how much sample size will I randomly select.

$$\text{Sample size} = \frac{\frac{z^2 \times p(1-p)}{e^2}}{1 + \left(\frac{z^2 \times p(1-p)}{e^2 N}\right)}$$

Equation 1 sample size formula source: (mobile.surveymonkey.com)

Where N= population size (in this study this will represent the total number of households), n= sample size, P= Standard deviation (0.5), and e= marginal error or acceptable sampling error and z=z-score. The Z-score is the number of standard deviations a given proportion is away from the mean. To find the right Z score to use, the table below is used. This implies that if my total population is big, my sample size will be large as well to find true results that will represent the whole population. The margin of error ranges from 1%, 5% & 10% the higher the error, the higher the chances the findings are inaccurate. T/A Makhwira has a population of 79,933(Office, 2019). For this study, considering the population size and available resources, the calculation of sample size will be adopted with a 90% confidence interval. This means the allowable precision level is 10% which in this case represents a marginal error of 0.1. Using the Number population, margin error of 10%, the standard deviation of 0.5, Z score of 1.65 to represent 90% of the population, the sample size is found to be 68

Table 1. z- score ranges source: (mobile.surveymonkey.com)

DESIRED CONFIDENCE LEVEL	Z-SCORE
80%	1.28
85%	1.44
90%	1.65
95%	1.96
99%	2.58

3.5 Data Analysis

Data analysis involved rearranging the responses. The analysis involved the categorization, ordering, manipulating, and summarizing data to obtain answers to research questions The descriptive analysis, which is in form of a qualitative description, was carried out on the responses of the subjects regarding their vulnerability in terms of social and economic context. The analysis was based on the review of secondary data as well as the collection and analysis of field data to allow triangulation and validation. Both primary and secondary data collected were analyzed using Software package for social science (SPSS), Microsoft excel & Arc GIS to produce charts, curves, and Maps to express the results collected during the study.

3.6 Ethical Considerations

The study commenced as soon as permission from the ethics board was granted. In Chikwawa, was obtained from the District Council and at the community level from village heads. Participants were recruited voluntarily and their identity was kept anonymous. Participants gave their consent by a written sign and for the illiterate; a thumbprint was used.

4. CHAPTER 4: RESULTS & DISCUSSION

4.1 Introduction

This chapter provides a discussion on the results of the study based on the objectives of the study. The chapter consists of parts which are; flood impacts on housing and agriculture, causative factors of Vulnerability to floods, comparison of elements at flood risk, and the extent of socio-economic vulnerability of the study area.
of the study.

4.2. Results of the study

4.2.1. Household Demographics

The socio-demographic characteristics of the 68 households included in our sample were acquired from Group village Malata and Jana. The sample was not fairly represented in terms of gender. Most respondents are female and married. 68% of the sample population are females and 32% are Males. The average family size in the whole population is 4 family members. The average age of the respondent is around 40-50 years, most respondents are between 20 and 50 years (55%) and 51 and 65 years (45%). The average number of years of schooling is 6.

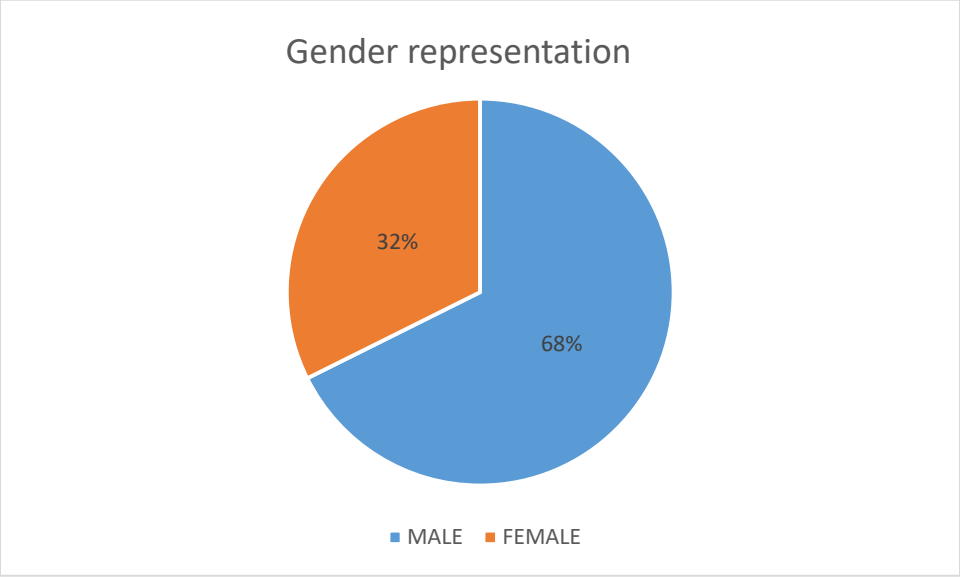


Figure 3. gender participation.

4.2.2 flood impacts on housing and agriculture

(a) Housing

Housing is one of the sectors affected by the devastating effect of floods in the study area. The extent of damage to the houses depends on the building characteristics. Floods caused structural damage to a building because inundation reaches or exceeds the elevation of the floor. The study found that unlike roofs with iron sheets, grass-thatched roofs exhibited water leakage after continuous rain. Furthermore, mud walls that soak water were reported to collapse easily. The sustainability of water protection capability is very low for the mud-made house because continuous rainwater makes the house wall softer and loose. The mud and grass-thatched houses are severely damaged after flooding whereas houses with iron sheets, cemented pillars, brick walls, and concrete houses are partially damaged from the floods. 100% of the participants of the research lost their houses during the flooding period. Housing in this study is classified based on the type of materials used for construction which are permanent, semi-permanent, and traditional houses. Most houses in the study area are local/traditional houses that were either built with sub-standard, sun-cured clay blocks/ bricks (adobe) or fire-cured clay blocks/bricks, built with mud not cement, common poor house design, poor roofing, and other poor building materials which could not withstand flood pressure and resulted into failure. Below is a representation of house characteristics in the study area.

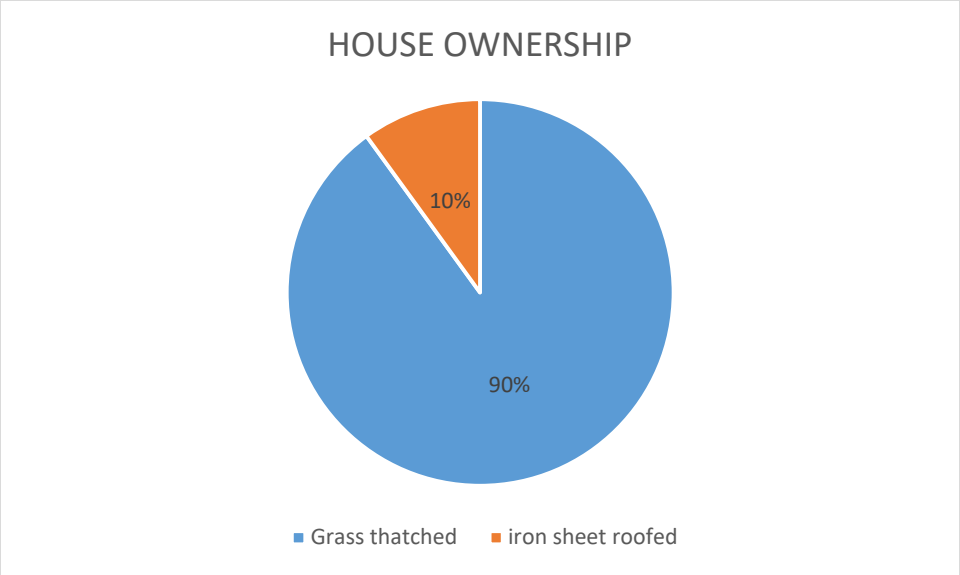


Figure 4. A Pie chart of roofing materials of houses in the area.

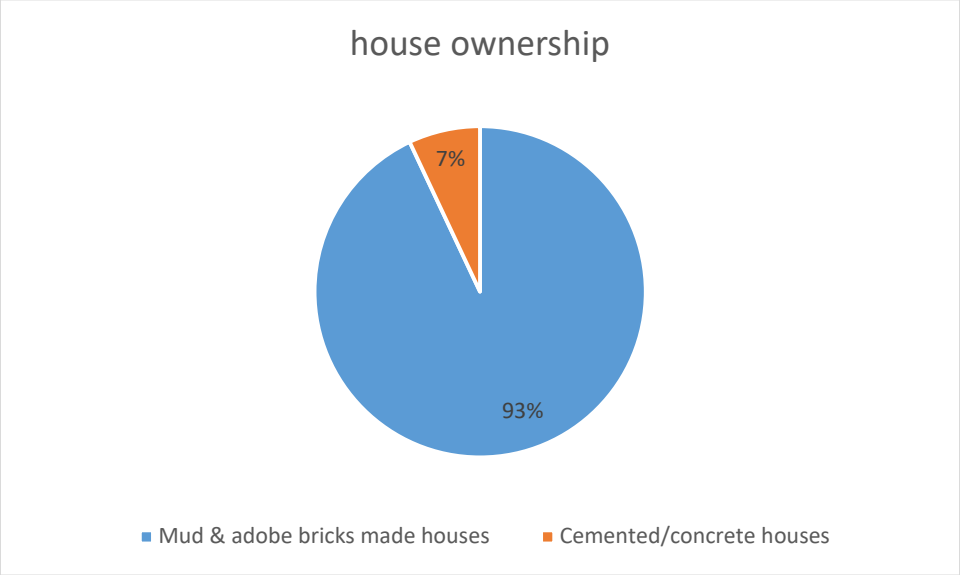


Figure 5. A pie chart on the wall structure of houses in the study area

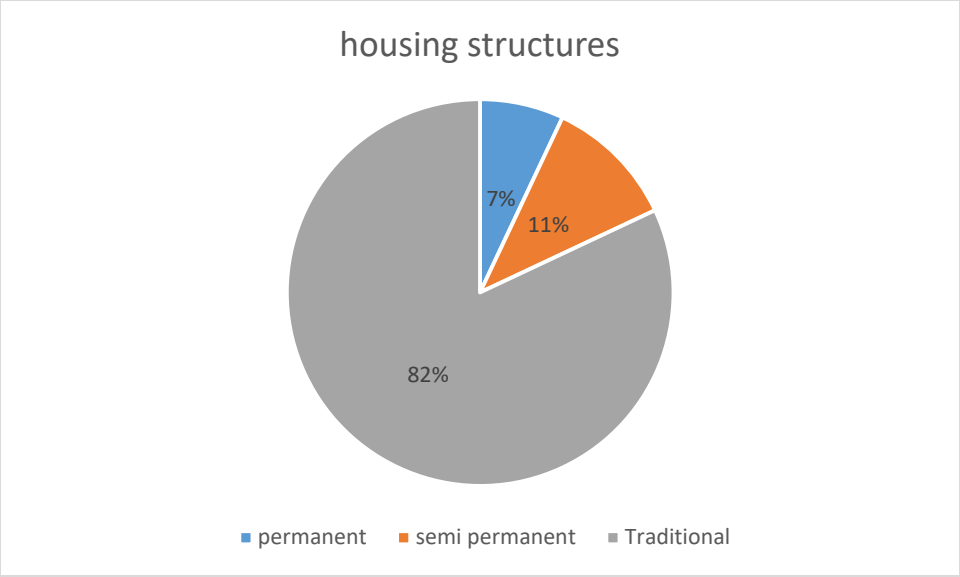


Figure 6. nature of houses in the study area

Different types of houses showed different levels of damage given the same intensity of hazard. Traditional houses experienced more damage than the rest. The state of damage was represented using temporal probability. 2015-2019 rainfall data for Livunzu EPA was used to calculate the return periods of each flood. This was done by ranking the data. Then computation of left and right probabilities were used to calculate the return period. Below are the formulas that were used.

Left probability $P_{left} = \frac{R}{N+1}$ where R= Rank number & N=Number of events

Right probability $P_{right} = (1\text{-}P_{left})$

Estimate return period $RP = \frac{1}{P\ right}$

Equation 2 on how to calculate a return period

The table below shows the calculated return periods and temporal probabilities

Table 2. showing Return periods

24 hours maximum rainfall(SORTED) in mm	YEAR	RANK	LEFT PROB	RIGHT PROB	RP (in years)
204.2	2015	1	0.16666667	0.833333333	1
198.7	2016	2	0.33333333	0.666666667	2
197	2019	3	0.5	0.5	2
118.3	2017	4	0.66666667	0.333333333	3
46	2018	5	0.83333333	0.166666667	6

NB: The return periods are rounded off to the nearest whole number.

Data for flood depth was recorded. The table below shows the average heights in correspondence with the level of damage of each flood event based on housing typology.

Table 3. Flood depth and damage data

	DAMAGE		
water depth (meters)	permanent	semi-permanent	Traditional
0	0	0	0
1	0	0.04	0.1
2	0.1	0.2	0.4
3	0.6	0.8	1
4	0.8	0.9	1
4.5	1	1	1

Figure 8 below shows the results of a vulnerability curve relating the flood hazard intensity with the number of damages it caused on different types of houses.

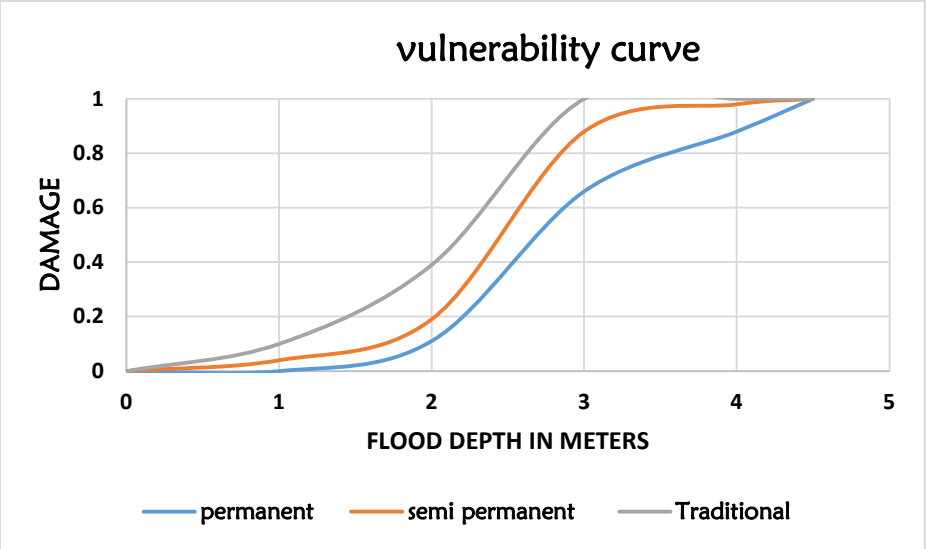


Figure 7 Showing vulnerability curve for house damages states during floods

(b) Agriculture

Despite the positive feedback floods bring in the study area, in this case, the study area's farming activities by depositing nutrients in the soil and provision of water for irrigation practices, flood promotes losses and damages on the agricultural sector of the community. Participants response on the effects includes loss of crop harvests and livestock, damaged farm inputs, facilities/infrastructures, damaged farm supply routes and markets, death and injury of farmers, higher market prices of food, soil erosion and deformed topography of the land. Flood damages were estimated based on floodwater depth, land use, seasonality, flood duration, magnitude, and frequency.76% of the participants admitted that they lose crop harvests every year to floods, 17% said they lose livestock and 7% loses both.

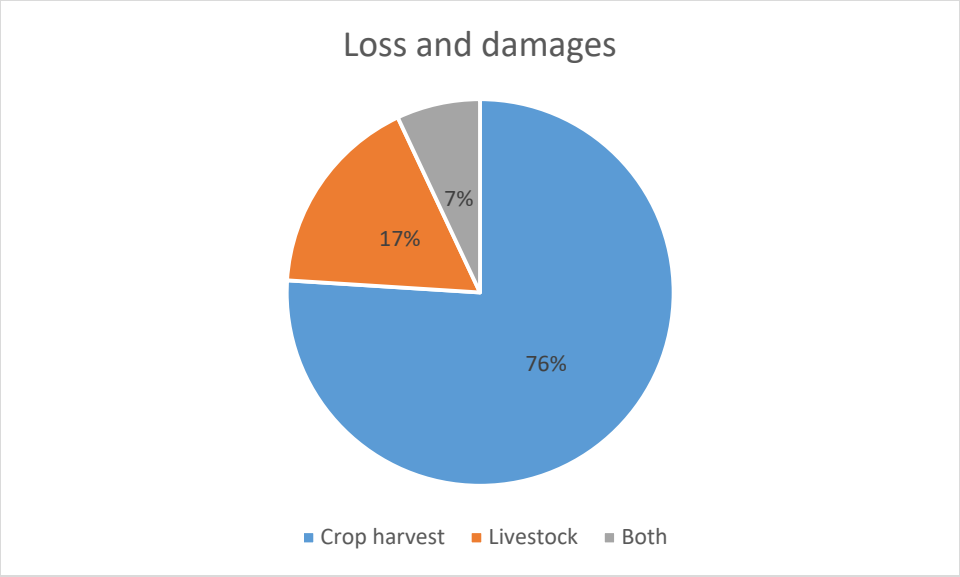


Figure 8. Showing damages and losses in agriculture

4.2.3 key underlying factors of Vulnerability of flood in the Study Area

The research participants indicated that the nature and cause of vulnerability in GVH Malata and Jana are due to the following factors. All the participants indicated that really in this area of study people are more vulnerable to floods. The following were indicated as the most natural and the causes of people vulnerability:

High social dependence on flood-sensitive sectors such as rain-fed agriculture for employment, daily income earnings, and food security. 83% of the participants admitted that they depend on farming for their survival, 8% depend on work,6% on business and 3% require support/ help I.e. persons with disabilities, the elderly, female-headed families, widows, and orphans, etc.

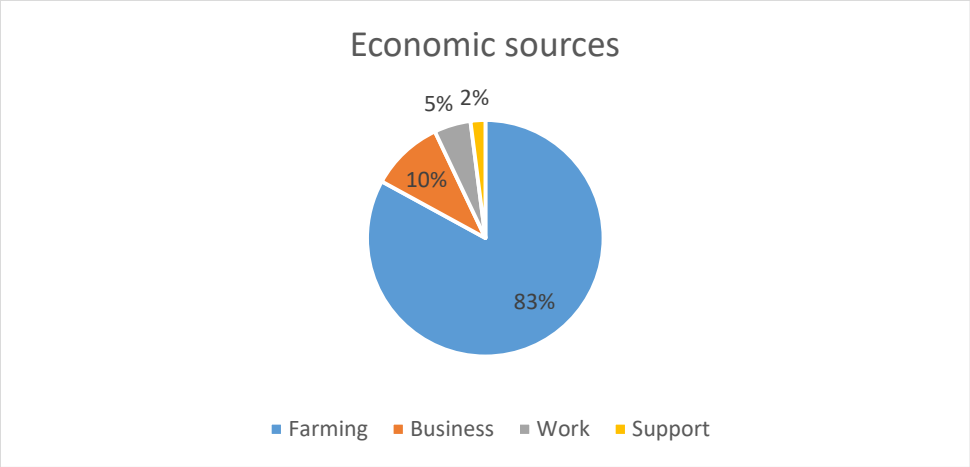


Figure 9.A Pie chart of daily earnings of people in the area.

The second factor is poverty, Low support, and unemployment. For the majority of the population, absolute lack of assets and means of livelihood and precarious economies present one key factor that configures risk to hazards such as floods. Some also said that they don't receive adequate assistance from the government to improve their social wellbeing as citizens of the country that makes them be under the poverty line. some proportion said even if the assistance comes from the government or non-governmental organizations they are not included as beneficiaries. Unemployment levels are high. 89% admitted that poverty levels in the area have influenced the vulnerability of elements at risk in many ways.

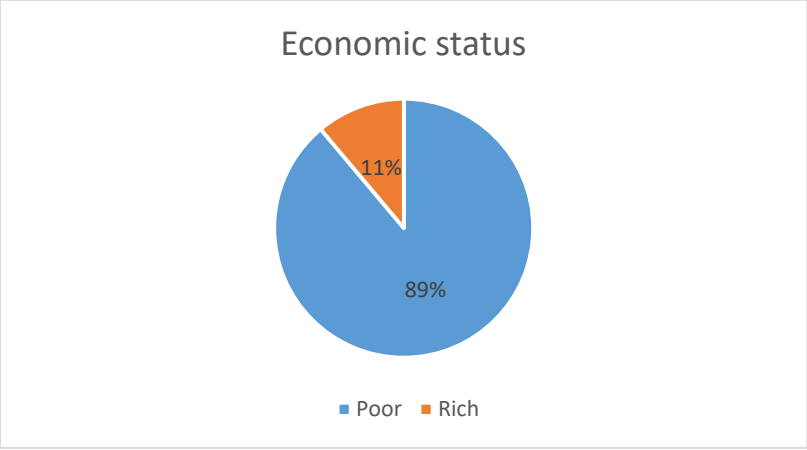


Figure 10. Displaying the economic status of people in the study area

Human settlement is another underlying factor in vulnerability. Housing patterns and designs of the area are not well prepared for the dynamic flood occurrence. Almost 97% of response shows that their houses are built with non-durable materials and with no building codes.

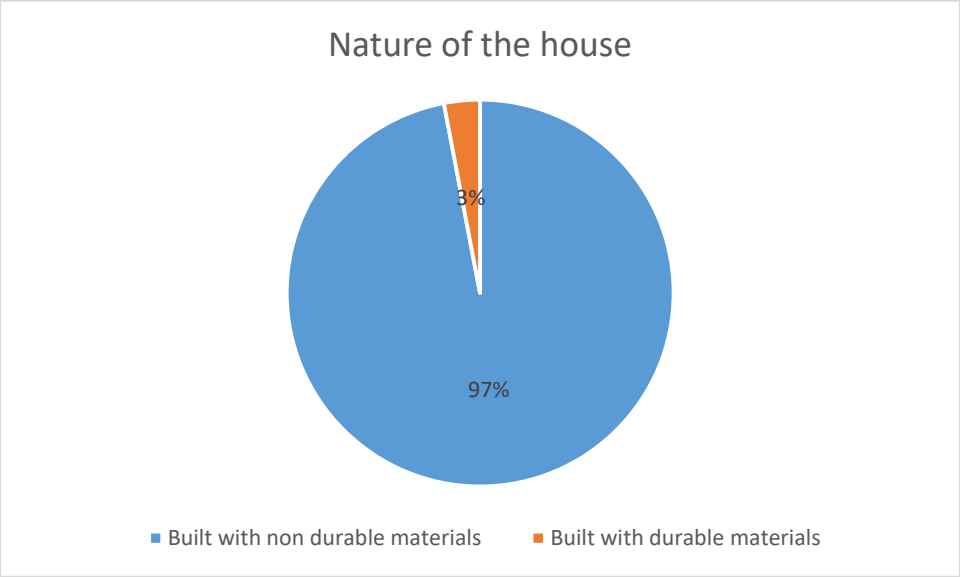


Figure 11. Showing the Nature of houses in the study area

The last factor is Low adaptive capacity of people. This was due to limited access to flood disaster knowledge, availability of Technology, and funding from Government and other stakeholders. The participants admitted that they have low adaptive capacity. 93% admitted that they don't evacuate to prevent floods, 95% showed that they don't prepare for floods, 96% doesn't employ mitigation measures, only 10 respond to the flood event and No one in the area manages to recover from flood event on their own because all their assets are lost in the process.

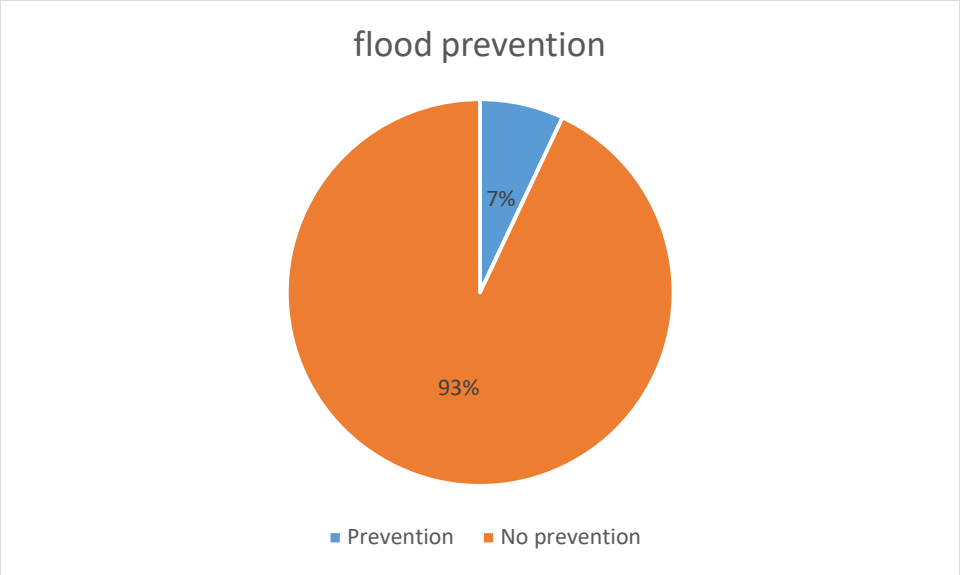


Figure 12. Showing flood prevention rate

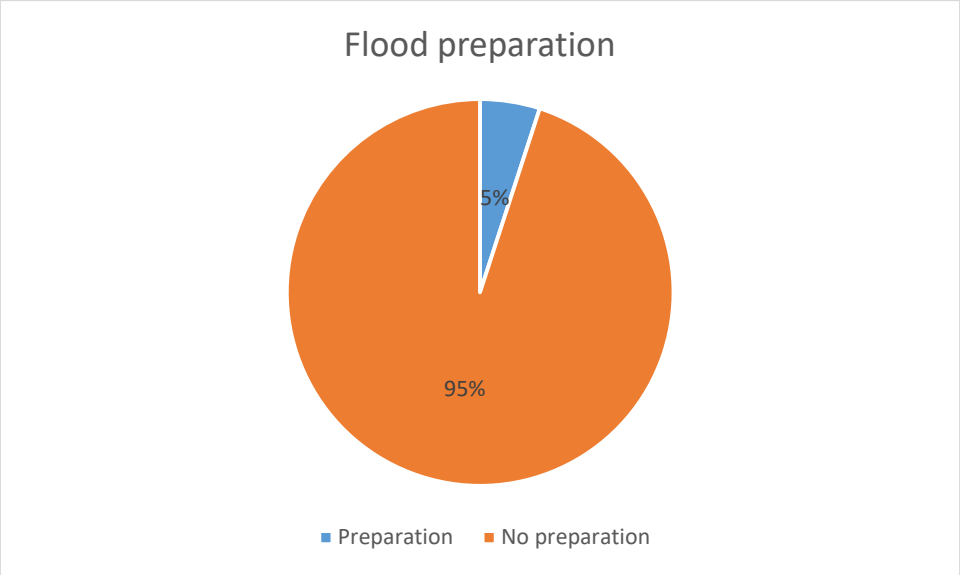


Figure 13: Showing flood preparation rate

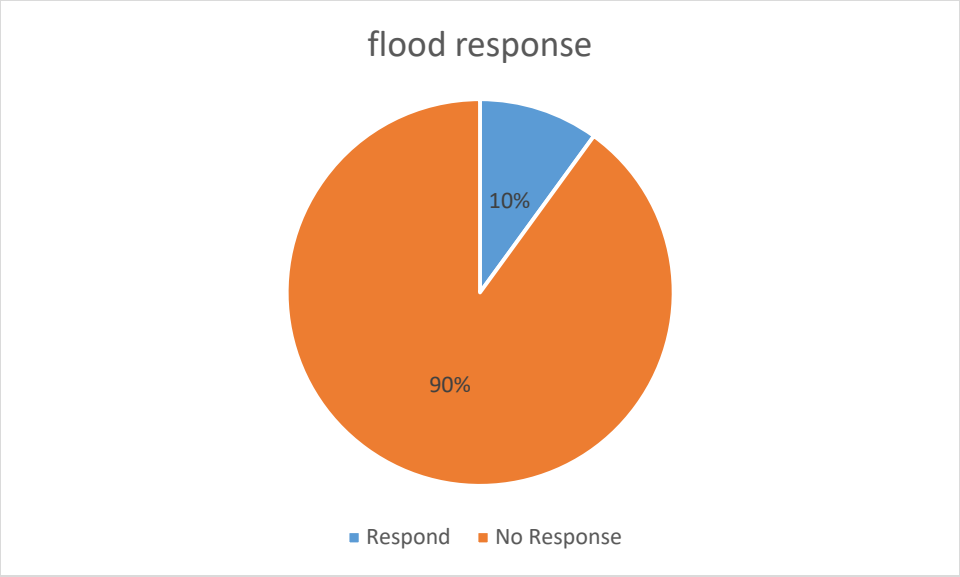


Figure 14. showing the response rate

4.2.4 Comparison of elements at flood risk

Despite that floods affect everyone in the society, the level of damage varies across different elements at risk of people in the society. The figure below illustrates the levels of vulnerability of different groups of people in society.

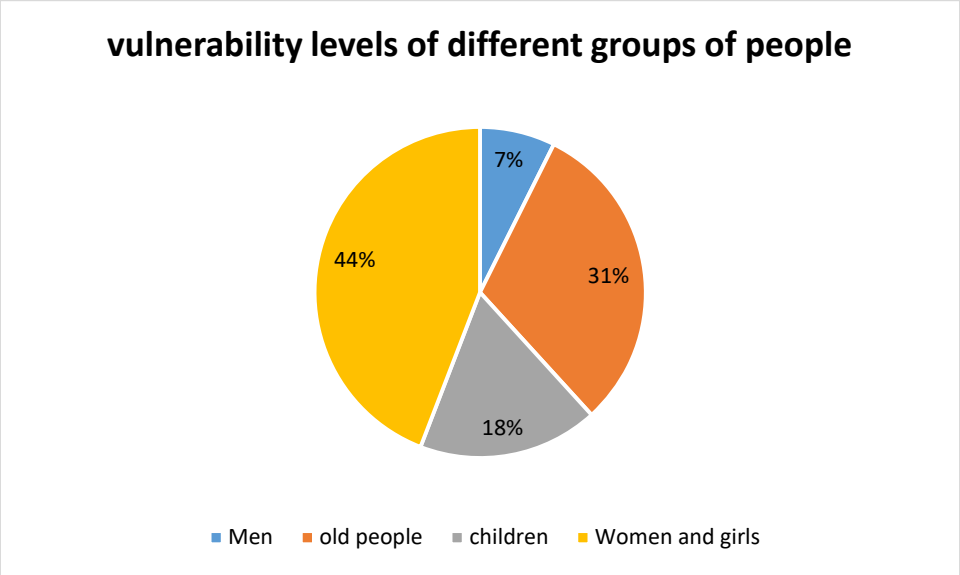


Figure 15 showing levels of vulnerability on different elements at risk of people.

4.2.5 The extent of socio-economic vulnerability in the study area

many participants admitted that the level of their vulnerability is high and its base based on the living conditions of people in the study area. Poor living conditions admitted by participants (94%) is high compared to the good living conditions accessed & enjoyed by few people (6%) in the area.

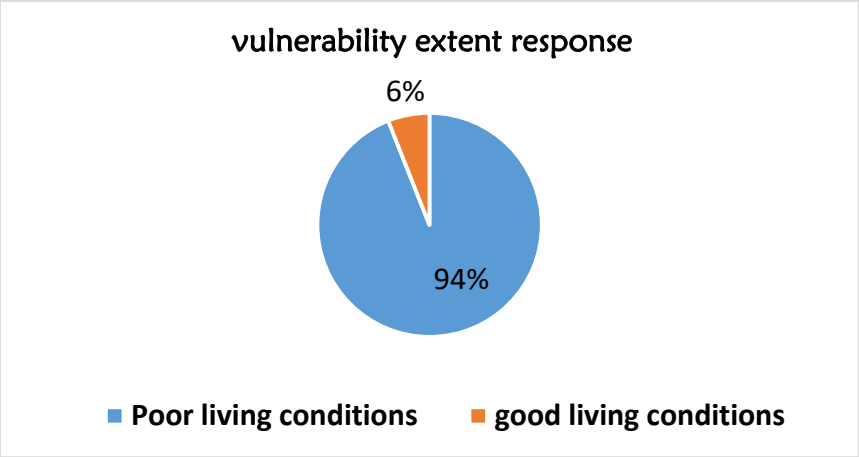


Figure 16. vulnerability extent

4.3 Discussion

The study area is one of the most vulnerable areas of flooding in the Chikwawa district. Every year flood occurred, it exhibited significant impact especially on the livelihood sectors and on people's lives. Most of the people directly depend on the agriculture sector in this area as a source of income. Flood in this area mostly affects the agriculture sector. Most of the respondents of the study said that the agriculture product, as well as livestock, was the most affected during the flood. Housing is also one of the social sectors that have always been affected by flooding events in the study area due to housing characteristics that are prone to the impacts of floods. Furthermore, social groups are vulnerable to floods at a differential scale.

4.3.1 flood impacts on housing and agriculture

(a) Housing sector

Houses were classified as permanent, semi-permanent, and traditional based on nature and housing materials. From the field, the study researcher observed that most of the houses are traditional nature and are either made of substandard, sun-cured clay blocks/ bricks (adobe) or flue-cured clay blocks/bricks. Furthermore, in the study area, people resort to the use of unskilled artisans or use themselves to construct houses. These artisans provide cheap labor, but the quality of their work is often poor. Thus, when floods occur, these poorly constructed houses are particularly susceptible to the impact. Floods also influence house damage due to Flood depth and Flood duration where the occurrence of an event lasts for hours or days due to the continuation of rainfall. The higher the flood depth, the more the houses are susceptible to the damaging impacts of floods.

In addition, flood hazard is also associated with other types of cascading hazards such as high winds or storms, lightning & slope instability which magnifies house damage.



Figure 17 Nature of houses in the area **Source:** Captured by the researcher

(b) Agriculture

Agriculture is the mainstay of the study area's economy. Almost 83% of people directly depend on agriculture for their livelihood. For the majority of the people in the study area, there is hardly any surplus land since the size of the landholding is very small to support the rapid population growth of the area and that gardens and farms are in a separate entity. Farms are located in buffer zones near the shire river and Livunzu river. Very few well-off farmers have switched from domestic to commercial farming as a large area of agricultural land is being swept away or covered by rocks by the flood through river erosion, sedimentation, and inundation. It was seen that mostly the villages along the Livunzu, Mkhathe, Mapelela, and shire rivers are suffering from flooding, inundation, and sedimentation. Four major crops Beans, maize, Rice, and Chitowe are reported to be damaged by the flood. Floods also damaged crop harvests by floods by destroying storage facilities (Nkhokwe). The price rate is higher for the seeds and is mostly procured from outside the locality. The poor farmers are obliged to use the wet seed which results in less germination.

High mortality rates of livestock are reported due to sudden attacks of diseases in pre-and post-flood situations. Also, due to poor food management, it is difficult to keep the livestock healthy and manage their appropriate feed during a flood event. Furthermore, after flooding the poor and landless people of the study area are mostly suffered from a huge amount of loans (Katapila) from different sectors of the livelihoods because farming which provides their earnings have been disrupted by floods. The mental stress increases day by day and the lifestyle also changes after any flood situation.

4.3.2 key underlying factors of Vulnerability of flood in the Study Area

The data collected and analyzed in this research indicates that people in Makhwira are vulnerable due to floods that are always experienced in this area. According to Malawi's fifth integrated survey(IHS5), the Chikwawa district is one of the poorest districts in the country (National Statistical Office, 2020). The majority of poor people in districts do not have access to formal financial services such as loans and credits for

business start-up capital, agricultural inputs, and non-farm items. At the individual, household, community, and national levels, loans and credit are critical to the economy. The percentage distribution of loan sources in the area is largely reliant on village banks and money lenders (Katapila) because it is a quick and convenient way to solve their problems. In this case, most families fail to come out of poverty due to high-interest rates from money lenders, therefore poverty reduction strategies such as cash transfers cannot show observable impact on households. In the same vein, poverty is directly proportional to vulnerability, therefore dependence on money lenders in the area will likely increase poverty hence increased vulnerability to hazards, this means that efforts to address poverty in these districts in a bid to conquer disaster impacts have to be significantly higher to produce better outcomes.

Lack of education is linked to poverty because education empowers the poor, the weak, and the voiceless by providing them with better opportunities to participate in national development. most people are unable to obtain an education as a result of their circumstances. According to IHS5 (2020), the results suggest that individuals living in Chikwawa have a very low literacy rate of 66.9 percent. Furthermore, persons who live in cities have a greater literacy rate (84.4%) than those who live in rural areas (61.9 %). Therefore, People from Chikwawa especially in rural areas of T/A Makhwira cannot reliably, effectively, and sufficiently participate in DRM processes due to relatively low literacy levels. The lower levels of literacy reduce their comprehension of early warning information leading to a reduction inappropriate response behavior. High illiterate levels are a possible factor from which vulnerability to disasters may reproduce rapidly. A high proportion of people who never attended school makes people unable to secure employment, a situation that escalates social-economic drawbacks. Not to mention the evidence also shows that there is a high mean proportion of people who never attended school in Chikwawa (22.3%).

Physical building typology is the relevant dimension that influences differences in vulnerability amongst different populations (Fatemi, 2020). Construction materials

determine the capacity for a house to withstand disaster situations such as floods. Materials used in Malawi are classified into permanent, semi-permanent, and traditional structures. Permanent structures are made of durable roofing materials and strong walling materials. Semi-permanent is similar to permanent, except it lacks at least one element that a permanent structure has and traditional structures lack materials used in permanent structures. On average, Chikwawa (40.6%) has a high proportion of households that account for traditional structures. Permanent structures are most likely to withstand the impacts of disasters such as floods since they are made up of durable materials however traditional structures are usually made up of grass and unburned bricks which are weak and during floods they can easily be disintegrated or washed away by floodwater. Therefore, Chikwawa households face a higher risk of being destroyed in times of floods due to the higher proportion of traditional structures in the areas. This ensures low adaptive capacity for the people to curb floods.

4.3.3 Comparison of elements at risk for flood

Different processes, objects, assets, and people are affected by floods at different levels. Elements at risk-focused in this study were children, women & girls, men, old people, and housing. On the social groups of people, it was found that women and girls are more vulnerable before, during, and after floods than the rest. This is due to women's representation as household heads in the study area. The IHS5 indicated that the orphanhood status is skewed much towards the death of a father than a mother. For instance, it was reported that men's deaths are at a rate of 74.6%. From the orphanhood distribution indicated, it shows that more men die than is the case with women. This implies that widows assume the household head roles. Women are therefore subjected to multiple tasks from nursing the children, household chores to production activities such as farming. Consequently, these women do not have sufficient time to engage in vibrant social-economic activities that reliably aid their vulnerability to disasters. However, women who head households in Chikwawa are more vulnerable to disasters owing to exposure to floods hazards. Additionally, as earlier discussed, Chikwawa has relatively low literacy levels. The low literacy levels

will make women unable to effectively engage in economic activities thus more vulnerable.

Gender-Based Violence is another factor where the majority of women lost their livelihoods and report being at risk of sexual violence and exploitation, particularly women from single-headed families after floods. The risks they were experiencing included attacks when traveling outside their communities to fetch firewood, water, and food, lack of separate washrooms and toilets for males and females in most camps. Camps in the area reported having no washrooms at all with women and girls bathing in the bush, making them more vulnerable to sexual abuse. Due to the shortage of tents, some women and girls reported sleeping in open spaces and fearing being attacked and/or raped.

Old people are also vulnerable to floods because they are weak to support themselves daily, they cannot manage to farm because of the weakness and they experience different diseases now and then. Chronic illnesses that old people suffered Chikwawa 28.3% who are mostly the old people. This implies that those who are ill cannot participate fully in activities that can reduce vulnerability to floods like income-generating activities. The response of chronically ill individuals to floods will be lower compared with those that are not ill.

4.3.4 The extent of socio-economic vulnerability in the study area

The level of vulnerability to floods in the area is high due to poor living conditions experienced by a lot of households. Pressure and Release model and mapping were used to demonstrate the level of socio-economic extent of flooding in the area.

The pressure and Release model shows the elements of the conceptual framework. These have been categorized into those related to vulnerability namely; defining root causes, identification of dynamic pressures, and creation of safe conditions. While Access model shows some of the things which make the victims be able to earn a living before, during, and after the floods. The data collected and analyzed in this research

imply several things. In the first place, it indicates that people in the Makhwira area are vulnerable due to floods that are always experienced in this area. The results emphasized the problems caused by floods in the area. The root causes that give rise to vulnerability (and which reproduce vulnerability over time) are economic, demographic, and political processes which are limited access to loans and credit, inequalities in land ownership and distribution which marginalize women or households headed by females, land topography and dependence on rain-fed agriculture. Those causes have induced pressures in the area such as environmental degradation for farming and settlement, lack of education, poverty levels are rising in the area and the households are not well trained and equipped on how they can support their daily lives including how they can protect themselves to the impact of floods. As such, the community exhibit low-income levels to support themselves, they cannot prepare for disasters and they are exposed to flood risk through their location of the settlement. nearness to Livunzu, Mapelela, Mkhathe, and Shire Rivers and river networks on the entire area has created poor living standards of people to be vulnerable to floods in this study area.

Spatial analyses of the study area carried out include buffer analysis and classification of terrain elevation. Vectored Livunzu river basin was buffered. A 1000 meters' buffer distance was marked on the Livunzu river basin. Progressively, each band was categorized as 200 meters/ band. Below is an illustration of a satellite image from Google earth for the study area captured by the researcher to understand the geospatial component of vulnerability in the study area.



Figure 18. google earth image showing Livunzu river & trading Centre with mang'ando and Jana villages.

The image was later used to classify the use of land in the study area. Landsat image was overlaid with the image to produce a land classification map as shown below. The classification showed that a large percentage of land in the study area is used for farming, unfortunately, it is not sustainable to support the lives and livelihood of the area because the farmland is highly exposed to flood zones (Livunzu river).

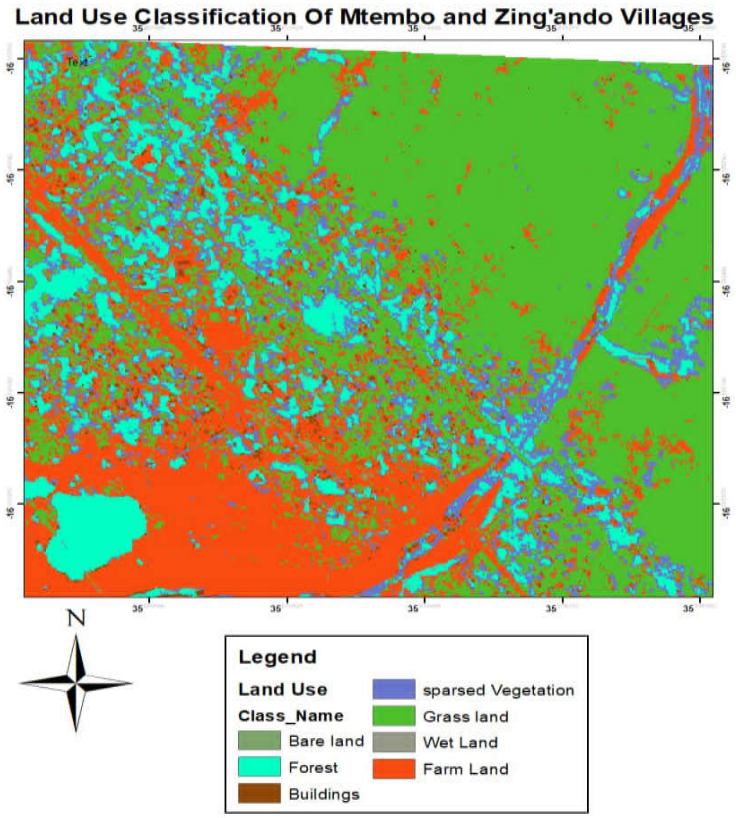


Figure 19. Showing a land classification map of Mtembo and Zing'ando villages

Buffer analysis was performed to determine flood risk extent following proximity to the river channel. It appears that areas such as Group village Malata and Jana near the river network are highly exposed to flood hazards. Areas that are at distance to the river are less exposed to flood hazards. This different buffered layer was overlaid with a digital elevation model using ArcGIS software to produce an exposure map. The flood-prone areas were classified concerning magnitude based on elevation and distance from the river channels and water footprints in the study area. The study area was categorized into zones (highest, high, medium, low, and lowest exposure zones)

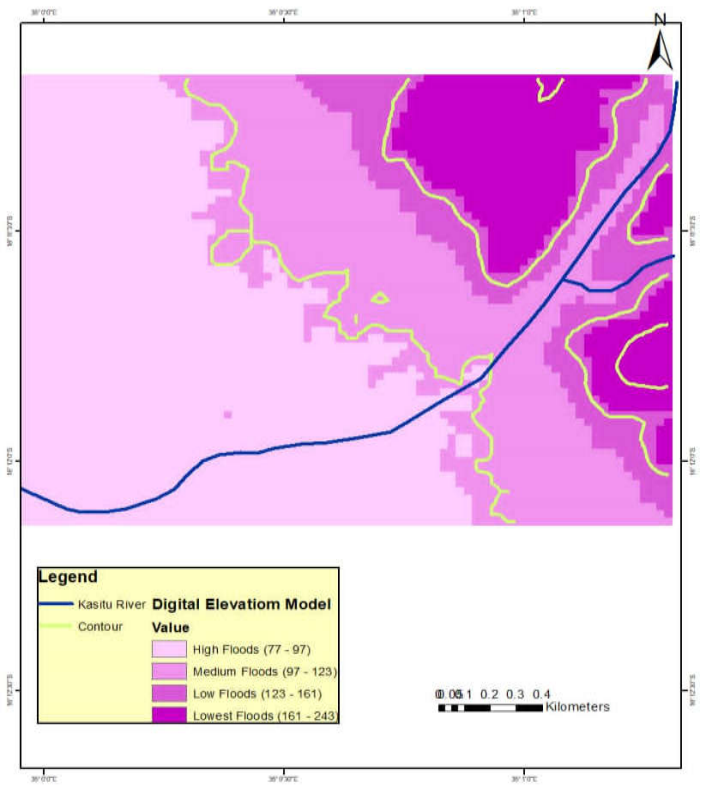


Figure 20. Showing digital elevation model and Livunzu river

Figure 22 shows that the study area is highly exposed to floods. This is as a result of local River channels (Livunzu River) that originate from the hillside flowing downstream towards Livunzu & the surrounding areas. However, when it is huge discharge of water from upstream and the river exceeds its bank at full stage for days, the low and medium exposed areas will become highly susceptible to flood. The map also provides existing risk information for land use planning and accurate development plans for the area hence, it will enable developers and engineers to perform a satisfactory evaluation of costs of flood damages and flood reduction benefits.

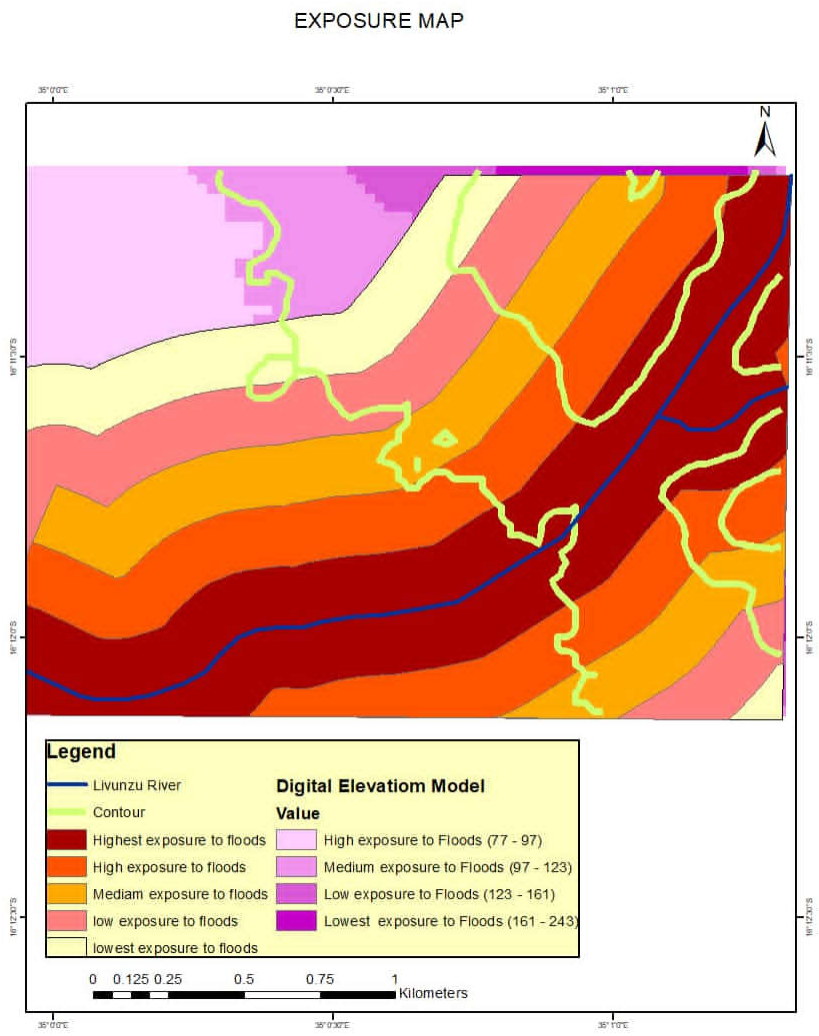


Figure 21. Exposure map of the study area

Lastly, the research findings are put together. This combination will be used to develop and prioritize strategies and investments to reduce the level of socio-economic vulnerability in the study area. The assessment will link enable the local authorities' hazard mitigation plan and to establish a baseline of information for planning and for evaluating the success of plans or strategies to reduce vulnerability.

5. CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The study has investigated socio-economic vulnerability to floods in Traditional Authority Makhwira in Chikwawa District using a survey, IHS5 & GIS. The study delineated the areas at flood risk, induced the level of damage it has on housing and rain-fed agriculture, classified the vulnerable areas, and pointed out the socio-economic factors which increase the population vulnerability in the study area.

Analysis has shown that people and resources are vulnerable to floods due to high poverty levels, poor settlements, high exposure to river networks, and low adaptive capacities such as lack of preparedness, uncoordinated planning during mitigation implementation, and lack of build back better in the recovery phase of a post-flood disaster. On a large scale, enhancing the use of indigenous measures and flood evacuation would be some immediate ways of reducing the levels of vulnerability among people in this area. Hence it requires commitment from all stakeholders to engage in all levels of flood risk management. There is a need for an effective long-term capacity-building program for the people in the area to build resilience against floods. People need education and warnings about flood hazards and disasters. The people should be trained and empowered with disaster management skills such as training local artisans on how to build strong houses so that they can contribute reduce flood impact in this area.

5.2 Recommendation

This study recommends that the government through its local authority, in this case, the Chikwawa district council should consider establishing a framework of assessing the social and economic vulnerability of people in the area to floods every year because of flood events that have been experienced in the area are increasing (dynamic) in magnitude and severity with time. There is a need for constant flood stage monitoring and continual vulnerability mapping by the local authority complemented by relevant agencies especially during November to February when there is a high probability of flooding.

It should also come out clear to the government and all stakeholders that DRM measures and strategies that are top-bottom, that are not in correlation with people's needs, and that are mostly based on outdated policies and frameworks do increase people's vulnerability.

All the communities that are located at the banks and within the buffer distance of 400 meters of Livunzu River and its major tributaries which are prone to floods should be urgently relocated while enacting legislation that would ban new development in floodplains of Makhwira.

Further studies should be carried out in different local authorities because vulnerability does not have the same dimensions in every area.

REFERENCES

Affairs, D. M. (n.d.). Disaster Risk Management Handbook Republic of Malawi Department of Disaster Management Affairs.

Brouwer, R., Admiraal, A., Dusseldorp, K., Bui, T., & Tran, T. H. (2010). Measuring and explaining socio-economic vulnerability to disaster flooding in Vietnam. July 2015, 1–37.

Chikwawa_District_Floods_report_11th_March. (n.d.).

H--proc_notices-notices_020_k-notice_doc_16174_131110003. (n.d.).

Balica, S.T., 2012, *applying the flood vulnerability index as a knowledge base for food risk assessment*, UNESCO-IHE, Institute for Water Education, Delft, Netherlands.

Balica, S.F., Popescu, I., Beevers, L. & Wright, N.G., 2012, *Parametric and physically-based modeling techniques for flood risk and vulnerability assessment: A comparison*, UNESCO-IHE, Institute for Water Education, Delft, Netherlands.

Cardona, O., 2003, a need for rethinking the concept of vulnerability and risk from a holistic perspective: A necessary review and criticism for effective risk management, viewed 08 November 2014, from http://www.desenredando.org/public/articulos/2003/nrcvrfhp/nrcvrfhp_ago-042003.pdf.

Dilley, M., Chen, R.S., Deichmann, U., Lerner-Lam, A.L., Arnold, M., Agwe, J. et al., 2005, *Natural disasters hotspots: A global risk analysis*, Synthesis report, The World Bank, Hazard Management Unit, Washington, DC.

Galderisi, A., Ceudech, A. & Pistucci, M., 2005, 'Integrated vulnerability assessment: The relevance "to" and "of" urban planning, in Proceedings (CD format) of the first

ARMONIA Project Conference 'Multi-hazards: Challenges for risk assessment, mapping, and management, Barcelona, Spain, 05-06 December 2005, pp. 5-6.

Grosshans, R., Venema, H. & Barg, S., 2005, Geographical analysis of cumulative threats to prairie water resources: Mapping water availability, water quality, and water use stresses, p. 40, International Institute for Sustainable Development, Winnipeg.

Hazarika, N., Barman, D., Das, A. K., Sarma, A. K., & Borah, S. B. (2018). Assessing and mapping flood hazard, vulnerability, and risk in the Upper Brahmaputra River valley using stakeholders ' knowledge and multicriteria evaluation (MCE). 11, 700–716. https://doi.org/10.1111/jfr3.12237

Jean-Baptiste, N., Kuhlicke, C., Kunath, A. & Kabisch, S., 2011, 'Review and evaluation of existing vulnerability indicators to obtain an appropriate set of indicators for assessing climate-related vulnerability, *CLUVA Deliverable D, 2*, p. 11, Helmholtz Centre for Environmental Research - UFZ, Munich.

Jelmer, V., 2013, Flood vulnerability assessment on a commune level in Vietnam, University of Twente, Enschede.

Judy, W.L., Tegg, S., Reisinger, A. & Quade, D., 2011, *Vulnerability and adaptation to increased flood risk with climate change*, Hutt Valley report 02, The New Zealand Climate Change Research Institute, Victoria University, Wellington.

Karmakar, S., Simonovic, S.P., Peck, A. & Black, J., 2010, 'An information system for risk-vulnerability assessment to flood', *Journal of Geographic Information Systems* 2(3), 129.

Kumar, S., & Ph, P. (2014). Vulnerability Concepts and their Application in Various Fields : A Review on Geographical Perspective VULNERABILITY CONCEPTS AND ITS

APPLICATION IN VARIOUS FIELDS : A REVIEW ON GEOGRAPHICAL PERSPECTIVE. May 2013. https://doi.org/10.3329/jles.v8i0.20150

Nethengwe, N.S., 2007, 'Integrating participatory GIS and political ecology to study flood vulnerability in the Limpopo Province of South Africa', Ph.D. thesis, West Virginia University, Department of Geology and Geography, Morgantown.

Ngie, A., 2012, A GIS approach for flood vulnerability and adaptation analysis in Diepsloot, University of Johannesburg, Johannesburg.

Kumar, S., & Ph, P. (2014). Vulnerability Concepts and its Application in Various Fields: A review on geographical perspective vulnerability concepts and its application in various fields: A review on geographical perspective. May 2013. Https://doi.org/10.3329/jles.v8i0.20150

Lec 7 vulnerability assessment. (n.d.).

Ludeña, C. E., Yoon, S. W., Sanchez-Aragon, L., Miller, S. J., & Yu, B.-K. (2015). Vulnerability indicators of adaptation to climate change and policy implications for investment projects. Inter-American Development Bank, Technical Note No. 858. 858(October), 49.

Malawi Government. (2015). Malawi 2015 Floods Post Disaster Needs Assessment Report Malawi 2015 Floods. 1–111.

Mtembenuzeni, j., & kushe, j. (2018). *Theory and practice of vulnerability to disasters in flood-prone areas in Chikwawa, Malawi*. *6*(3), 137–146. Https://doi.org/10.13189/eer.2018.060301

Mwape, y. P. (2009). An impact of floods on the socio-economic livelihoods of people: A case study of sikaunzwe community in kazungula district of Zambia university supervisor: Mr. Andries Jordaan.

Njala, c. D. (2019). Flood overlay mapping using satellite images and gis tools: Case study Nsanje. The pressure and release model. (n.d.).

(PDF) The Concept of Vulnerability and Resilience. (n.d.).

Office, N. S. (2019a). *Main Report. May*.

Office, N. S. (2019b). MALAWI POPULATION AND HOUSING CENSUS REPORT-2018 2018 Malawi Population and Housing Main Report. May.

Thesis, B. (n.d.). *No Title*.

Wisner, b., Blaikie, p., cannon, t., & Davis, I. (2014). At risk: Natural hazards, people's vulnerability, and disasters. *At-risk: Natural hazards people's vulnerability and disasters*, 1–471. Https://doi.org/10.4324/9780203714775

(PDF) The Concept of Vulnerability and Resilience. (n.d.).

Affairs, D. M. (2013). *Disaster Risk Management Handbook Republic of Malawi Department of Disaster Management Affairs. 1*.

Hazarika, N., Barman, D., Das, A. K., Sarma, A. K., & Borah, S. B. (2018). *Assessing and mapping flood hazard, vulnerability, and risk in the Upper Brahmaputra River valley using stakeholders ' knowledge and multicriteria evaluation (MCE). 11*, 700–716. https://doi.org/10.1111/jfr3.12237

Heylin, M. (1986). Disaster. *Chemical & Engineering News*, *64*(5), 3. https://doi.org/10.4324/9781351138444-36

Inozemtsev, I., & Lopes, C. (2017). *Flood risk mapping and an evacuation route planning: the case of Zomba, Malawi*.

Kumar, S., & Ph, P. (2014). *Vulnerability Concepts and their Application in Various Fields : A Review on Geographical Perspective VULNERABILITY CONCEPTS AND ITS APPLICATION IN VARIOUS FIELDS : A REVIEW ON GEOGRAPHICAL PERSPECTIVE. May 2013*. https://doi.org/10.3329/jles.v8i0.20150

Ludeña, C. E., Yoon, S. W., Sanchez-Aragon, L., Miller, S. J., & Yu, B.-K. (2015). *Vulnerability indicators of adaptation to climate change and policy implications for investment projects. Inter-American Development Bank, Technical Note No. 858. 858*(October), 49.

Malawi Government. (1991). *THE DISASTER PREPAREDNESS AND RELIEF ACT, 1991 MALAWI GOVERNMENT. 1*.

Mtembenuzeni, J., & Kushe, J. (2018). Theory and Practice of Vulnerability to

Disasters in Flood Prone Areas in Chikwawa, Malawi. *Environment and Ecology Research*, *6*(3), 137–146. https://doi.org/10.13189/eer.2018.060301

National Statistical Office. (2020). *The Fifth Integrated Household Survey (IHS5) 2020 Report. November*.

Niang, I., Ruppel, O. C., Abdrabo, M. A., Essel, A., Lennard, C., Padgham, J., & Urquhart, P. (2015). Africa. *Climate Change 2014: Impacts, Adaptation, and Vulnerability: Part B: Regional Aspects: Working Group II Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, 1199–1266. https://doi.org/10.1017/CBO9781107415386.002

Office, N. S. (2006). Main report. In *Genetics in Medicine* (Vol. 8, Issue 5 SUPPL. 1). https://doi.org/10.1097/01.gim.0000223467.60151.02

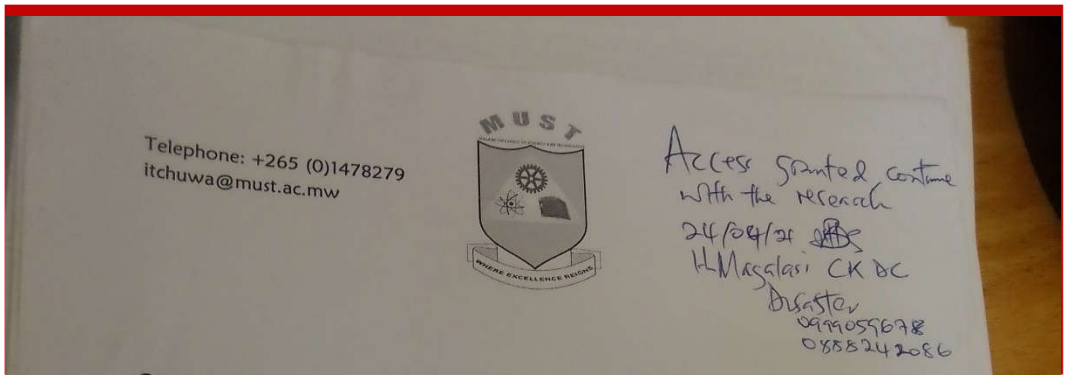
Office, N. S. (2019). *MALAWI POPULATION AND HOUSING CENSUS REPORT-2018 2018 Malawi Population and Housing Main Report. May*. http://www.nsomalawi.mw/images/stories/data_on_line/demography/census_2018/2018 Malawi Population and Housing Census Main Report.pdf

Thesis, B. (n.d.). *No Title*.

Wisner, B., Blaikie, P., Cannon, T., & Davis, I. (2014). At risk: natural hazards, peoples vulnerability, and disasters. *At-Risk: Natural Hazards Peoples Vulnerability and Disasters*, 1–471. https://doi.org/10.4324/9780203714775

APPENDICES

Appendix 1: shows Access approval by Chikwawa Relief & Rehabilitation officer (DRM officer)



Appendix 2: shows the nature of houses in the study area.

