

An assessment of community flood vulnerability and adaptation:
A case study of Greater Tzaneen Local Municipality, South Africa

by

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in fulfilment of the requirements for the degree of Masters of Environmental Science
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DECLARATION

I, **Munyai Rendani Bigboy**, hereby declare that this dissertation submitted to the department of Geography and Geo-Information Sciences for the award of Masters in Environmental Sciences at the University of Venda, has not been previously submitted for a degree at this or any other institution. This is my own work in design and execution, and all reference materials contained herein have been fully acknowledged.

Signature.....Date.....

DEDICATION

To my guardian Tshilidzi Robert Mudau.

ACKNOWLEDGEMENTS

I thank the LORD God Almighty for being my guide and giving me sufficient strength and good health to complete my study. He is the supporter and my daily inspiration. All honour and glory to Him, the LORD is my banner indeed.

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ABSTRACT

The Limpopo lowveld is at risk of floods from tropical storms from the South West Indian Ocean. The flood risk is particularly high in low altitude areas with poor infrastructure and limited resources. This study assessed flood vulnerability and adaptation at Lenyenye, Ga-Kgapane Masakaneng and Nkowankowa Section B and C within the Mopani District in the Limpopo Province of South Africa. The research objectives were to establish the determinants of flood vulnerability, assess the levels of flood vulnerability and the community's coping strategies.

A quantitative survey approach was employed using questionnaires which were administered to affected households to identify determinants of flood vulnerability, indicators and coping strategies by communities. A qualitative survey was also undertaken to supplement the information obtained from the quantitative survey. Key informant interviews were conducted with disaster management authorities in the study area to provide information on indicators, flood experience, adaptation and mitigation measures. Field observations were undertaken to observe the physical landscape and flood impacts. Secondary data were acquired through records, maps, Census 2011 and from the South African Weather Service. Collected data were imputed into the flood vulnerability index to measure the level of flood vulnerability. The results of this study will contribute to flood disaster risk reduction in the lowveld.

The results indicate that flood vulnerability in the study areas is determined by dwelling quality, poor or lack of drainage, education levels, employment status, rainfall amount and topography. The calculated flood vulnerability levels in the three case study villages indicate that Ga-Kgapane Masakaneng, Lenyenye and Nkowankowa Section B and C have a 'vulnerability to floods' level. However, the FVI also showed that the economic aspect scored a high vulnerability to floods in Ga-Kgapane. In Nkowankowa Section B and C; physical component obtained a 'high vulnerability to floods.' Major coping strategies in the three case villages were: making 'Le-guba' around houses; sand-bags; making a furrow and channel around houses and on roads; temporary relocation and lastly relocating to a safer area. Key recommendations are public awareness; integrating modern mitigations with local knowledge; development of programs to ensure resilience through incorporation of (Integrated Development Planning) IDP and flood management and flood early warning system.

Key words: Vulnerability, Exposure, flood Susceptibility, flood vulnerability index, Resilience and Adaptation.

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LIST OF ACRONYMS

DMC	: Disaster Management Centre
NDMC	: National Disaster Management Centre
DMA	: Disaster Management Act:
EM-DAT	: Emergency Events Database
FVI	: Flood Vulnerability Index
GDP	: Gross Domestic Products
GIS	: Geographical information System
GPCC	: Global Precipitation Climatology Centre
IDP	: Integrated Development Planning
IPCC	: Intergovernmental Panel on Climate Change
ITCZ	: Intratropical Convergence Zone
MDDMC	: Mopani District Disaster Management Centre
NDMC	: National Disaster Management Centre
RDP	: Reconstruction and Development Programme
RSA	: Republic of South Africa
RDMS	: Rural called Disaster Mitigation Service
SALGA	: South African Local Government Association
SASSA	: South African Social Security Agency
SPSS	: Statistical Package for the Social Sciences
UN/ISDR	: United Nation/International Strategy for Disaster Reduction

CHAPTER 1: INTRODUCTION

1.1. Background

This study assesses flood vulnerability and adaptation; determinants of flood vulnerability, levels of vulnerability to floods and community coping strategies. Floods result from excessive run-off or rise in water level in a particular area which is more than what a particular environment can contain (NDMC, 2015). “Floods are one of the most common and widely distributed natural risks to life and property”, (Balica, 2012: 153). The worst part is that rainfall is among the key causes of floods and it cannot be prevented due to its natural occurrence.

The damages that are due to floods can be reduced and prevented by structural measures such as dams and dikes, while non-structural measures include early warnings system and education (Veenstra, 2013: 1). Various communities around the globe are experiencing increases in the frequency of floods. The increases have led to the destruction of the physical environment and loss of human lives. Flood damage is expected to become a catastrophic event because of changes in the global climate due to global climate warming. These changes will exacerbate high probability of extreme weather conditions of droughts and floods. According to the Intergovernmental Panel on Climate Change (IPCC, 2007) projections, floods and droughts have become some of the worst threats to the human race around the world. Serious attention is needed to adapt, prevent, mitigate, respond and reduce flood impacts on the socio-economic and physical environment.

The number of people at risk has been growing each year and the majority reside in developing countries with high poverty levels, making them more vulnerable to natural disasters (UN/ISDR, 2006). This is because developing countries are experiencing scarcity of resources resulting in poor reduction, adaptation and response to flood hazards. However, this does not mean that developed countries are excluded from the risk and vulnerability to floods. It is important to consider that vulnerability and adaptation are contextual and should not be generalized. If these two components of flood vulnerability are generalized, the result might be uncertain. Individuals and communities are exposed differently. They are vulnerable to floods because of socio-economic factors such as wealth, education, race, ethnicity, religion, gender, age, class, disability, and health status (Cardona et al., 2012). Flood vulnerability and adaptations are firmly rooted within the context of the natural environment and the specific socio-economic factors of a particular area (Munyai, 2015: 9).

Zuma et al. (2012) noted that the annual risk of flooding in South Africa is 83.3% and the level of vulnerability is high due to socio-economic factors and geographical location. The geographical location of South Africa is composed of two major regions; the interior plateau and the narrow coastal belt (Le Roux and Van Huyssteen, 2010).

According to the UN/ISDR (2011), 77 flood disaster events were recorded between 1980 and 2010 in the Eastern Cape, KwaZulu-Natal, North-West and Limpopo Provinces of South Africa. This study revealed that floods are one of the most experienced natural hazards affecting both rural and urban communities in South Africa. The greatest concern is their socio-economic impacts. The socio-economic standard of South African people exacerbates susceptibility to floods, even though a small amount of rain falls annually. Flood prone areas should be identified to improve management of floods and flooding from high level planning proposal to informed design (Balica, 2012).

There are different types of floods; coastal, river, flash and urban floods (Balica, 2012:13 and MunichRe, 2007) which are caused by different mechanisms. Therefore, their impacts, frequency, magnitude and occurrence locations may vary. However, the occurrence of flash floods is ubiquitous. In this study; river, flash and urban floods were considered because of the location and characteristics of the study area.

River floods are floods that occur along river valleys, and these are natural events. The magnitude of the river flood waters depends on the season. Some floods occur seasonally with summer or winter rainfall (NDMC, 2015). Tropical cyclones also contribute to river floods. River floods do not occur abruptly but build up gradually – although sometimes in a short time (Balica, 2007: 14). Though floods are naturally occurring phenomena along the rivers, they pose indirect threats to riverine communities such as spreading of diseases.

According to Balica (2012: 3), flash floods are sudden temporary inundations of various scales and are often destructive. They occur in a very short time approximately six hours with the excessive amount of rainfall. Soil is normally saturated because the magnitude of the rainfall is greater than the rate of infiltration, resulting in surface run off. Flash floods are normally caused by thunderstorms, intense rainfall and tropical cyclones in a small area. Flash floods are one of the most hazardous floods. They cause huge damages and destroy human lives. Unfortunately, they occur with limited time for advanced warning and they carry a large volume of fast-flowing water (Munyai, 2015: 2).

1.1. Problem statement

Floods are among the most devastating natural disasters and cost many lives every year (Dilley et al., 2005). There is a remarkable rise in the frequency of floods in South Africa. This has resulted in loss of human lives, damage to properties and infrastructure and environmental degradation. Communities that have been seriously exposed are those who dwell in lowveld areas, close proximity to rivers and high rainfall susceptible areas in South Africa. Low socio-economic standards have also exacerbated susceptibility of many local communities in rural areas.

Floods due to tropical cyclone Eline in 2000, tropical storms in 2011, 2013 and 2014 raised various concerns with regard to floods and vulnerability in South Africa. Several studies have tackled floods from various angles to find a clear understanding of the problem. Flood studies have been conducted from different fields in South Africa; but a paucity of assessment of vulnerability of flood hazards remains. Many local communities have been declared vulnerable to floods but little is known about the extent of their vulnerability. Therefore this study assesses the extent of flood vulnerability and adaptation in Nkowankowa Section B and C, Lenyenye and Ga-Kgapane Masakaneng in the Mopani District Municipality of Limpopo Province, South Africa which have been affected by the flood hazard repeatedly in recent years.

1.2. Objectives

1.2.1. Research Aim

The aim of this study is to assess flood vulnerability and adaptation in Nkowankowa Section B and C, Lenyenye and Ga-Kgapane Masakaneng in the Mopani District Municipality of Limpopo Province, South Africa.

1.2.2. Specific Objectives

The specific objectives of this study are to:

- To assess the contextual factors that determine flood vulnerability.
- To assess the level of flood vulnerability among the community households.
- To evaluate the communities and institutional flood coping strategies.

1.2.3. Research Questions

- What contextual factors determine flood vulnerability and their related weighting by affected households?
- To what extent are Nkowankowa Section B and C, Lenyenye and Ga-Kgapane Masakaneng-vulnerable to floods?
- How do local communities and government structures cope with the flood hazards in Nkowankowa Section B and C, Lenyenye and Ga-Kgapane Masakaneng?

1.3. The study area

This study was conducted in Greater Tzaneen Local Municipality in South Africa's Limpopo Province (Figure 1.1) where communities are vulnerable to various natural disasters including floods (Mopani District Disaster Management Centre, 2015). The proximity of the area to the South Indian Ocean makes it vulnerable to landfalling tropical cyclones. The study focused on communities in Nkowankowa Section B and C, Lenyenye and Ga-Kgapane Masakaneng (Figure 1.2).

These are some of the lowveld areas in the Municipality of the Greater Tzaneen and were selected because of recurrence floods events that occurred from 2011 to 2014. Nkowankowa Section B and C cover an area of 10.23 km² on generally flat terrain with a total population of 11 242 (1 098.92 per km²) whilst the total households' number is 1 860 (Statistic South Africa, 2011). Lenyenye has a total population of 8 099 and the total area covered is 8.81 km² (919.30 per km²) with 980 households. Ga-kgapane Masakaneng village covers an area of 4.83 km² with a population of 5 879, 706 households and a population density of 1217.81 per km².



Figure 1.1: A map showing the location of the study area (Mopani District) within South Africa and the southern Africa region. The South Indian Ocean is a basin conducive for tropical cyclone genesis during the austral summer.

Mopani District Municipality

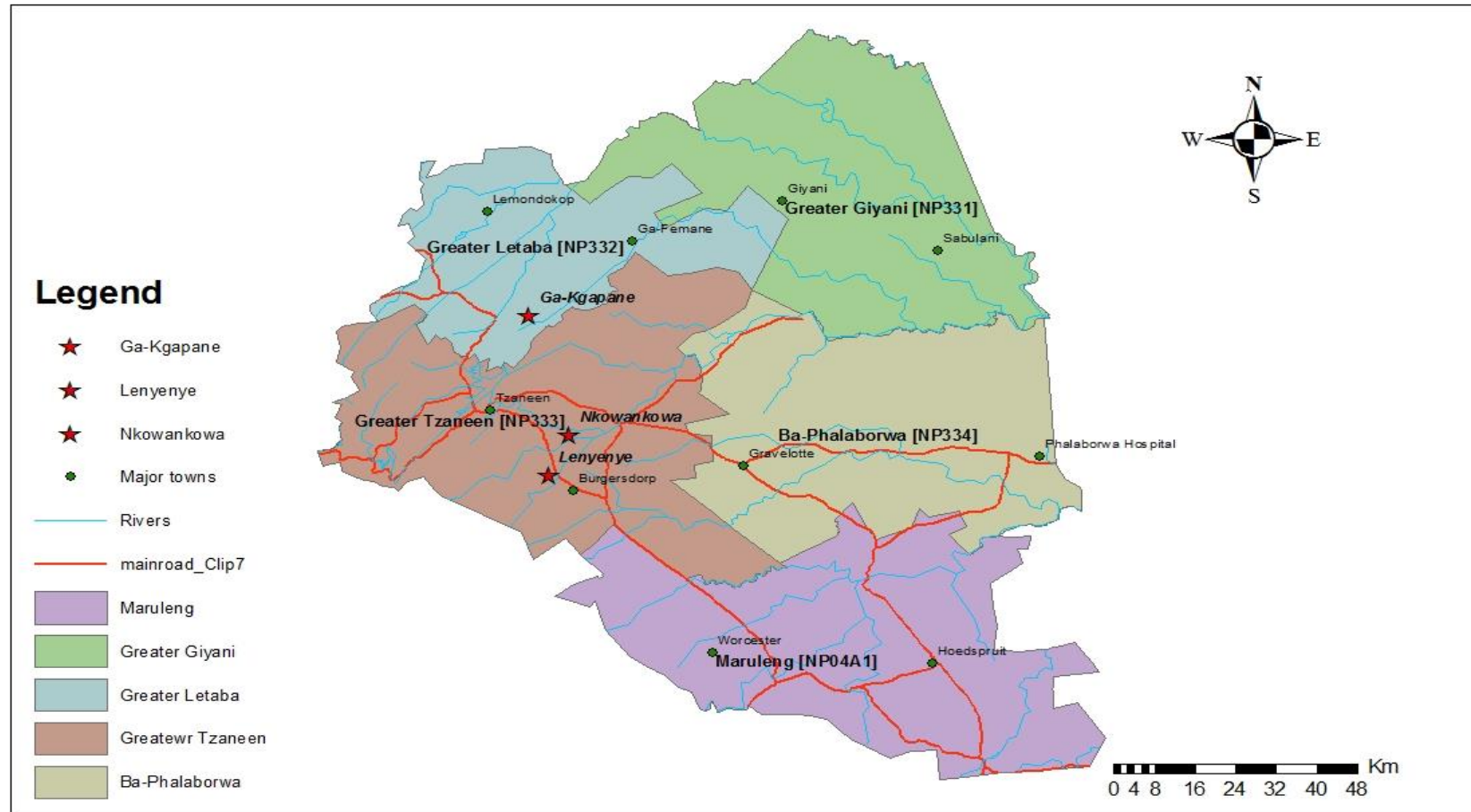


Figure 1.2: The study area (Nkowankowa, Lenyenye and Ga-Kgapane). The rainfall station at Tzaneen was used to analyse rainfall variability in the area.

1.4. Justification of the study

Vulnerability is dynamic, scale-dependent, site-specific and multi-dimensional (UN/ISDR, 2011). Therefore, there is a need for flood vulnerability assessment in every specific area. This is because the economic, social, environmental and physical components of flood vulnerability and adaptation are very contextual and operate within the context of specific socio-economic and the physical environments. The socio-economic and physical environment components were integrated in this study.

Vulnerability studies are conducted at all levels; global, continental, national, provincial and local. The larger the scale, the smaller the accuracy of vulnerability index results (Munyai, 2015). This study assesses flood vulnerability from a local context with the aim to improve local decision making processes by selecting action plans to reduce vulnerability at local level (Balica, 2007). Policy-makers and local planners are provided with detailed information from vulnerability assessment. The assessment of flood vulnerability in these local areas will help local planners, community leaders, municipal managers and different stakeholders to manage flood hazards and vulnerability. This will enhance their planning and decision making processes. The application of Flood Vulnerability Index reference tool will enhance necessary coping strategies for the levels of flood vulnerability.

1.5. Definitions of key terms

Vulnerability is the degree to which a system is susceptible to and unable to cope with diverse effects of climate change (Intergovernmental Panel on Climate Change (IPCC), 2007).

Flood susceptibility is the probability of negative consequences of flood into the environment and social factors (Samuels et al., 2009).

Exposure is the state and change in external stresses that a system is exposed to (Lawrence et al., 2011).

Sensitivity is the degree to which a system is affected, adversely or beneficially, by a given exposure (IPCC, 2007).

Resilience is adaptation capacity of each community to changes in hazardous area by modifying itself to achieve an acceptable structural and functional level (Galderisi, 2005).

Flood Vulnerability Index is the statistical methodology of assessing floods based on main three factors such as exposure, susceptibility and resilience using the following (Balica, 2012).

[FVI= ES/R]

E-exposure, S-susceptibility and R-resilience

Adaptation is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2007).

1.6. Organization of the dissertation

This dissertation consists of six chapters. Chapter 1 has introduced this study and provided a background of flood vulnerability and adaptation, problem statement, aim and objectives of the study, delimitation, study area description and justification. Chapter 2 deals with a thorough review of the literature on floods vulnerability and adaptation. Sampling techniques, data collection and methods of analysis are explained in detail in Chapter 3. The results are presented, analysed and interpreted in Chapter 4. Chapter 5 entails the discussion of the key findings, whilst key recommendations and conclusions are provided in Chapter 6.

CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

The main aim of this chapter is to review related literature on flood vulnerability and adaptations from a global perspective and within the South African context. The majority of definitions of vulnerability are within the context of a failure of an exposed system to adapt and cope with a hazard. Therefore, the inability of any system to resist hazards increases the vulnerability, while resilience limits the vulnerability. The capacity of adapting and survival cannot be omitted since resilience is one of the very significant factors that reduce or limit vulnerability. Flood vulnerability can be expressed in terms of functional relationships between expected damages regarding all elements at risk and the susceptibility and exposure characteristics of the affected system, referring to the whole range of possible flood hazards (Scheuer et al., 2010: 3).

There are three factors of vulnerability and they are expressed within the context of flood vulnerability in this study. These are exposure, resilience and susceptibility; with four associated components of floods such as economic, social, physical and environmental components. According to Scheuer et al. (2010: 3) the more vulnerable a system is, the more risk elements it contains and the more susceptible and the more exposed those at risk elements are. Flood vulnerability is more concerned with the values and materials that are in a particular area, especially the harm, loss and damage that can be caused into the system.

2.2. Vulnerability

Vulnerability is a broad concept which is studied from the field of social, environmental, biological and physical sciences. However, in this study vulnerability was approached from socio-economic and environmental perspectives. There have been contradictions and similarity of various fields defining vulnerability. The concept of vulnerability emerged from the social sciences in the 1970s. The term vulnerability was derived from the Latin root vulnerable, meaning “to wound” (Kasperson et al., 2005). Nevertheless, all companions and contradictions are rooted in the very same path of potential loss or being harmed (Hebb and Mortsch, 2007).

According to IPCC (2007: 883), vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change. This definition was mainly based on the climatological and meteorological hazards that are exacerbated by the global climate change. Other socio-economic and natural hazards were not targeted by the IPCC definition.

The United Nations/International Strategy for Disaster Reduction (UN/ISDR) (2004), explained vulnerability as the conditions determined by social, economic, physical and environmental factors. Processes and activities that exacerbate the susceptibility of a community to the consequences of hazards are also included. This description is more focused on the factors that increase susceptibility than the adaptive capacity of a community. A community can be a simple system with all the four components of flood vulnerability and all the processes which take place in a system.

Vulnerability firmly describes the function of exposed system (community), its failure and resilience capacity. Vulnerability concept has been recently linked and applied to climate change impact assessments and is a multifaceted and contested construct (Nathalie et al., 2011: 22). There are various definitions of vulnerability due to the different approaches and perspectives toward the vulnerability of a system. Vulnerability is not only linked to meteorological hazards, but also to a series of dynamic processes involving socio-cultural, economic and political processes (Nathalie et al., 2011: 22).

Vulnerability quantifies the associated risk within the context of environmental and socio-economic capacity to adapt to floods (Munyai 2015: 9). Flood vulnerability is the degree to which the different social groups or classes within a society are differentially at risk, both in terms of probability of occurrence of an extreme flood event and helping different classes to recover (Nethengwe, 2007; Cardona, 2003). Flood vulnerability goes hand in hand with the ability, capacity, response and recovery of the system in a particular population experiencing floods.

Kasperson et al. (2005:146) approach vulnerability from three major dimensions: “exposure to stresses, perturbations, and shocks; the sensitivity of people, places, and ecosystems to stress or perturbation, including their capacity to anticipate and cope with the stress; and, the resilience of exposed people, places, and ecosystems in terms of their capacity to absorb shocks and perturbations while maintaining function”. These dimensions are interconnected as they contribute to the vulnerability of a system.

Balica (2007:24), described vulnerability as a function of the character, magnitude and rate of climate variation to which a system is exposed, including its sensitivity and its adaptive capacity. A system is exposed and becomes vulnerable to a specific hazard which in this case is floods (Balica, 2007). In the susceptibility and exposure of a system, certain capacity to adapt to the flood phenomenon is available, which can be either strong or weak. Balica (2007:26) concluded that vulnerability is the extent of harm which can be expected under certain conditions of exposure, susceptibility and resilience. Balica’s definition is similar to

Gbetibouo and Ringler (2009: 1) where vulnerability is conceptualized as a function of three factors: exposure, sensitivity and adaptive capacity.

Klein (2004) has developed a well-articulated conceptual framework (indicated in figure 2.1) describing vulnerability and its components and interaction. This framework clearly indicates that sensitivity, exposure and adaptive capacity are the major driving forces behind the vulnerability of a system. Whether the vulnerability is low, medium, high or very high; these factors are responsible for such an extent.

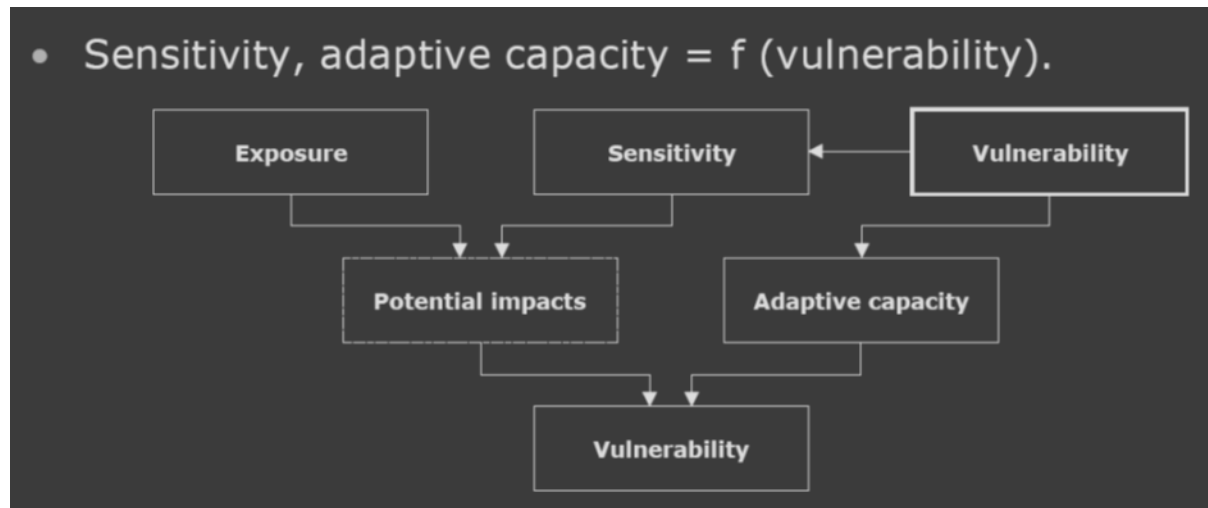


Figure 2.1: Interaction between the components of vulnerability (Klein, 2004)

Vulnerability concept is composed of terms such as risk, natural hazards, coping and adaptive capacity, sensitivity, resilience, poverty and even food security in disaster and development studies literature as well as in climate change discourses (Nathalie et al., 2011:22). Vulnerability is a multiple structure, with various integrations of spheres such as physical, environmental, institutional and social (O'Brien et al., 2007). In a general presentation, natural hazards are a threat to human life.

Beside the above descriptions and definitions of vulnerability, this study understands vulnerability as the extent to which an exposed and susceptible system (community) resists a hazard. Ideas of vulnerability have changed over the past two decades and consequently there have been several attempts to re-define and capture what is meant by the term (Balica, 2009: 1). The significant change is in the approach. Historically, vulnerability was studied from the context of the natural environment but recently there has been a shift to the socio-economic approach.

There is clear articulation of all the flood events that have occurred around the world. The most apparent causes have been close proximity to a river, living in a coastal area and

heavy rainfall. Floods and flooding vulnerability have become more socio-economic or an integration of the physical environment and the socio-economic components. This is due to a great rise in the effects and frequency of floods in rural communities, especially in developing countries.

According to Balica (2012: 18), floods are regarded as the most dangerous and harmful natural hazard. The number of affected people, damages, lives lost and destruction due to floods in the past four years have surpassed disasters from any other natural hazard. Their magnitude and intensity have been increasing tremendously under the influence of global climate change. No one is spared from the effects of global climate change. Due to the threat and current vulnerability and effects of floods, necessary mitigation measures and management to limit the impacts have been proposed by Balica, (2012); Ngie, (2012); SALGA, (2011); Rabalao, (2010) and Munyai, (2015).

2.3. Global overview

Globally, floods have had a remarkable effect including serious damages in developed countries (Wisner et al., 2004: 201). Floods cause more economic losses in the world than any other hazard. The World Bank (2007) also indicated that floods are a major risk affecting Gross Domestic Products (GDP) in the world. They are very contextual, meaning that their impacts and vulnerability are dependent on specific circumstances (Rabalao, 2010: 14). This contextually emphasizes the greatest need of flood risk vulnerability assessment at all levels; local, regional, provincial, national and international.

Globally, there is evidence that the number of people affected and economic damages due to flooding are rising at an alarming rate (FloodList, 2015). This rise is exacerbated by the global climate change, where temperatures are rising leading to warm climate. Rainfall intensity, volume, timing, antecedent conditions of rivers and their drainage basins, as well as human encroachment into floodplains and lack of flood response plans increase the damage potential (Kundzewicz et al., 2007). The effects of settlement development and urbanization have also worsened the magnitude and rate of flood occurrence. Many communities are exposed and have become more susceptible or sensitive to flood hazards.

Another crucial aspect is the geographical location of various communities in the world such as floodplain, proximity to river and low altitude. These geographical locations are often overpopulated and exacerbate flood vulnerability. Figure 2.2 indicates that vulnerability to floods is ubiquitous, the red dots on the map represent areas that are vulnerable to floods on a global scale. The World Bank (2007) hotspot analysis identifies four major locations at risk

to floods, these include South/Central America, Southern/Eastern Europe, Africa South, East Asia and South Asia.

Because of an increasing magnitude and frequency of floods, assessing people vulnerability to floods has become increasingly important, whether as a part of risk management system, or for policy support requirements (Muriadi and Wijaya 2014). Detailed information regarding the exposure, susceptibility and resilience of every specific area changes over time. This means that assessing people's vulnerability to floods should be a continuous exercise.

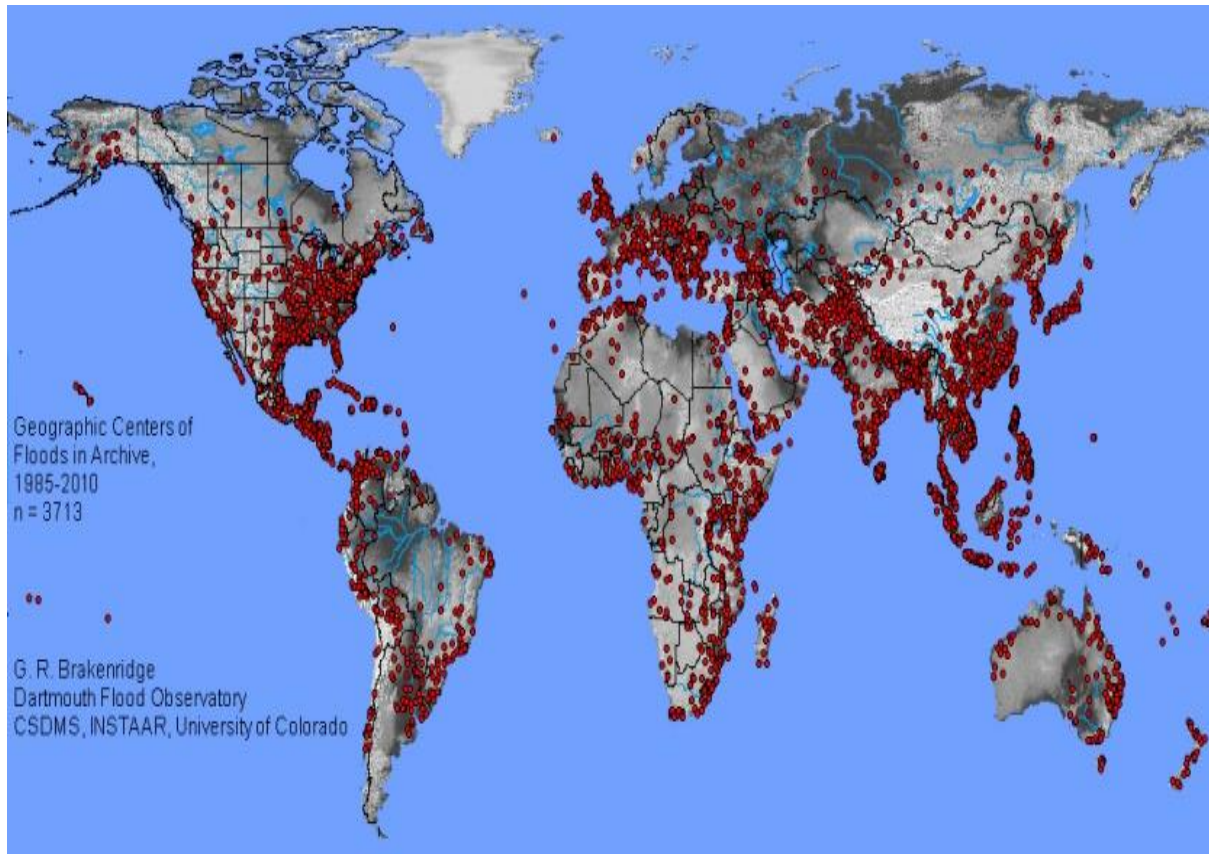


Figure 2.2: Global flood risk from 1985 to 2010 (Brakenridge, 2012)

2.3.1. Flood vulnerability in Europe and North America

In Europe especially the Netherlands, France and Romania are not excluded from exposure and susceptibility to floods. Alexandru et al. (2012) and Popovici et al. (2013), mapped flood vulnerability in Romania and it was noted that it is one of the worst exposed and susceptible countries in Europe. This was based on the 2005, 2006 and 2010 flood events. FloodList (2015) postulated that river floods in Europe could directly affect more than half a million people a year by 2050 and nearly one million by 2080 as compared to about 200 thousand today. Australia is not excluded either because the Hutt River Valley floods have left many concerns in the southern North Island of New Zealand (Lawrence et al., 2011).

In the Americas Canada, USA and Mexico are among the most susceptible countries to floods. According to FloodList (2015), a national emergency alert system is now in place with the goal to alert any Canadian immediately if a potentially life-threatening event is threatening a community. This is done to limit and reduce the impacts of any natural disaster including floods.

2.3.2. Flood vulnerability in Asia

Asia is among the worst affected by natural hazards including floods (Emergency Events Database [EM-DAT], 2016). In Asia approximately 78% of the natural disasters were floods and flooding from 1980 to 2005 (World Bank, 2007).

China is one of the most susceptible countries that are exposed to floods than any other country in Asia (FloodList, 2015). “In 2015 June 25th; rainfall affected north-western and central eastern China, causing deadly floods and landslides in several provinces (Figure 2.3). In Shaanxi Province, 4 people died while 13 went missing. Approximately 34 000 evacuated, over 10 400 houses were damaged and 451 000 people were affected” (FloodList, 2015). Heavy rainfall caused a river to overflow and affected people around the river. However, human activities also contributed to these floods events through poor settlement development.

The second largely affected country in Asia is India, followed by Bangladesh and Indonesia respectively (FloodList, 2014). The key cause of floods in Asia is seasonal cycle; winters are cold with a little amount of rainfall whereas summers are composed of high rainfall causing floods and flooding. The challenge is that institutions only concentrate on response and recovery, rather than prevention, preparedness and mitigation.



Figure 2.3 Floods in Wuxi County, Shaanxi Province China (Source: FloodList, 2015)

2.3.3. Flood vulnerability in Africa

Africa has been linked to various natural hazards and many countries are unable to mitigate and prevent the impacts. A magnitude of floods that in Europe or North America can have minimal effects, can have great effects in Africa due to lack of resilience and resources to respond and recover from flood hazards. In Africa, vulnerability and exposure to flood hazards are mostly due to the socio-economic indicators such as household income, employment status, dwelling type and other socio-economic factors (Munyai, 2015: 11). The greatest problem facing Africa is poverty, which is exacerbating flood impacts. Nevertheless, the relief and drainage of African countries are also not excluded from attribution of flood hazards.

UNEP (2004) identified three key areas which influence high vulnerability to floods in Africa; the size of the population that will be affected, the vulnerability of the affected population and the lack of adaptive institutional capacity to manage the impacts. Floods and droughts have become the greatest threats in the whole continent of Africa. These extreme conditions have been phenomenal, increasing frequency and severity of floods in the last ten (10) years.

Although Africa is seriously exposed to floods, there are little mitigations and management strategies because communities are continuously exposed and vulnerable (Munyai, 2015: 12). The resilience capacity depends on the availability of resources. This means that these communities have low resilience due to poverty; as the most vulnerable victims of floods are poor individuals.

Lack of resilience has further intensified flood vulnerability in Africa and limiting economic development. The continent Africa, home to approximately one billion people, is more vulnerable than any other continent to climate change (UNEP, 2006). Balica (2007) noted that the higher the density of people in a particular area, the higher the vulnerability to floods. Therefore, the high and exponentially increasing population in Africa worsens the state of flood vulnerability. Africa appears ill-prepared to adapt to the powerful effects of climate change (Temesgen et al., 2014). Damages to properties, drowning, destruction of infrastructure and loss of lives resulted from institutional ill-preparedness. There is a great need for more precise strategies on the reduction and prevention of floods in Africa.

Temesgen et al. (2014) noted that, “the first is adaptation, policymakers in Africa need to prioritize investment on research for the development of improved agronomic practices, agricultural enterprises and enterprise mixes that can thrive under moisture stress, and better water and soil conservation techniques.” Indigenous knowledge is very significant and

if it can be collaborated with modern or scientific adaptations, many lives and properties would be protected.

Floods have been deadly and catastrophic in Northern Ghana, Alexandria Egypt, Sahrawi in Algeria, Malawi, Sierra Leone, Adamawa in Nigeria, Niger, Mali, Guinea and Mozambique (FloodList, 2015). Between 1996 and 2005, there were 290 flood-disasters in Africa alone, which left 8,183 people dead and 23 million people affected, and caused economic losses of \$1.9 billion (*ibid*). Both urbanized and poor cities in Africa are not spared from the exposure and susceptibility to floods, meaning that there is a great necessity of adaptation and flood management strategies by all people; poor and rich.

Southern Africa is also exposed and susceptible to flood. Their vulnerability and exposure is high due to their social and economic components; composed of indicators such as level of income, quality of infrastructure, high unemployment rate, lack of preparedness, poor quality of dwelling and others. The most critical problem is lack of adaptive institutional capacity to manage and reduce all the impacts of floods. Chisola (2012) noted that flood disasters have been experienced continuously for the past five years. Improved adaptation and mitigation measures can mitigate flood vulnerability in Africa.

2.3.4. Flood vulnerability in South Africa

In South Africa, various mitigation strategies have been proposed and applied; meteorologists from the South African Weather Service developed some mitigation strategies such as tracking the paths of tropical storms and providing early warnings in time when heavy rainfalls are anticipated using radar and satellite images (Singo et al., 2011). Nevertheless, the extent of flood vulnerability keeps on rising during rainfall. Prevention, reduction and mitigation rather than response and recovery are very necessary in South Africa. The government of South Africa has established awareness campaigns and dwelling quality improvement programmes, but these are not sufficient.

The most vulnerable provinces in South Africa are the Eastern Cape, KwaZulu-Natal, the North-West and Limpopo (Le Roux and Van Huyssteen, 2010). However, this does not spare other South African provinces from vulnerability and exposure to floods. The 2015 rainy season affected many local areas in South Africa. In Limpopo, reports about flood events were all over television, journals, radios, newspapers and magazines. Some local areas within Lephalale, Mopani and Vhembe District municipalities were declared- flood hazard zones.

In the Mopani District Municipality local municipalities such as Maruleng, Greater Giyani, Greater Tzaneen, Greater Letaba and Ba-Phalaborwa are not spared from flood hazards, exposure and vulnerability. The flood events that occurred in Mopani are the 2012 floods, 2013 floods, 2014 floods and 2015 floods. In 2012 a total of 662 households were affected by floods, Molalane village being the hardest hit (MDDMC, 2015:12).

The most applied coping measures were recovery and responses. Communities received tents, clothes, blankets, food, water and water purification sachets. The MDDMC (2015:13) recorded that South African Social Security Agency (SASSA), National Disaster Management Centre (NDMC), Department of Social Development and Working on Fire Team distributed 662 food parcels, 1556 loaves of bread, 1946 blankets, 71 tents, 77686 litres of bottled water and another 55669 of them in Drakensig Hall, tanks of water from JOJO tanks and 30000 water purification sachets with 185 of litres of water. Some of the houses were flooded, the Blyde River spilled over, the Klasserie River overflowed, and some roads were closed.

More than R259,3 million was required to rehabilitate, reconstruct and upgrade infrastructure (MDDMC, 2015:17). These floods were caused by a Tropical Low Pressure (TLP) system that developed over the South Indian Ocean west of Madagascar, this TLP system moved inland over the southern part of Mozambique and entered South Africa affecting Northern Kwa Zulu Natal (KZN) up to the Northern Limpopo Province (South African Weather Service, 2012). TLP caused intensive rainfall and resulted in extraordinary floods occurring in residential zones and in rivers.

On the 16th of January 2013, SAWS (2013) announced a warning of heavy rains over North West, Gauteng, eastern Free State, KZN, Limpopo and Mpumalanga from 18th January 2013 to 20th January 2013. These rains were caused by intense Low Pressure (LP) moving in from Botswana. The ground had become saturated and run-off resulted in rivers flooding. A total of 18 people were injured, 16 people died, 465 tents and 1187 food parcel were required. Ga- Kgapane, Nkowakowa, Lenyenye and Phalaborwa communities were affected but Ga- Kgapane was the worst affected (MDDMC, 2015:22). It is convincing that when there is heavy rain, these lowveld areas become flooded. Ga- Kgapane, Nkowakowa and Lenyenye are among the vulnerable to flood communities but their levels of vulnerability are not yet clearly known. This study intended to assess their vulnerability levels and recommend relevant coping strategies.

2.4. Flood producing weather systems in Limpopo Province

Whilst there are several factors that contribute to the occurrence of floods in an area, the primary cause is heavy and excessive rainfall. It is therefore important to discuss the weather systems that affect the study area and how they may cause floods. The Limpopo Province lies in a zone affected by both tropical and subtropical weather systems where rainfall can be highly variable and unreliable. Due to this location the area is affected by cloud bands extending from the tropics (Angola) to the southwest Indian Ocean. These cloud bands produce between 30 – 60% of annual rainfall over the region (Hart et al., 2013) and are the dominant source of rainfall in this region (Driver, 2014). Convective rainfall and thunderstorms accompanied by heavy rain may also occur during the early summer.

Though not frequent, tropical lows, tropical storms and tropical cyclones which landfall over southern Africa use the Limpopo River valley to propagate inland (Malherbe et al., 2012). Whilst they contribute less than 10% of annual rainfall, they are responsible for about 50% of all heavy rainfall and flooding events in the Limpopo River basin (Malherbe et al., 2012). More recently tropical storm Dando affected the Limpopo and dumped more than 150 mm of rainfall in two days from 17-18 January 2012 (Chikoore et al., 2015) while flooding the Kruger National Park.

Another weather system which produces extreme rainfall which can lead to floods is the cut-off low. It is a low pressure system found in the mid-troposphere, detached from the basic westerly winds which are characteristic of the upper air. They can occur throughout the year but tend to peak from March to May with a secondary peak from September to November (Singleton and Reason, 2007). Sometimes cut-off lows and cloud bands may be “blocked” by a blocking high pressure system in the South Indian Ocean such that heavy rainfall will persist in one area leading to floods in the low lands.

South Africa’s northeast (Limpopo) is a region significantly affected by the remote El Niño phenomenon which causes anomalous weather in many tropical and subtropical regions around the world. For example, during La Niña, the atmospheric circulation favours higher rainfall and frequent genesis of tropical cyclones in the Mozambique Channel whilst the risk of land-falling cyclones and flooding is higher. Several studies have shown that there has been a general decline in rainy days in southern Africa but coupled with increased frequency of heavy rainfall events (e.g. New et al., 2006; IPCC, 2013).

2.5. Approaches to natural hazards

There are several approaches to natural hazards. The major themes include hazard as being caused by nature and other causes stated are people's behaviour and how they manage their lives in relation to the geographical environment in which they live (Chisola, 2012). Floods are naturally caused, but humans exacerbated their occurrence. Floods were previously understood through the causality approach which is based on previous (historical) impacts, rather than a predictive approach. However, the modern approach is a combination of both historic and predictive methods to mitigate and prevent hazard effects. Wisner et al. (2004) and Chisola (2012) discussed three main approaches to natural hazard theory in the social sciences; dominant approach, behavioural approach and structural approach.

The dominant approach is naturally based because floods are regarded as a phenomenon caused by the natural environment. Hazards are caused by nature, and thus there has to be control, monitoring and prediction of natural events to find a solution (Wisner et al., 2004). The natural environment is uncontrolled and dynamic according to dominant theory. However, modern studies have criticised this theory due to further understanding of floods phenomenon. Wisner, et al. (2004) postulated that vulnerability is socially constructed, pointing out, that not only has the natural environment caused vulnerability but there was a need to consider the social side of natural hazards.

The behavioural approach explains the response by human beings to hazards (Chisola, 2012). This theoretical approach is more about adaptation than considering the causality. The main idea is the relationship between humans and the environment, and their reaction to any natural hazard. The interconnection between human beings and their living environment and resilience which is produced by their efforts is considered as the behavioural approach (Burton et al., 1978). The most critical aspects are vulnerability of a population, livelihood, utilization of the natural resources and coping mechanism to flood hazards (Burton et al., 1978). There is a great link between human beings' reaction to natural risks and hazards and their socio-economic status.

The structural approach is based on the institutional structures that aid vulnerable people to cope with natural hazards. This is more than just individual capacity or ability to adapt but institutional structures that are available. According to Wisner et al., (2004) the structural approach is "the study of the human, environment system within the structuralism view aims at identifying the ways in which political and economic structures determine or con-strain individual adjustment to the environment". There are two main systems that are interacting in this approach; human and environmental system.

The above approaches are significant in this study because there is a link between the vulnerability of the study areas and both the behavioural and structural approach. Therefore, this study implemented both behavioural and structural approaches to understand flood vulnerability, determinants of vulnerability and floods coping strategies.

2.6. Determinants of flood vulnerability

Factors that determine flood vulnerability are those that decide or influence the form of flood vulnerability in a specific area. These factors differ by location and socio-economic characteristics. Every area has its own identical physical topography and socio-economic characteristics hence the different determinants of flood vulnerability. The basic principle is that each factor contributes to vulnerability. The influence can be high or low depending on the significance of the factor.

“Understanding the multi-faceted nature of vulnerability and exposure is a prerequisite for determining how weather and climate events contribute to the occurrence of disasters, and for designing and implementing effective adaptation and disaster risk management strategies” (Cardona et al., 2012). The multi-faceted nature of vulnerability includes both the physical environment and socio-economic components. It actually improves ways of assessing flood vulnerability determinants since all aspects are considered.

Cardona et al. (2012) found that the most apparent factors were economic, social, geographic, demographic, cultural, institutional, governance, and environmental factors. Factors were grouped and varied across temporary and spatial scales. Vulnerability, resilience and exposure are very dynamic, change over time and should be assessed over a space of time. Meanwhile, factors that determine flood vulnerability also change over time, therefore updated information and data should be considered when assessing these determinants. For instance, economic characteristics of a particular area do not remain the same each year but are always subject to change.

Flood vulnerability is easily defined when all the factors that determine vulnerability to floods are identified and assessed. The components of vulnerability are combined to determine overall vulnerability to flood (Karmaka et al., 2010). Determinant factors can be identified through the combination of major components of flood vulnerability-economic, physical, infrastructural and social (Karmaka et al., 2010). These components play a key role in the identification of determinants of flood vulnerability. Even though in other studies the categorization of floods components was different, vulnerability computation was still possible. Most researchers considered economic, social, physical and environmental factors

as major components that made vulnerability less complex (Balica, 2012; Balica et al., 2009; Bogardi and Birkmann, 2004; Cardona, 2003; Dapeng et al., 2012 and others).

Ahmed (2004) noted that vulnerability is linked to complex sets of interacting conditions or situations. Some of these conditions include nature of the dwelling, geography and location, access to infrastructure and social interaction and organization. These factors make a complete system within the context of socio-economy and physical components. Very few researchers rank or weight factors that determine flood vulnerability; it is believed in this study that factors do not have similar influence or contribution to flood vulnerability. Therefore weighting or ranking determinants assist policy makers to make informed decisions.

2.7. Indicators of flood vulnerability

The flood vulnerability index tool is a tool used to measure flood vulnerability levels, but does not collect data for computation processes. This is an indicator based method that relies on the indicators in order to measure vulnerability. There are various methods of collecting these indicators. However, the most significant processes are selection and identification of relevant indicators. Indicators may be social, economic or physical environment.

The basic principle of being able to select and use indicators is to understand them and know what they represent. Balica (2009) defined an indicator as an inherent characteristic which quantitatively estimates the condition of a system. Indicators are usually focus on small, manageable, tangible and telling piece of a system that can give people a sense of the bigger picture. Although indicators are significant in vulnerability studies, they do not tell a full story about the phenomena but give only a general view of a system or community.

Indicators should be able to show or indicate vulnerability to a hazard, this means that policy makers should come up with necessary strategies to mitigate and reduce vulnerability. According Briguglio (2003), indicators are necessary tools that can, when applied adequately, predict the likely effects of a disaster. They should also provide additional information to set more precise and quantitative targets for vulnerability reduction (Balica, 2009). These indicators are also dynamic, that is, they change over time. Vulnerability indicators are grouped into three factors and four components of vulnerability.

Procedures for indicator selection follow two general approaches, one based on a theoretical understanding of relationships and another based on statistical relationships (Adger, 2004). The theoretical approach is based on a deductive research where indicators are selected through conceptual framework. The first step in a deductive or theory-based approach is to

understand the phenomenon that is being studied and the main processes involved (Adger, 2004). This includes its magnitude, intensity and the duration of a particular phenomenon.

In a deductive approach, a hypothesis is tested by operationalizing the concepts in the hypothesis and collecting the appropriate data to explore the relationship between the measures (Adger, 2004). The stronghold of the deductive approach is on the available vulnerability indicators of other studies. A deductive approach is more pre-determined and follows a specific path of the theoretical framework.

An inductive approach often uses empirical generalisations, filled with content and statements of regularities (Veenstra, 2013). The theory consists of generalisations derived by induction from data: meaning that the finding of patterns in data that can be generalised (Adger, 2004). Therefore a researcher should go to a place where the phenomenon can be observed and conduct a survey.

This study employed a deductive approach supplemented by a preliminary survey to avoid using indicators that were not relevant to the study area. Theoretical indicators were selected based on the preliminary survey. This means that theoretical indicators were discarded and the remaining characteristics were merged into a set of indicators (Veenstra, 2013). Balica, (2009) noted that the standard practice is to collect a list of indicators using criteria such as: suitability, following a conceptual framework or definitions, availability of data, and sensitivity to formats. There are a number of studies that were used for theoretical indicators, including Balica (2007); Balica et al. (2009); Balica et al. (2012); Birkmann (2006); Briguglio (2003); Connor and Hiroki (2005); Veenstra (2013) and Nabegu (2014).

2.8. Adaptation strategies to flood hazards

Vulnerability cannot be fully understood without assessing the resilience or the capacity of victims to cope with a hazard. Societies have various ways of surviving during flood events, whether these events are severe or not. This means that at any level of flood vulnerability; from the lowest to the highest there will always be a capacity to cope with vulnerability. Although the capacity to adapt might be low or high, the issue is that there is a capacity to cope and adapt with a particular vulnerability to floods.

A fully resilient community is rare to find since the most crucial requirement for strong resistance is good finances. This means that socio-economic characteristics play a key role in determining whether a community has a strong or weak resilience to hazards. Better socio-economic standard enhances societal resilience by producing resources such better dwellings, better evacuation routes and others resources.

Dewi (2007) noted the following concepts of coping mechanisms that communities have: communities do not do anything about floods but learn how to live with them. The usage of non-structural measures like flood insurance. The usage of intensive and extensive structural technologies, for example floods levees, terracing of land and soil conservation. Joint usage of non-structural measures and structural technologies are believed to be the best alternative.

There are various coping strategies found in other studies, even though most coping strategies are an immediate reaction against flood events. Over-reliance on the response and recovery approach does not limit flood impacts. This is crucial especially to specific locations affected by recurrent of floods.

2.9. Rural disaster management programmes in South Africa

In South Africa, the National Disaster Management Centre (NDMC) was established in terms of Section 8 of the Disaster Management Act, 2002 (Act No 57 of 2002) (DMA) (Republic of South Africa (RSA), 2005). It was established by the Department of Cooperative Governance and Traditional Affairs. The main objective of the National Centre is to promote an integrated and co-ordinated system of disaster management, with special emphasis on prevention and mitigation, by national, provincial and municipal organs of state, statutory functionaries, other role-players involved in disaster management and communities (RSA, 2005). However, disaster risk management in South Africa is established as a public sector function within each sphere of government (Van Niekerk, 2006). Disaster management is a shared responsibility which must be fostered through partnerships between the various stakeholders and co-operative relationships between the different spheres of government, the private sector and civil society. Disaster reduction is more than just a line function responsibility but all the stakeholders have their part to play.

Various disaster management organizations and programmes have established in South Africa. The Rural Development and Land Reform Department established a sub-programme called Rural Disaster Mitigation Service (RDMS) within the Geospatial Services, Technology Development and Disaster Management Branch. Its main objective is to reduce disaster in rural areas through ensuring a continuous and integrated system of disaster management (DRDLR, 2013). RDMS put more emphasis on disaster prevention, preparedness and mitigation within the rural development and land reform programmes.

The South African Local Government Association (SALGA) has also vested interest in the successful implementation of the Disaster Management Act and Policy Framework in South Africa. The main goal of SALGA is to successfully support local government and to assist

with focussed capacity enhancement (Botha et al., 2011). Various departments are also trying to mitigate and reduce natural hazard impacts including Agriculture Fisheries and Forestry and Environmental Affairs. Despite the contributions of various stakeholders and departments, natural disasters such as floods and drought are continuously affecting the society. The majority of governmental and non-governmental organizations lack funding to strengthen their capacity to maintain disaster risk management programmes.

2.10. Conceptual Framework

Different indicators of flood vulnerability can be understood when flood vulnerability factors and components are aligned (Figure 2.4). Vulnerability components can be assessed using different indicators to understand the vulnerability of a system to floods (Balica, 2009: 3).

Exposure denotes values that are available to a particular area, including various indicators of land use such as agricultural farms, people and products, infrastructure, cultural heritage, goods and other valuable resources. In general, exposure accounts for various at risk within a system. Exposure indicators are also attached to elevation type, proximity to the river, closeness to inundation areas and return periods of different types of floods in the floodplain (Messner and Meyer, 2005: 4).

Susceptibility is often described as the potential of a system to be harmed by a hazardous event due to some level of fragility, relative social or economic weaknesses or disadvantageous condition (Veenstra, 2013: 5). It also includes all political characteristics of a certain area. Apart from exposure and sensitivity or susceptibility, resilience of the system should be assessed to complete understand the vulnerability of a system. Reliance is linked with the capacity of the system, rather than just coping strategies against flood hazards. Therefore, resilience is the adaptation capacity of each community to changes due to hazards by modifying itself to achieve an acceptable structural and functional level (Galderisi, 2005). A system has to retain and sustain its normal processes during hazardous events. This means that, a system must bounce back after disturbance, that ability of a system to retain its functionality is resilience (Munyai, 2015: 6).

The resilience of a system can be created through both autonomous and planned adaptation measures of minimising vulnerability (Lawrence et al., 2011: 7). The major difference between resilience and coping capacity is that resilience deals with maintaining significant levels of adaptation and function within a community, rather than responding after flood hazards. There is a minor similarity between coping capacity and resilience. Even though

resilience is a more dynamic concept that applies not only to recovery from specific shocks it accommodate a broad range of on-going pressures (Lawrence et al., 2011: 7).

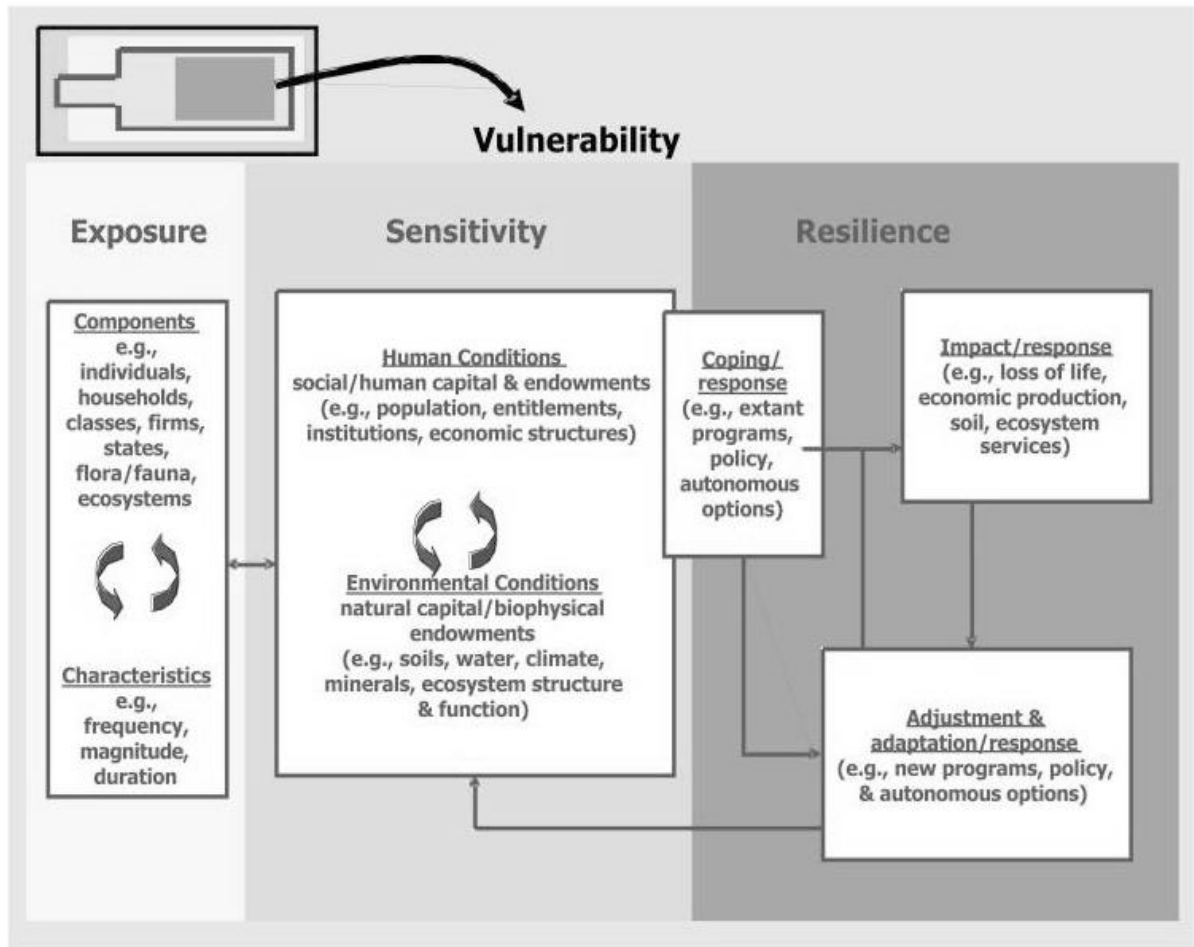


Figure 2.4: The conceptual framework adopted from Turner et al. (2003)

2.11. Summary

Various perspectives and perceptions have been reviewed in this chapter. Vulnerability has been defined by various authors with different perspectives. Understanding vulnerability helps society to come up with proper disaster risk management strategies. Globally, societies are vulnerable to floods, but vulnerability levels and coping capacity differ. The next chapter describes the methodology used in this study and various research designs with methods of data collection and analysis.

CHAPTER 3: RESEARCH METHODOLOGY

3.1. Introduction

This chapter gives a description of the research methodology. It describes the research designs implemented and how data were collected. It also gives a detailed description of the sampling method and the analysis and interpretation of data. Flood vulnerability index is also explained including all the components and factors necessary for index computation.

3.2. Research Design

This study was based mainly on a quantitative survey research design, which was supplemented by a qualitative survey. Quantitative vulnerability uses normative and deductive approaches which are based on indices and indicators. Qualitative research is flexible, open-ended and allows new details, information and ideas to be captured (Munyai, 2015: 22). Qualitative vulnerability is participatory and involves individual experiences of flood hazards, their view and coping strategies. Table 3.1 shows a summary of methods used to achieve the specific objectives of this study.

Table 3.1: Summary of research questions, data source, methods and procedures, and data analysis.

Research Questions	Data Source	Methods and procedures	Data Analysis
What are the contextual factors that determine flood vulnerability and their related weighting by the affected households?	Households South African Weather Service Census 2011	Questionnaire; Field Observation and Key informant interview	Descriptive statistics; cross tab; tables; pie charts and graphs
To what extent is Nkowankowa section B and C; Lenyenye and Ga-Kapane Masakaneng vulnerable to floods?	Households South African Weather Service Census 2011 Mopani District Disaster Management Centre	Questionnaire; Field Observation and Key Informant interview	FVI-scale; 0 signifies low and 1 signifies high vulnerability to floods
How do the local communities and government structures cope with the flood hazard?	Households; Key informants and field observation	Questionnaire; Field Observation and Key informant interview	Descriptive statistic; cross tab; tables; pie and graphs

This study used a case study design approach because it is focused on and interested in specific communities. The purpose of this study is to identify and assess the contextual factors that determine flood vulnerability, assess the level of flood vulnerability among the community households and evaluate the community and municipal flood coping strategies in three villages; Lenyenye, Ga-Kgapane Masakaneng and Nkowankowa section B and C. The

primary reason of selecting these villages was due to the recurrent of flood events they experienced during rainfall.

Quantitative data collection relied on questionnaires for the three study areas and target households. The questionnaires were distributed with the assistance of a local language translator; predominantly Tsonga/Shangana, and Northern Sotho. Meanwhile, qualitative data was provided by key informant interviews and the instrument was composed of mainly semi-structured questions and life histories.

3.3. Sampling

Questionnaires were distributed to households to identify determinants of flood vulnerability and coping strategies in the communities' households. The questions included exposure, susceptibility and resilience indicators to show the extent of flood vulnerability. The affected households were sampled using the systematic random sampling method. Systematic sampling (also known as interval sampling) relies on arranging the study population according to some ordering scheme and then selecting elements at regular intervals through that ordered list (Groves et al., 2011). It also ensures at the same time that each unit has equal probability of inclusion in the sample. In this method of sampling, the first unit was selected with the help of random numbers and the remaining units were selected automatically according to a predetermined pattern (Cochran, 2007). Systematic random sampling method has been used to sample households in similar studies (e.g Dhakal et al., 2000 and Thinda, 2009).

According to Statistics South Africa (2011) the total population of the Greater Tzaneen Local Municipality is 390095 people. Tzaneen is spread across 101 communities and the total number of households is 108926 (Statistics South Africa, 2011). However, the sample size is comprised of three communities which are susceptible to floods including Nkowankowa Section B and C, Lenyenye and Ga-Kgapane Masakaneng (MDDMC, 2015). These three communities were selected due to the recurrence of flood events.

The three communities and the total number of households are as follows: Nkowankowa Section B and C (1860), Lenyenye (980) and Ga-Kgapane Masakaneng (706) (Statistics South Africa, 2011). Equivalently, 50% of the total households (which is the unit of analysis in each community) were systematically sampled in a quantitative order of 1 in every 20th households. The households' sample sizes were calculated as follows:

$$\text{Lenyenye} = \frac{\text{Total number of households}}{100} \times 50$$

$$= 490$$

Systematic sample of every 1 in 20th of the 490 households = 25

$$\text{Nkowankowa C \& B} = \frac{\text{Total number of households}}{100} \times 50$$

$$= 930$$

Systematic sample of every 1 in 20th of the 930 households = 47

$$\text{Ga-Kgapane Masakaneng} = \frac{\text{Total number of households}}{100} \times 50$$

$$= 353$$

Systematic sample of every 1 in 20th of the 353 households = 18

The total number of the questionnaires = 25+50+25 =90

The researcher decided to raise the questionnaires to 100. Nkowankowa received three extra questionnaires and Ga-Kgapane Masakaneng was given seven more additional questionnaires to make a total of 100. These extra questionnaires were added in order to evenly distribute them in the three communities.

Key informant interviews were conducted with two Storm Water managers of Nkowankowa Section B and C, Lenyeneye and Ga-Kgapane Masakaneng. The informants were selected using the purposive sampling technique. According to Palys (2008), purposive sampling is the deliberate seeking out of participants with particular characteristics, according to the needs of the developing analysis and emerging theory. It is also focused and directed at acquiring certain attributes related to the problem (Munyai, 2015). The Director and the Risk Assessment Manager of Mopani District Disaster Management Centre's were also interviewed. Key informant interviews covered municipal coping strategies, information about indicators and flood impacts.

3.4. Data collection

In order to achieve research specific objectives and computing the flood vulnerability index, primary and secondary data sources were used in this study. The use of both data sources strengthened the certainty and validity of the study's findings. This is because both data sources play a key role by providing information about social and natural sciences. Primary data were acquired through a quantitative questionnaire, a qualitative key informant interview, and field observation; while secondary were collected through Census 2011, South

African Weather Service, records and maps. MDDMC was helpful with the majority of records, map and information about the indicators.

3.4.1. Quantitative Questionnaire

The questionnaire consisted of closed-ended and open-ended questions and allowed the respondents to add other views concerning flood hazards and vulnerability. The structure of the questions was informed by a preliminary survey. This was done to improve the relevancy of the questionnaire questions. These include questions about the determinants of flood vulnerability, community's coping strategies and socio-economic impacts of floods. The socio-economic impacts included health, education, infrastructure and personal properties. The following indicators were discussed: awareness, education level, frequency of flood occurrence, cultural heritage, early warning systems, emergency services, flood insurance and other relevant indicators.

Questionnaires were systematically administered to the households. The basic objective of a questionnaire is to get facts and opinions about a phenomenon from households who are experiencing or informed on flood effects (Babbie and Mouton, 2001). A questionnaire is a useful tool in studies conducted in the natural and social sciences. This is because it maintains the privacy of the respondents by ensuring they participate anonymously.

3.4.2. Qualitative Key Informant Interview

The key informant interviews were held with the two storm water managers in the villages and two government officials from Mopani District Disaster Management Centre. These interviews consisted of open-ended and closed-ended questions about exposure, susceptibility and resilience in these communities. They also included questions related to municipal coping strategies, indicators and socio-economic impacts of floods. The socio-economic impacts included health, education, infrastructure and personal properties. The interviews also covered exposure indicators such as land use, ground water level, infrastructure quality, dam, storage capacity and others.

The main objective of using key informant interviews was to reveal the respondents' perceptions about flood and vulnerability in these villages. Their views also aided and validated the responses from households. These officials contributed a lot to the necessary or key strategies against floods. Key informant interviews were based on Strength, Weakness, Opportunity and Threat (SWOT) analysis.

3.4.3. Field Observation

Field observation was useful for observing the physical landscape and flood impacts including collapsed bridges, damaged infrastructure and others. A digital camera assisted in

taking photos of damaged toilets, road-potholes, infrastructures, dwelling conditions, and houses' cracks. Topography was analysed through Google-Earth by analysing the angles of the slope in terms of the steepness and plainness of the slope. Field observation is one of the greatest instruments to reveal the ground truth about phenomena. This avoids relying only on the social survey data. In the current study, field observations improved the findings and validated the results.

3.4.4. Statistics South Africa and South African Weather Service

Census (2011) data provided useful information about flood vulnerability indicators such as population density, total population, sanitation, unemployment rate and dwelling types. The census data were also used to describe the three villages. These data were purely arranged and calculated from Statistics South Africa (SSA).

The South African Weather Service (SAWS) provided crucial information about the rainfall data and frequency of heavy rainfall, and evaporation rate. The SAWS was significant, especially for the flood vulnerability index. The information was entered into climatological models to indicate the precise indicators mentioned above.

3.5. Data Analysis

In data analysis, descriptive statistics were used to analyse determinants of flood vulnerability, socio-economic characteristics, impacts and coping strategies. Tables, graphs and pie charts were used for presentation and grouping of data. Cross-tabulation was used in order to analyse the relationship between different variables and demographic characteristics in relation to flood vulnerability.

The rainfall patterns of the study areas are studied to also understand the vulnerability of the study area to heavy rainfall which may lead to floods. Rainfall is defined as Twenty-four (24) hour rainfall amount reaching and exceeding 50mm. The rainfall data used was obtained for a station at Tzaneen and was obtained from the South African Weather Service. The spatial variability of rainfall is shown using satellite rainfall estimates obtained from the Global Precipitation Climatology Centre (GPCC) at monthly resolution. The GPCC dataset is based rain gauge observations and is available at $0,5^{\circ} \times 0,5^{\circ}$ since 1901 (Schneider et al., 2013). The weather systems responsible are then identified and described.

Questionnaire data were analysed through Microsoft Excel 2010 and Statistical Package for Social Sciences (SPSS) 23. These data were coded and arranged well and entered into Microsoft Excel 2010 and converted to SPSS 23 to create descriptive statistics. The entered data were summarized into percentages and frequencies.

Key informant interviews' responses were analysed using content analysis and answers were arranged into themes. Themes and answers were then grouped into identical categories, classified and synthesized. Descriptive narrative technique was employed to describe the results of the key informant interviews.

All the information and data collected through field observation were presented in this study in a form of writing and pictures to elicit flood vulnerability. Most of the answers from households were supported by various pictures taken during field observation.

3.5.1. Flood Vulnerability Index

The information collected from interviews, field observations, Statistics South Africa, South African Weather Services, maps and records were imputed into the flood vulnerability index. This index was used to measure the extent of flood vulnerability and the study adopted the Flood Vulnerability Index from Balica (2012).

Flood vulnerability factors and components play a key role in the assessment of vulnerability. Exposure and susceptibility affect vulnerability positively whilst resilience affects vulnerability negatively. Therefore, susceptibility and exposure indicators are placed in the nominator because they increase flood vulnerability index while resilience indicators limit the flood vulnerability index, hence they are placed in the denominator (Quang et al., 2012). The formula of Flood Vulnerability Index is:

$$\text{FVI} = (\text{E} \times \text{S}) \div \text{R} / (\text{E} + \text{S}) - \text{R}$$

E-exposure, **S**-susceptibility and **R**-resilience

Selection of indicators is vital for computation of flood vulnerability. Pre-determined indicators were selected through reviewing of related literature: Balica (2012), Balica et al. (2009), Scheuer et al. (2010), Messner and Meyer (2005), Peck et al. (2007) and Kienberger et al. (2013). In this study, a deductive approach was applied to select the indicators. This approach included the use of theoretical indicators from related vulnerability studies. A deductive approach identifies the best possible indicators based on existing principles and conceptual framework by dividing flood vulnerability indicators among flood vulnerability factors and components (Balica, 2012: 41). It is also important to understand processes relating to the causes and impacts of floods within these communities, so that the best possible indicators can be selected.

Theoretical indicators might be irrelevant or relevant in this study hence a preliminary survey was conducted to get an overview of all possible and relevant indicators of flood vulnerability. Once the preliminary survey was completed, indicators from the survey and literature were

discarded and merged so that relevant indicators could be identified. The most significant factors in the selection of indicators are suitability and availability of data or information in these communities.

Flood vulnerability index aims to identify hotspots related to flood risk in different areas of the world, so that it can be applied as a tool to assist planners and policy makers in prioritising areas of intervention and also as an instrument to provide useful information for awareness raising (Balica, 2012: 40). The whole concept of FVI is that there is a hazard, (flood event), which is affecting the system's main components; social, economic, environmental and physical. This system is exposed and susceptible to floods, but also has its own resilience (Balica, 2012: 41). Indicators should be able to assist decision and policy makers to identify and set goals and provide guidance for strategies to reduce and limit vulnerability. The index gives a number from 0 to 1, signifying low or high flood vulnerability (Table 3.2)

Table 3.2: Interpretation of Flood Vulnerability Index and descriptions of index value

VULNERABILITY INTERPRETATION	
Index Value	Description
Less than 0.1	Very small vulnerability to floods
0.01 to 0.25	Small vulnerability to floods
0.25 to 0.50	Vulnerability to floods
0.50 to 0.75	High vulnerability to floods
0.75 to 1	Very high vulnerability to floods

Source: Balica, 2012

3.6. Chapter Summary

This chapter described the methodology that was used in this study including the employed research designs such as qualitative and quantitative. Sampling methods, various data collection methods and analysis of data were fully described. Data required computing the Flood Vulnerability Index and all the components and factors of flood vulnerability index tool were described. The next chapter will present and interpret the collected data in the three study villages.

CHAPTER 4: DATA PRESENTATION AND ANALYSIS OF RESULTS

4.1. Introduction

This chapter presents the analysis and interpretation of the results of the social survey, field survey and flood vulnerability index calculations. It begins with the presentation of socio-economic characteristics, factors that determine flood vulnerability, levels of flood vulnerability and lastly flood coping strategies. All 100 questionnaires were successfully distributed to the households and returned to the researcher after they were completed. Of these, 25 questionnaires were distributed at Lenyenye and also at Ga-Kgapane Masakaneng whilst the remaining 50 were administered in Nkowankowa Section B and C.

4.2. Rainfall variability in the study area

The mean annual cycle of monthly rainfall in Tzaneen shows strong seasonality with a peak during the austral summer months from November to March (Figure 4.1). The mean annual rainfall is 487 mm whilst average monthly rainfall during the rainy season can reach and exceed 80 mm/month during December, January and February. The months from May to September are largely dry with little or no rainfall. Malherbe et al (2012) determined that more than 85% of rainfall in the Limpopo Province is received during the austral summer, from October to March.

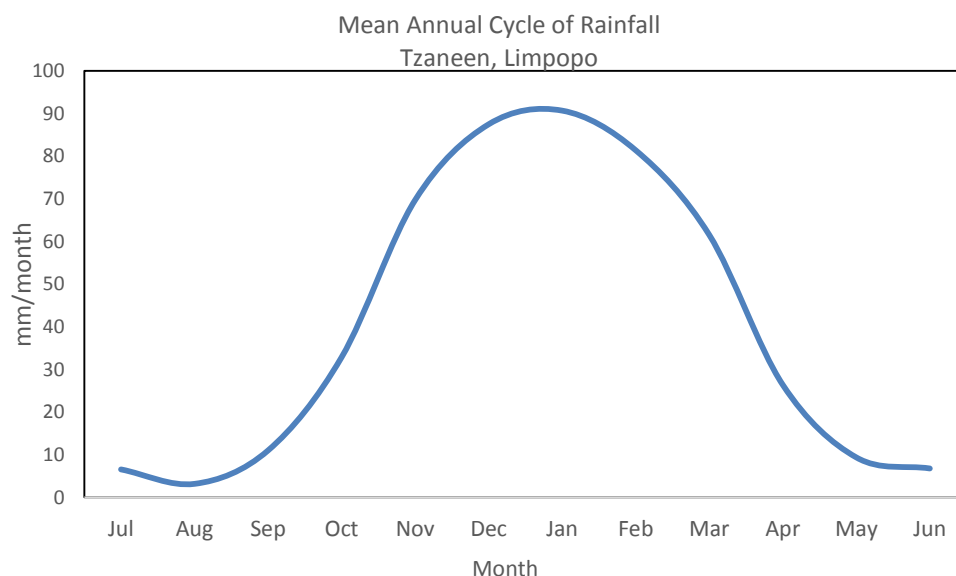


Figure 4.1 Mean annual cycle of monthly rainfall (mm) at Tzaneen, Mopani District

From year to year (season to season), the rainfall of the study area is highly variable. Anomalously high rainfall occurred during 1988, 1996, 2000, 2011 and 2013 mainly associated with tropical storms or remnants of tropical cyclones from the southwest Indian Ocean (Figure 4.2).

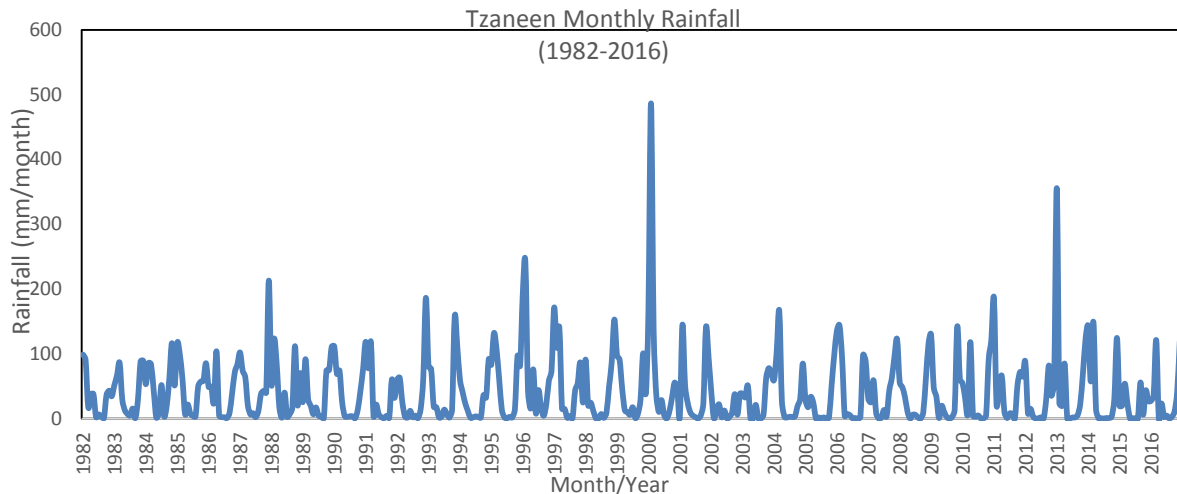


Figure 4.2 Inter-annual variability of rainfall (mm) in the study area from 1982 to 2016

The most significant cyclone on record was the devastating tropical cyclone Eline which affected Limpopo Province between 22 and 28 February 2000 and dumped more than 500 mm of rainfall in Tzaneen in a few days (Figure 4.3).

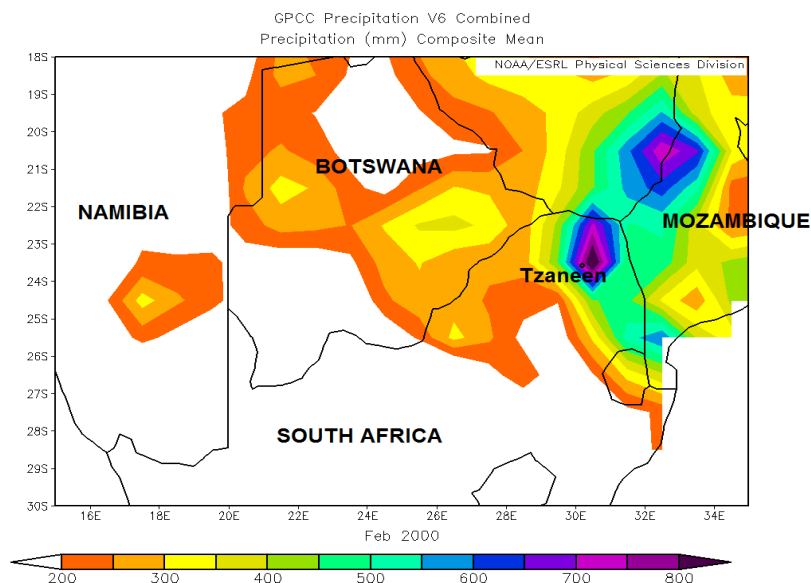


Figure 4.3 Heavy rainfall (shades of blue/purple) that affected Zimbabwe, Mozambique and South Africa during February 2000. Values in millimetres.

Heavy rainfall from ex-cyclone Bonita produced more than 240 mm in Tzaneen in 1996 (Figures 4.4) whilst tropical storms in January 2011 (Figure 4.5) and January 2013 (Figure 4.6) also resulted in excessive rainfall in Tzaneen and the surrounding areas.

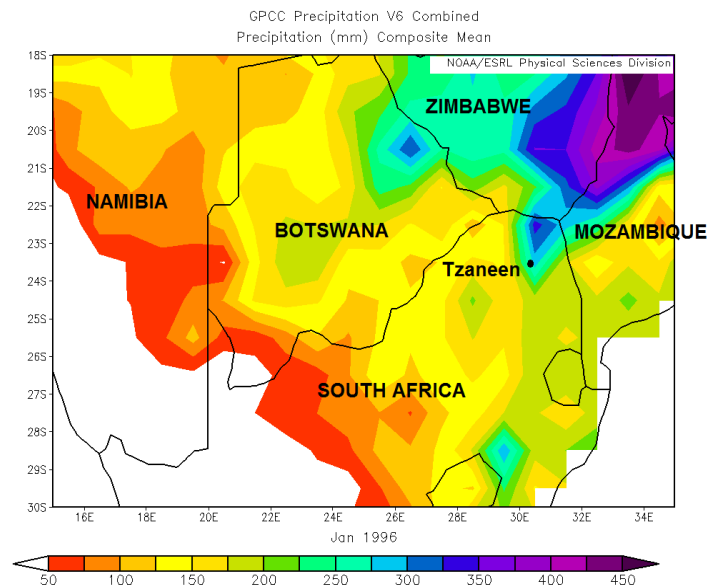


Figure 4.4 Heavy rainfall (in shades of blue/purple) that affected Mozambique, Zimbabwe and northeast South Africa during January 1996. Values in millimetres.

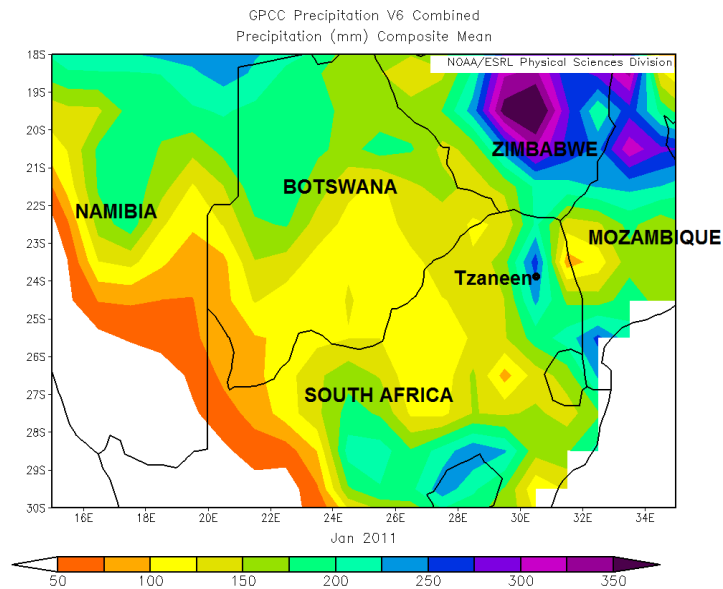


Figure 4.5 Heavy rainfall (in shades of blue/purple) that affected Zimbabwe, Mozambique and northeast South Africa during January 2011. Values in millimetres.

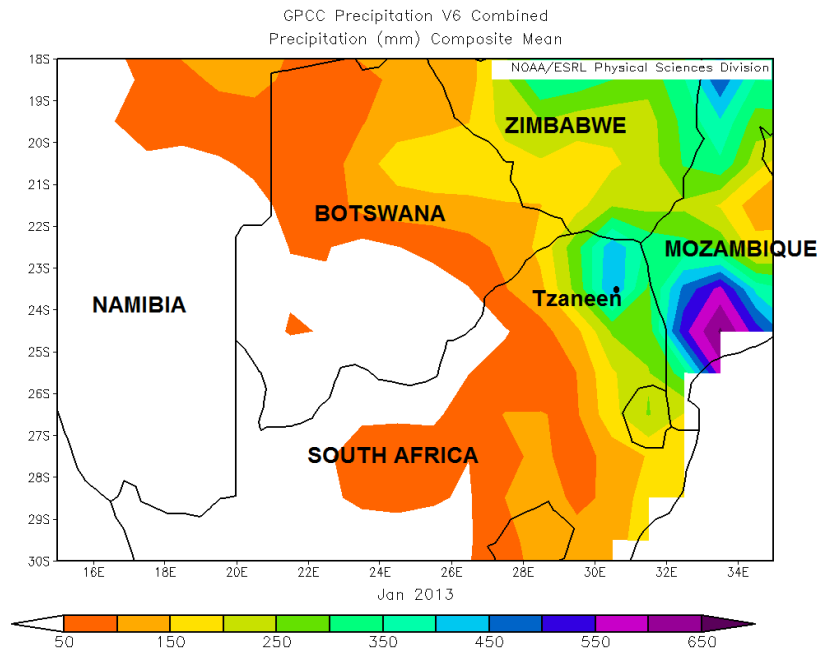


Figure 4.6 Heavy rainfall (in shades of blue/purple) that affected northeast South Africa and Mozambique during January 2013. Values in millimetres.

Besides flood periods, the Limpopo Province (and therefore the study area) is also vulnerable to droughts and heat waves which are often related to the occurrence of the El Nino phenomenon. Drought periods have affected the study area during periods such as 1991/92, 2015/16 whilst most of the cyclone landfalls and tropical lows have affected Tzaneen (and Limpopo) during the La Nina phase of the El Nino phenomenon. Thus, the study area has a high coefficient of variability with extremes of rainfall which may increase in future as a result of global warming and climate change.

4.3. Demographic structure of respondents

Gender plays a significant role in flood vulnerability. In many societies, women's access to resources and power is mediocre compared to that of men, hence they are more vulnerable to hazards than men. Figure 4.7 shows the respondents' men/women ratio in Ga-Kgapane Masakaneng to be 55% male and 45% female, Lenyenye 35% male and 65% female and Nkowankowa section C and B 35% male and 65% female. The social survey revealed that a majority of the respondents (61%) in the three study areas were female. In general, of the 61% females; 67% were heads of households; this revealed that most of the respondents were females heading their own households.

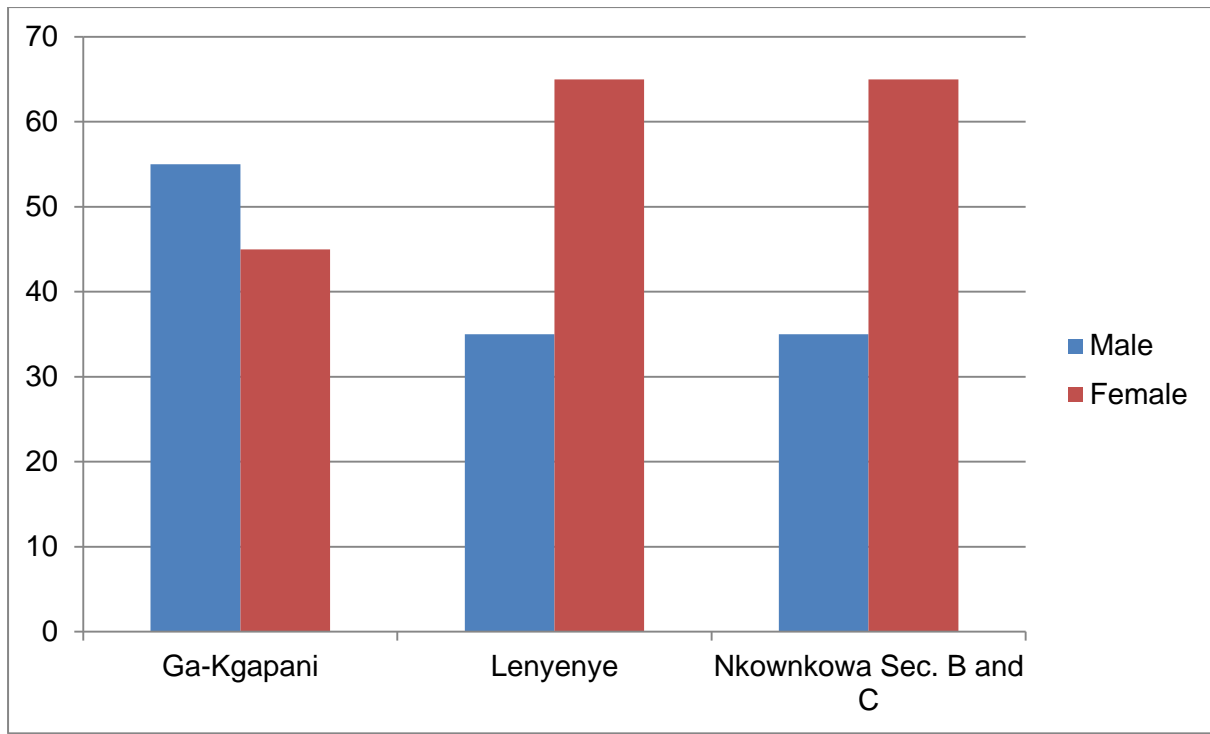


Figure 4.7: Gender of respondents in three villages.

Source: Social survey, 2016

Figure 4.8 indicates the age groups of the respondents who participated in this study. It is believed that senior citizens (above 64) and children (less than 14) are more vulnerable than youth and middle age groups. The age groups ranged from under 20 to above 50 years old, in the three study areas. In Ga-Kgapane Masakaneng most respondents (40%) were between 41 and 50 years old; Lenyenye shows that most of the respondents (50%) were above 50 years old and Nkownkowa with most respondents (31.7%) between 31 and 41 years old. The overall results of the three cases show that a majority of the respondents (27%) were between 31 and 40 years old. Few youth participated in this study, because most of the youth had migrated to urban areas for further education, employment and a better life.

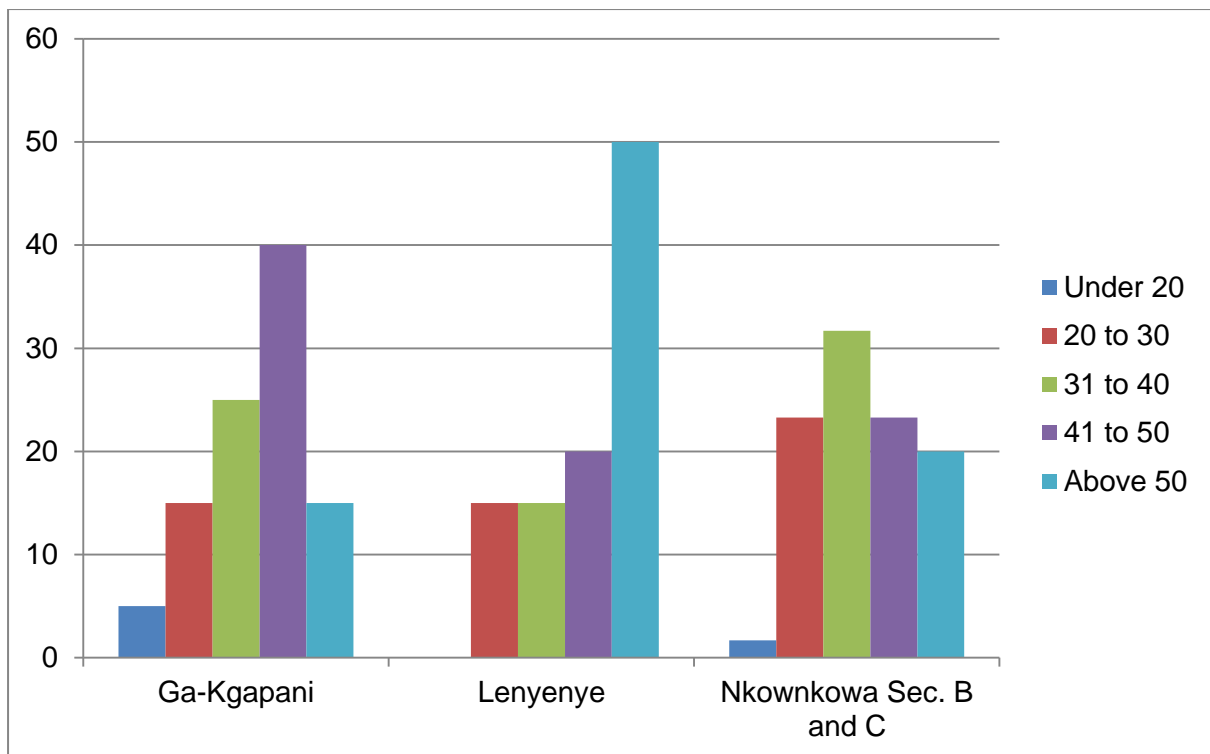


Figure 4.8: Age group of respondents in three villages.

Source: Social survey, 2016

Figure 4.9 indicates education levels of respondents in the three case study villages. Ga-Kgapane Masakaneng indicates that most respondents (40%) had primary and secondary school education; 15% had no formal education, and 5% had tertiary education. For Lenyenye, a majority of the respondents (45%) had secondary school education, 30% had no formal education; 20% had primary school education and 5% had tertiary education. Nkownkova section B and C reflects that most respondents (44.1%) had secondary school education; 28.8% had tertiary education; 16.9% had no formal education and 10.2% had not gone beyond pre-school. The social survey generally revealed that most of the respondents in this study had low education levels (secondary school education- 43.43%).

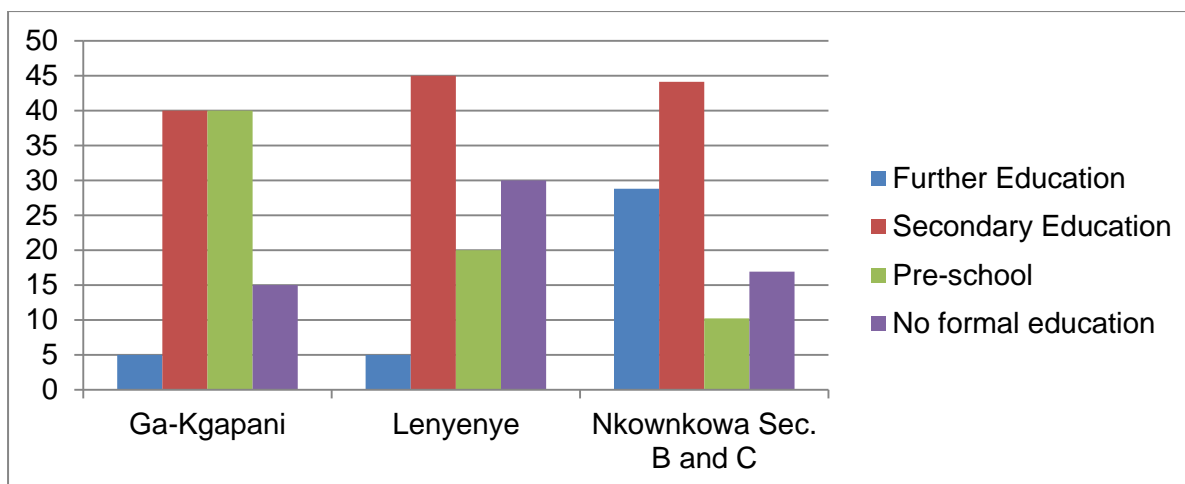


Figure 4.9: Education levels of the respondents in three villages.

Source: Social survey, 2016

Figure 4.10 shows the number of members in a household who had disabilities in the three case study villages. Generally, most of the respondents (84.3%) did not have a disabled member in their households. Ga-Kgapane Masakaneng shows that a majority of the respondents (80%) did not have a disabled person in their household and the remaining 20% had a disabled person in their households. In Lenyenye, a majority of the respondents (90%) did not have a disabled member in their household; 5% had one member who was disabled and 5% had more than three disabled members. Nkownkowa section B and C reflects that most of the respondents (83%) did not have a disabled member in their households; 8.3% had one disabled member and 3.3% had more than three disabled members.

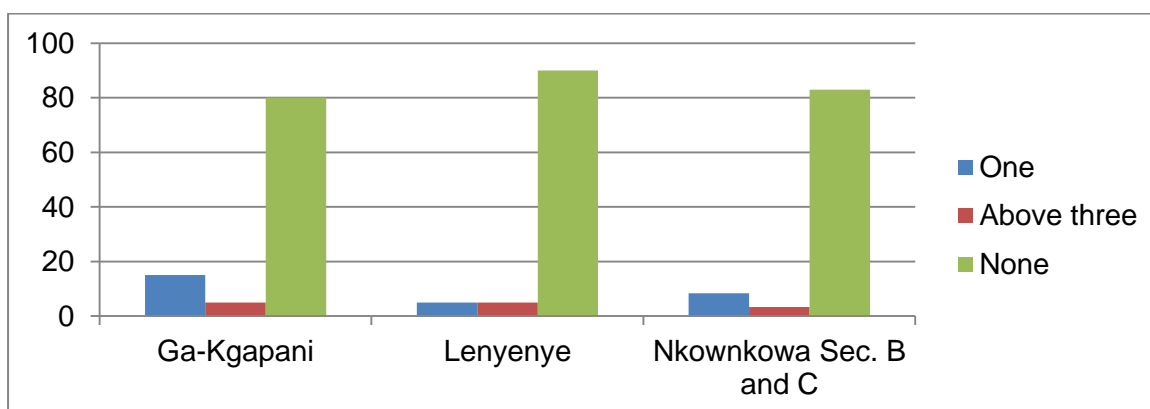


Figure 4.10: Members with disabilities in a household.

Source: Social survey, 2016

Figure 4.11 shows that most of the respondents (65%) in the three case study villages were single. Ga-Kgapane with 45% of the respondents who were single; 35% married; 10% widowed and the remaining 10% divorced. Lenyenye shows that majority of the respondents (50%) were single; 30% were married; 10% divorce and another 10% widow. Nkowankowa reflects that most of the respondents (43.3%) were single; 40% married; 15% widow and the remaining 1.7% were widow.

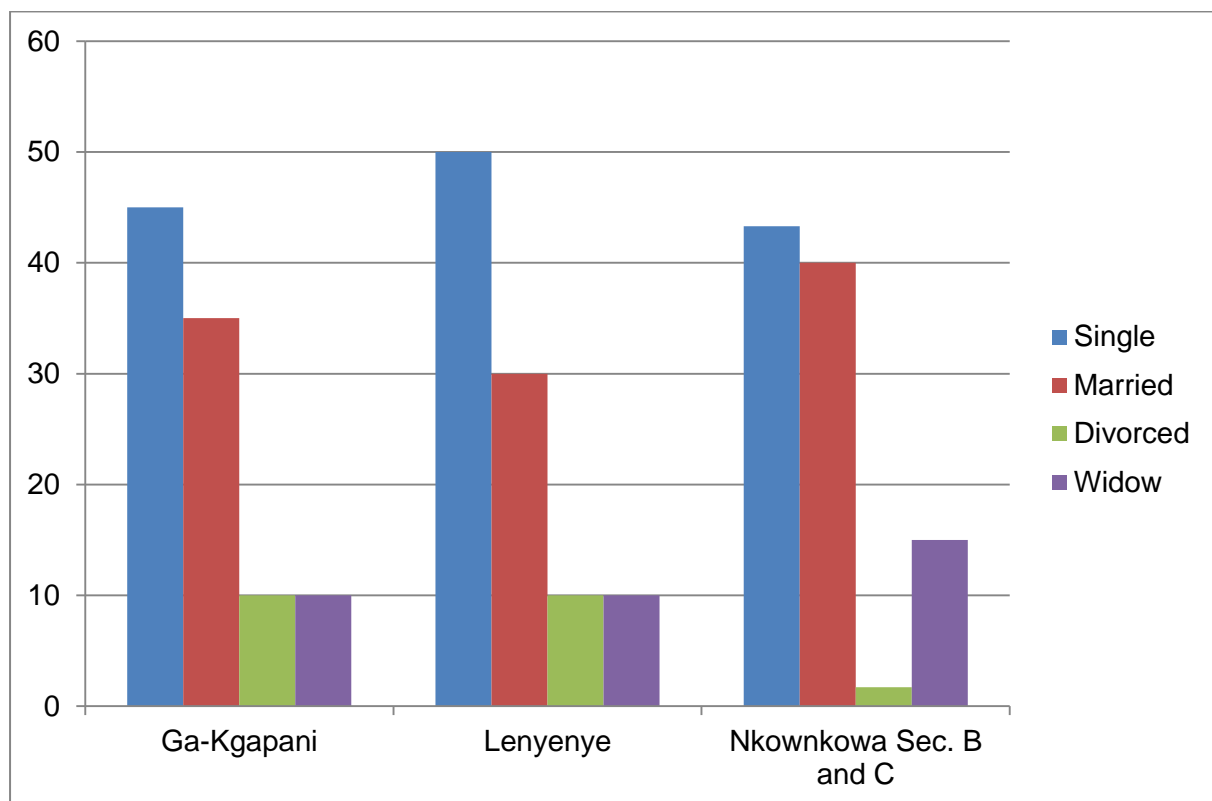


Figure 4.11: Marital status of the respondents in three villages.

Source: Social survey, 2016

Figure 4.12 shows that most of the respondents (66.8%) were unemployed in the three study areas. The survey indicated that a majority of the respondents (55%) were unemployed in Ga-Kgapane Masakaneng; 25% self-employed and 20% said that they were employed. For Lenyenye; 80% were unemployed; 20% were employed and none of the respondents were self-employed. Nkowankowa section B and C shows 65.5% as unemployed; 19% employed and 15.5% self-employed. Comparing the levels of unemployment and employment in this study revealed that the number of unemployed people was higher than that of employed and self-employed people. This simply means that there was a high rate of unemployment in these three villages.

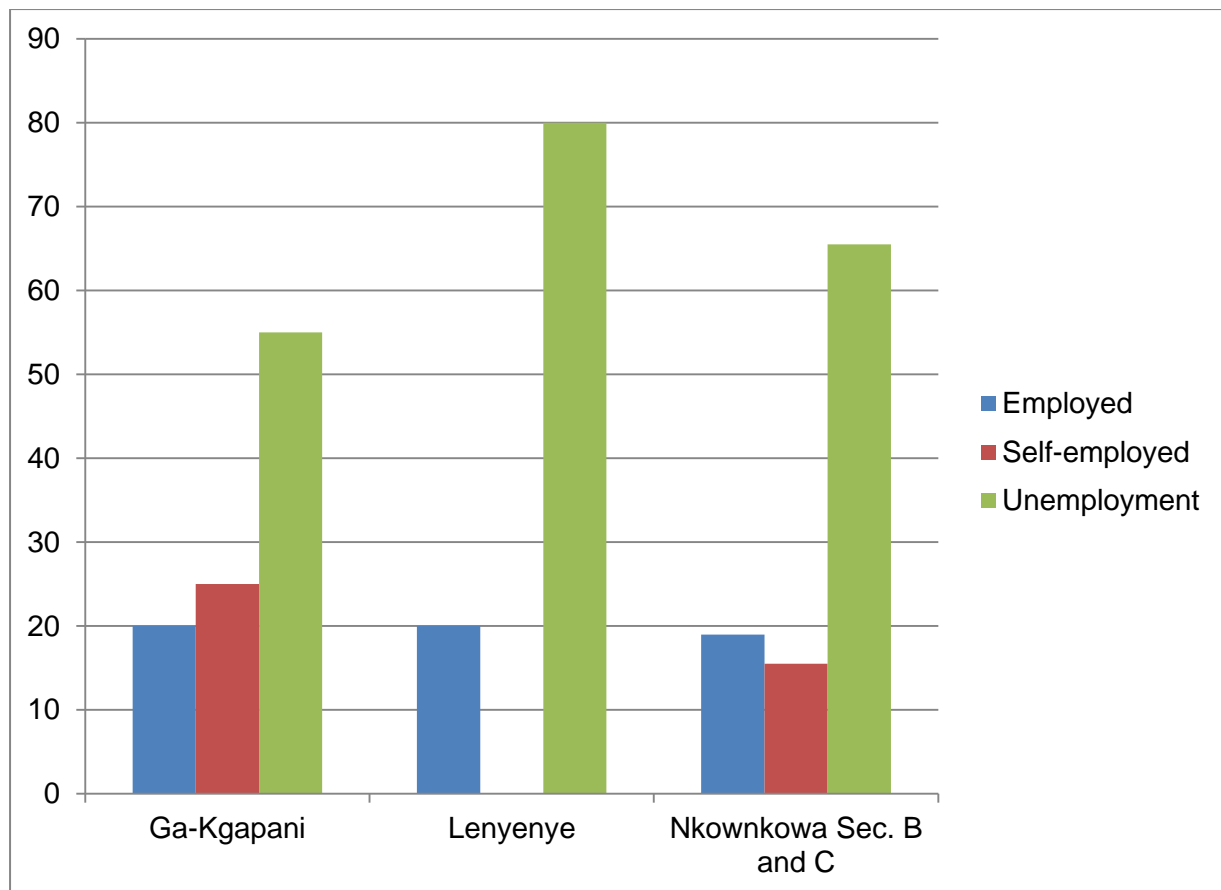


Figure 4.12: Percentage of respondents' employment.

Source: Social survey, 2016

Figure 4.13 shows the monthly income earned by household members in the three study areas. The survey revealed that most of the respondents (47.46%) in the three villages earned less than R1000 per month. Ga-Kgapane Masakaneng had 50% of the respondents in the income bracket of less than R1000; 44.4% in the R1000 to R5000 bracket; and 5.6% in the R5001 to R10000 bracket. Lenyenye, had 57.9% of the respondents in the income bracket of less than R1000; 21.1% in R1000 to R5000; 5.3% in R5001 to R10000 and between R10001 to R15000. Nkowankowa had 34.5% of the respondents in the income bracket of less than R1000; 44.8% in R1000 to R5000; 12.1% on R5001 to R10000; 6.9% in R10001 to R15000 and 1.7% earning above R15000.

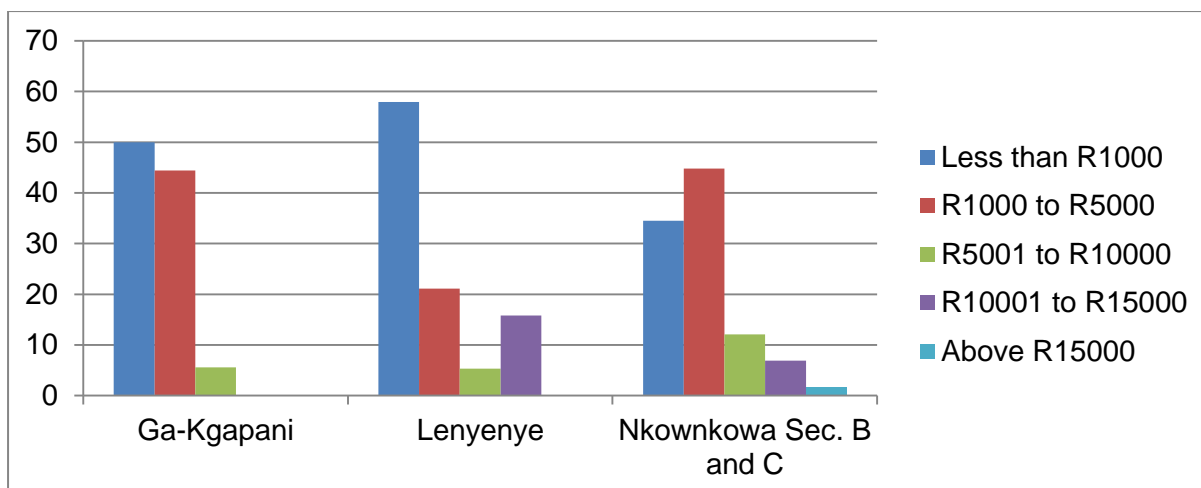


Figure 4.13: Household income of the respondents in three study areas.

Source: Field survey, 2016

Figure 4.14 shows that most of the respondents (48.63%) in the three study areas had between 3 to 4 members in a household. Ga-Kgapane Masakaneng had 20% of the respondents between 1 to 2 members in a household; 65% between 3 to 4 members and 15% have between 5 to 6 members. For Lenyenyé, 45% had 1 to 2 members per households; 25% had between 3 to 4 members; 20% in between 5 to 6 members and 10% had above 7 members in a household. Nkownkowa section B and C had 27.1% of the respondents with between 1 to 2 members; 55.9% with 3 to 4 members; 15.3% with 5 to 6 members and 1.7% had members above 7 per household.

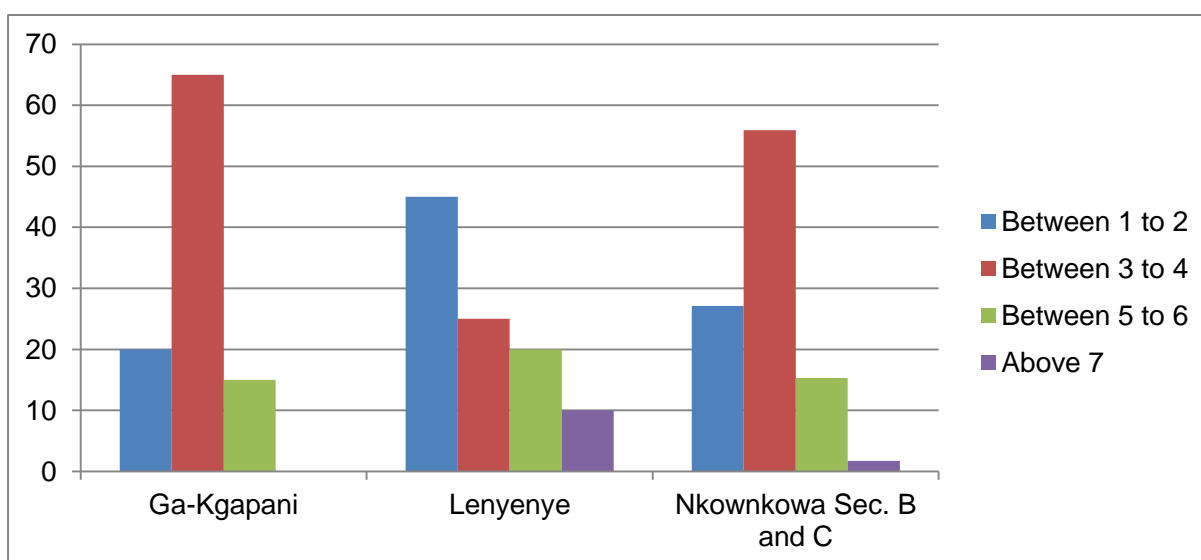


Figure 4.14: Family size in a household for the three study areas

Source: Social survey, 2016

4.4. Factors that determine flood vulnerability

To establish factors that determine flood vulnerability in Lenyenye, Ga-Kgapane Masakaneng and Nkowankowa Section B and C; a questionnaire was distributed to households to identify determinants of flood vulnerability. Households were also asked to rank all the identified factors from the most significant to the least significant. The main objective of ranking the factors was to assess the significance of each factor in determining flood vulnerability for each community. Factor analysis was used to analyse factors that determine flood vulnerability.

For each study area, all factors are presented in the form of a pie chart with the percentage of their ranking; from the most significant to the least significant. Therefore the higher the percentage of a factor, the more significant it is in determining flood vulnerability.

Figure 4.15 shows factors that determine flood vulnerability and their rankings in Ga-Kgapane Masakaneng. Most the respondents (38% of 100%) considered 'Lack of drainage system' as the most significant factor determining flood vulnerability in Ga-Kgapane Masakaneng. Dwelling quality was the second significant factor with 24%; 14% for rainfall and topography as the third and the least significant was employment status with only 10%. The reason why lack of drainage system was the most significant is because there was no drainage system at all. Therefore during rainfall flood water did not have a proper channel to flow but accumulated in households and un-drained streets.

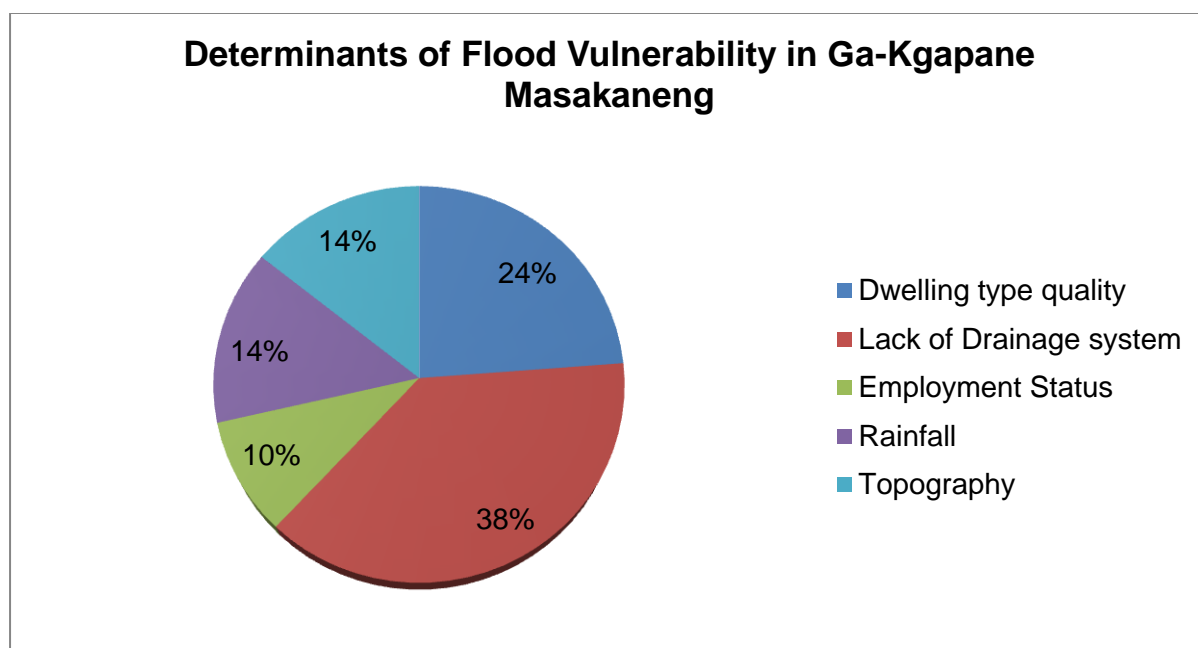


Figure 4.15: Factors that determine flood vulnerability in Ga-Kgapane Masakaneng

Social: Field Survey

The figure 4.16 below shows the street in Ga-Kgapane Masakaneng where there is no proper road and drainage system to control water during rainfall.



Figure 4.16: Lack of drainage system in Ga-Kgapane Masakaneng Street

Source: Field survey, 2016

The Road and storm-water manager of Greater Letaba Disaster management Section mentioned that lack of drainage systems led to the development of dongas around people's houses, posing more hazard than just floods. "I filled some of the open dongas around people's houses myself," said the Road and storm-water manager. Figure 4.17 indicates the donga around one of the households in Ga-Kgapane Masakaneng. The critical point discussed by the Road and storm-water manager was that Ga-Kgapane Masakaneng was not supposed to be a residential area because it had previously been used as a dumping site, but people occupied the area unlawfully. Figure 4.18 shows the dumping materials that have been uncovered by people to occupy the area.



Figure 4.17: A Donga around houses in Ga-Kgapane Masakaneng

Source: Field Survey, 2016



Figure 4.18: Dumping materials around houses in Ga-Kgapane Masakaneng

Source: Field survey, 2016

Most respondents from Lenyenye (50%) considered ‘poor drainage system’ as the most significant factor determining flood vulnerability in the area (Figure 4.19). Rainfall was the second significant factor with 25%, topography the third with 10% and the least significant factors were dwelling quality, employment status and education level all at 5%. Poor drainage system was considered the most important factor because there on the existing was not well maintained, thus exacerbating flood vulnerability.

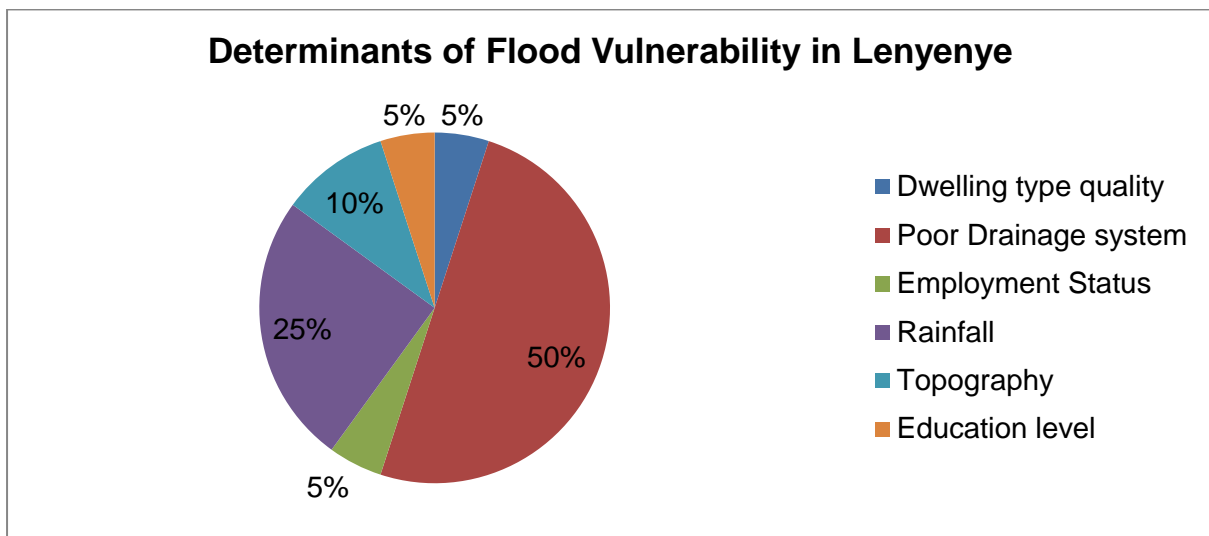


Figure 4.19: Factors that determine flood vulnerability in Lenyenye

Source: Field survey, 2016

Figure 4.20 shows roads in Lenyenye where the drainage system was poor due to lack of proper maintenance. The problem of drainage system worsened the flood vulnerability in this area; both pedestrians and drivers experienced the problem of floods. Instead of water flowing through bridges and small channels within the drainage system, the water was blocked and the movement was hindered, causing overflows; flooding the entire road.

Another problem was that; school-going children found it hard walk to school during rainfall. “The speed of flood water is high (downstream) and young children can be overpowered by water,” said the Acting Director of MDDMC. The Director also mentioned that the drainage system of Lenyenye was filled with small stones and litter, making it difficult for water to flow smoothly.



Figure 4.20: Poor drainage system on Lenyenye's roads.

Source: Field survey, 2016

For Nkowankowa section B and C, most of the respondents (36%) said that poor drainage system was the most significant factor that determined flood vulnerability, the second significant factor was topography with about 34%, employment status was the third with 16%, the fourth significant was dwelling quality with 8%, rainfall was the fifth with 4% and the least significant was education with 2%. Figure 4.21 presents all factors that determine flood vulnerability in Nkowankowa section B and C. Lack of maintenance on drainage system was a key problem that exacerbated flooding in Nkowankowa.

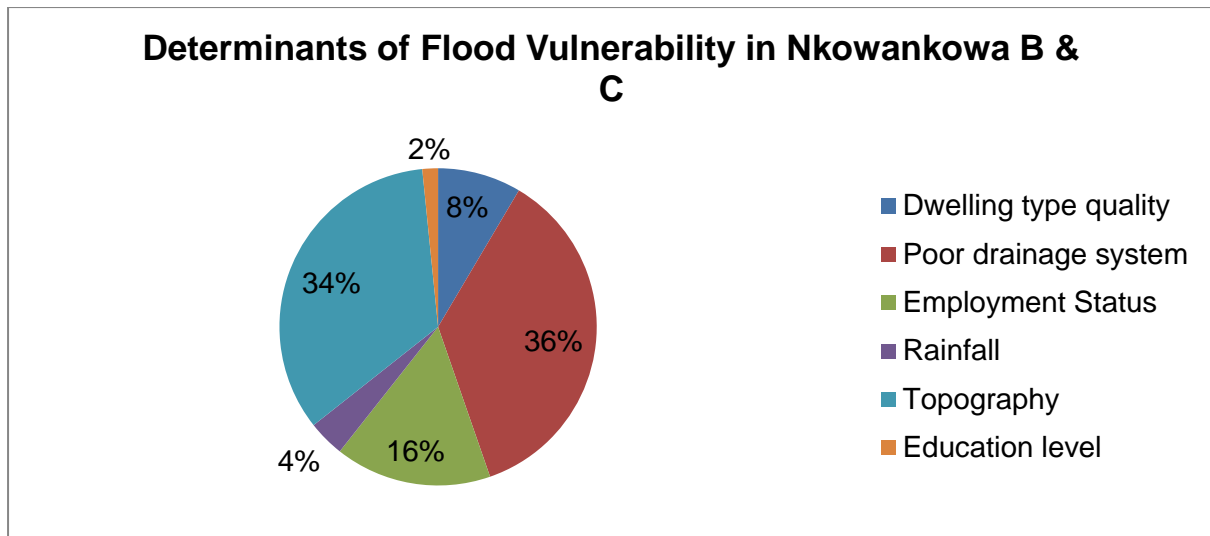


Figure 4.21: Factors that determine flood vulnerability in Nkowankowa section B and C.

Source: Field survey, 2016

It is clear that poor drainage system was a dominant factor in determining flood vulnerability on Nkowankowa according to the respondents (Figure 4.22). However, the second most significant factor (topography) should not be overlooked since the variation between the ranking of topography and poor drainage is 2%. Topography is as significant as poor drainage system. The whole village of Nkowankowa is flat, during heavy rainfall it appears like a big dam holding flood water on the streets, gardens and roads. Figure 4.23 indicates the problem of flat-topography in Nkowankowa.



Figure 4.22: Municipal workers draining water due to poor drainage system in Nkowankowa.

Source: Field survey, 2016



Figure 4.23: Flooded Street in Nkowankowa due to both flat topography and poor drainage system.

Source: Field Survey, 2016

The Risk assessment manager of MDDMC said that Nkowankowa section B and C are flat areas and most of the people occupied land that was not suitable for residential purposes. Floods affected all households residing in such places. These places did not have a drainage system and streets were not well planned, most respondents who resided in these places complained about house cracks and collapsed houses.

4.5. The level of flood vulnerability

Flood vulnerability Index was used to measure the levels of flood vulnerability in the three study areas. Vulnerability was also measured in all dimensions; social, economic and physical environment for each study area. Table 4.1 shows selected indicators, components and factors of flood vulnerability and their function or relationship with flood vulnerability.

Twenty-six indicators were selected in the three study areas; the information about indicators were collected from the Mopani District Disaster Management Centre, Director of MDDMC, Greater Tzaneen Disaster Management Section, Greater Letaba Disaster management Section, South African Weather Service, Household questionnaires and Census 2011. It was found that data or information about soil moisture and ground-water level indicators were not available. These two indicators, therefore couldn't be part of the flood vulnerability index even though they were significant in these study areas. The researcher used the deductive

approach adopted from Balica (2012) and Veenstra (2013). However in this study, the deductive approach was supplemented by preliminary survey for relevancy of selected indicators.

4.1: Flood Vulnerability Index; selected indicators in Nkowankowa section B and C, Lenyenye and Ga-Kgapane Masakaneng

Indicators	Components	Factors	Function/relationship with vulnerability
Frequency of Flood Occurrence	Physical	Susceptibility	Higher number of occurrences/ year, higher vulnerability
Evaporation Rate	Physical	Susceptibility	Higher the evaporation, lower vulnerability
Unemployment	Economic	Susceptibility	Higher % , higher vulnerability
Dwelling quality	Economic	Susceptibility	Poor quality(mud material), high vulnerability
Infrastructure quality (e.g. roads, storm drainage)	Economic	Susceptibility	Higher % of good quality dwelling, lower vulnerability
Preparedness/Awareness	Social	Susceptibility	Higher number of people aware, lower vulnerability
Education level	Social	Susceptibility	Higher number of people uneducated, higher vulnerability
Disabled People	Social	Susceptibility	Higher number of disabled, higher vulnerability
Number of days with heavy rainfall	Physical	Exposure	Higher number of days, higher vulnerability
Topography	Physical	Exposure	The flatter/low lying area of

			the slope, higher vulnerability
Household income	Economic	Exposure	High household income, low vulnerability
Maintenance of Infrastructure	Economic	Exposure	High maintenance, lower vulnerability
Population Density	Social	Exposure	Higher number of people, higher vulnerability
Population growth	Social	Exposure	Fast PG, higher vulnerability.
Dam and storage capacity/quality	Physical	Resilience	Higher capacity, lower vulnerability
Floods Recovery Time	Physical	Resilience	High recovery time, less vulnerability
Dam and storage capacity	Economic	Resilience	Higher capacity, lower vulnerability
Economic Recovery	Economic	Resilience	High economic recovery, less vulnerability
Response team	Economic	Resilience	Effective response team, lower vulnerability
Early Warning system	Social	Resilience	Having WS reduces the vulnerability
Emergency service	Social	Resilience	Efficient ES, lower vulnerability
Evacuation Route	Social	Resilience	Better quality of roads, improve quality evacuation
Past experience	Social	Resilience	Higher number of people with PE, lower vulnerability.

Source: Filed Survey, 2016

Flood vulnerability Index scale was used; 0 representing the lowest vulnerability and 1.0 the highest vulnerability to floods. The formula of FVI is as follows:

Flood vulnerability is equals to; Exposure plus Susceptibility minus Resilience

$$\text{FVI} = (\text{E} + \text{S}) - \text{R}$$

$$\text{FVI}_{\text{physical}} = [\text{FO}, \text{Er} + \text{Rainfall FH}, \text{T}] - [\text{DSC}, \text{FRT}]$$

FO: Frequency of Flood Occurrence; **Er**: Evaporation Rate; **H Rainfall**: Number of days with Heavy Rainfall; **T**: Topography; **DSC**: Dam and Storage Capacity/quality; **FRT**: Floods Recovery Time

$$\text{FVI}_{\text{Economic}} = [\text{Um}, \text{Dq}, \text{Iq} + \text{Hi}, \text{Mi}] - [\text{DSC}, \text{Ecor}, \text{Rt}]$$

Um: Unemployment; **Dq**: Dwelling quality; **IQ**: Infrastructure quality; **Hi**: Household income; **Mi**: Maintenance of Infrastructure; **DSC**: Dam and Storage Capacity/quality; **Ecor**: Economic recovery; **Rt**: Response Team

$$\text{FVI}_{\text{Social}} = [\text{P/A}, \text{Ed}, \text{Dp} + \text{Pd}, \text{Pg}] - [\text{Ws}, \text{Es}, \text{Evr}, \text{Pe}]$$

P/A: Preparedness/Awareness; **Ed**: Education Level; **Pd**: Population Density; **Pg**: Population Growth; **Ws**: Early warning System; **Es**: Emergency service; **Evr**: Evacuation Route; **Pe**: Past Experience

Table 4.2 shows flood vulnerability of Ga-Kgapane Masakaneng; the economic component indicates High vulnerability to foods, while physical shows small vulnerability to floods, both economic and social dimensions show ‘vulnerable to floods’ level. Economic component scored higher vulnerability than physical and social components in Ga-Kgapane. This means that flood vulnerability in Ga-Kgapane Masakaneng was exacerbated by their economic state or characteristics; where most of the respondents were unemployed and those employed earned a low income. The Ga-Kgapane Masakaneng should pay more attention to economic factors to mitigate flood vulnerability. Generally, Ga-Kgapane had ‘vulnerability to floods’ level (Table 4.2).

Table 4.2: Flood vulnerability levels in Ga-Kgapane Masakaneng

Ga-Kgapane Masakaneng Flood Vulnerability		
FVI Components	FVI Values	FVI Designation
FVI physical	0.20	Small vulnerability to floods impacts
FVI Economic	0.52	High vulnerability to floods impacts
FVI Social	0.27	Vulnerability to floods impacts
FVI Total or General	0.34	Vulnerability to floods impacts

Source: Field Survey, 2016

Table 4.3 shows that for Lenyenye, the physical component has the smallest vulnerability to floods whereas economic and social components obtained 'vulnerability to floods' level. It was found that the social and economic components worsen the flood vulnerability impacts in Lenyenye village. More efforts should focus in the socio-economy of this village to reduce and mitigate floods. The overall level of flood vulnerability of Lenyenye is shown in table 4.3 as 'Vulnerability to floods.'

Table 4.3: Flood vulnerability levels in Lenyenye

Lenyenye Flood Vulnerability		
FVI Components	FVI Values	FVI Designation
FVI physical	0.14	Small vulnerability to floods
FVI Economic	0.38	Vulnerability to floods
FVI social	0.40	Vulnerability to floods
FVI Total or General	0.34	Vulnerability to floods

Source: Field survey, 2016

Table 4.4 indicates flood vulnerability levels in Nkowankowa section B and C. The index values of the economic and social dimensions show that they have ‘vulnerability to floods’ level. The Physical dimension in Nkowankowa scored higher vulnerability than both economic and social dimensions with ‘high vulnerability to floods’ level. This means that the physical component is more significant in the flood vulnerability of Nkowankowa, especially the topography; which is very flat and allows huge amounts of flood water to accumulate in this area (Figure 4.23). However, the overall level of vulnerability is ‘vulnerability to floods.’

Table 4.4: Flood vulnerability levels in Nkowankowa section B and C

Nkowankowa Section B and C Flood Vulnerability		
FVI Components	FVI Values	FVI Designation
FVI physical	0.58	High vulnerability to floods
FVI Economic	0.39	Vulnerability to floods
FVI social	0.34	Vulnerability to floods
FVI Total or General	0.40	Vulnerability to floods

Source: Field survey, 2016

Table 4.5 and figure 4.24 indicate comparative analysis of flood vulnerability results between the three study areas. Nknowankowa village is indicated to be more vulnerable to flood than the other two study areas. Meanwhile the difference between Lenyenye and Ga-Kgapane is slightly even though Lenyenye seems to be a little more susceptible. Nkowankowa is more vulnerable because is characterized by low-altitude.

Table 4.5: Comparative analysis of flood vulnerability index between the study areas

Comparative Analysis of Flood Vulnerability Index			
FVI Components	FVI Values		
	Ga-Kgapane	Lenyenye	Nkowankowa B and C
FVI Physical	0.20	0.14	0.58
FVI Economic	0.52	0.38	0.39
FVI Social	0.27	0.40	0.34
FVI Total or General	0.34	0.36	0.40

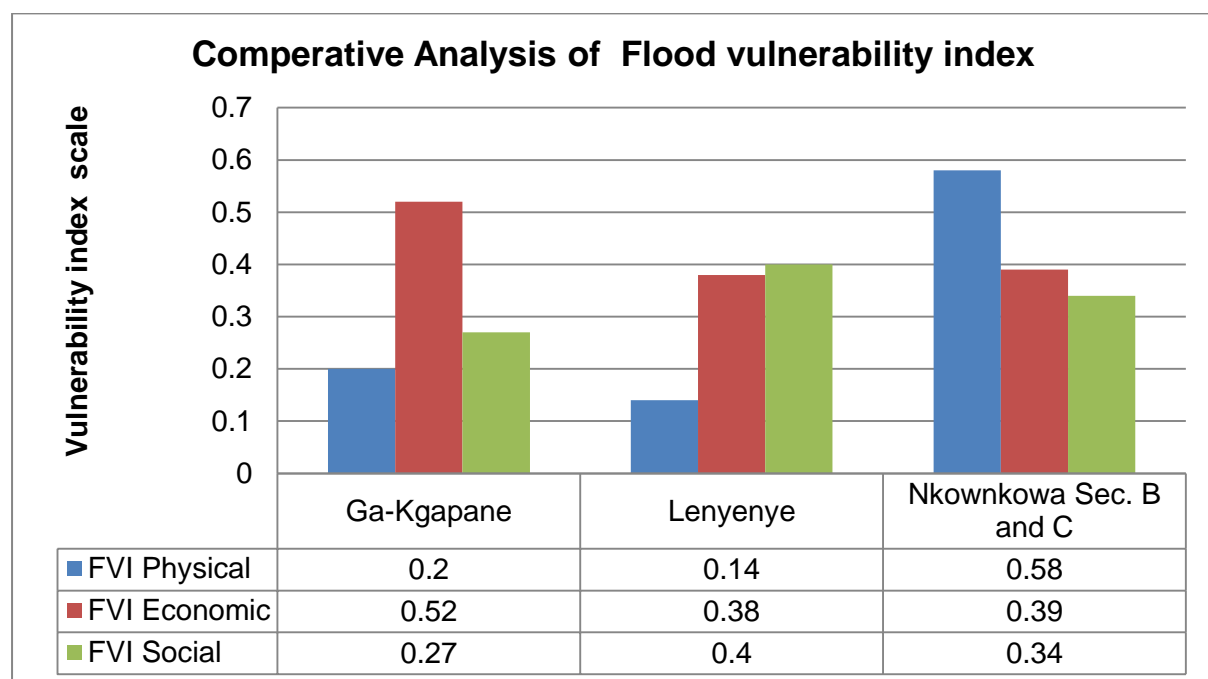


Figure 4.24: Comparative analysis of flood vulnerability index between the study areas.

4.6. Flood coping strategies

Floods caused severe damages in Ga-Kgapane, Nkowankowa and Lenyenye. Households were seriously affected; some of the houses were flooded, some individuals drowned, rivers spilled and overflowed, and certain roads were cut off or closed. The Social survey, key informant interviews and field observations were main instruments to identify flood coping strategies in all the three study areas. Households and key informants (government officials) were also asked to rank all identified coping strategies according to their preference.

Table 4.6 shows community's coping strategies in Ga-Kgapane Masakaneng, most of the respondents (30.5%) preferred to make 'Le-guba' (a small wall surrounding a house: see Figure 4.19), the second (23.7%) preferred coping strategy was sand-bags; 22% preferred a furrow around houses and on roads; the fourth (10.2%) preferred coping strategy was temporary relocation; the fifth and sixth (5.1%) preferred coping strategies were relocating to a safer area and building protective walls around homes and terraces in fields. The least (3.4%) preferred coping strategy was building houses with stone and cement.

Table 4.6: Households coping strategies in Ga-Kgapane

Household floods coping strategies in Ga-Kgapane Masakaneng	Preference %
Making 'Le-guba' around houses	30.5
Sand-bags	23.7
Making a furrow around houses and on roads	22
Temporary relocation	10.2
Relocating to a safer area	5.1
Building protective wall around home and terraces in fields	5.1
Building house with stone and cement	3.4

Source: Social survey, 2016

Figure 4.25 shows 'Le-guba' surrounding houses in Ga-Kgapane Masakaneng, this indicates that most of the respondents built 'Le-guba' to cope with floods. The road and storm water management in Ga-Kgapane Masakaneng said that the best way to deal with floods in Ga-Kgapane was to relocate people because the area was not meant for residential purposes and it had previously been used as a dumping site. However, due to high population growth,

this would not be a simple task. The Acting Director of Mopani District Disaster Management Centre also mentioned that as the population was increasing, it was better to build a drainage system and well built houses to prevent further damage. This was because most of the respondents were not willing to relocate.

The government built some RDP houses in Ga-Kgapane Masakaneng but the main problem was the quality and the location of the area. Many RDP (Reconstruction and Development Programme) houses had been damaged by flood water and households were at risk and vulnerable to floods. Figure 4.26 shows an RDP house which is severely damaged and requires serious attention. The foundation and slab of this house are exposed to floods.



Figure 4.25: Le-guba surrounding respondents' households in Ga-Kgapane Masakaneng.

Source: Field survey, 2016



Figure 4.26: One of the houses which is at risk in Ga-Kgapane Masakaneng.

Source: field survey, 2016

In Lenyenye, 27.8% of the respondents preferred to make 'Le-guba', the second (22.2%) preferred coping strategy was making furrow around houses and on roads; 16.7% preferred to relocate temporarily; the fourth preferred coping strategy was sand-bags (13.9%); the fifth preferred coping strategy was building protective walls around homes and terraces in fields (8.3% of respondents). Relocating to a safer area occupied the sixth (5.6%) position. The least (5.5%) preferred coping strategy was building houses with stone and cement (Table 4.7).

Table 4.7: Households coping strategies in Lenyenye *Source: Social survey, 2016*

Household floods coping strategies in Lenyenye	Preference %
Making 'Le-guba' around houses	27.8
Making a furrow around houses and on roads	22.2
Temporary relocation	16.7
Sand-bags	13.9
Building protective wall around home and terraces in fields	8.3
Relocating to a safer area	5.6
Building house with stone and cement	5.5

Source: Social survey, 2016



Figure 4.27 indicates 'Le-guba' surrounding the respondents' houses in Lenyenye.

Source: Field survey

Table 4.8 presents various coping strategies in Nkowankowa section B and C. The survey revealed that a majority of the respondents (26.8%) preferred making a furrow around houses. Making 'Le-guba' around houses was the second (23%) preferred strategy; sand-bags was the third (20.7%); the fourth (15%) was temporary relocation; the fifth (9.4%) was building protective walls around homes and terraces in fields; relocating to a safer area occupied is the sixth (3.3%) preferred and the least (0.9%) preferred coping strategies were building houses with stone and cement and constructing a personal drainage system.

Table 4.8: Households coping strategies in Nkowankowa section B and C *Source: Social survey, 2016*

Household floods coping strategies Nkowankowa section B and C	Preference %
Making a furrow around houses and on roads	26.8
Making 'Le-guba' around houses	23
Sand-bags	20.7
Temporary relocation	15
Building protective wall around home and terraces in fields	9.4
Relocating to a safer area	3.3
Building house with stone and cement	0.9
Personal drainage system	0.9

The Acting Director of MDDMC stated that there were three ways in which floods could be mitigated in Nkowankowa section B and C by re-constructing and improving the drainage system to cater new residential areas, building RDP houses for individuals who built their houses with mud and relocating individuals occupying unauthorized land. The survey also indicated that there were respondents who did not receive any help from the government. Residing in an unauthorized area might be one of the reasons why they did not receive help during flood events.

Figure 4.28 shows a furrow on the street as a way in which the Nkowankowa community coped with floods. However, when floods are intense; this coping strategy tends to exacerbate the impacts of floods. This is because flood water can wash away soil easily if it rains for continuous periods of time.



Figure 4.28: A furrow on a street in Nkowankowa

Source: Field survey, 2016

The storm water manager in Nkowankowa indicated that sometimes they were compelled by the situation to drain water from the streets and local roads (Figure 4.22). However, some individuals dug furrows to channel the water away from their houses. This also created problems for neighbours, because large amounts of the redirected flood water could flood somebody else's house. Figure 4.29 shows a furrow or channel draining water away from a household in Nkowankowa.



Figure 4.29: A furrow to redirect flood water away from a household in Nkowankowa

Source: Field Survey, 2016

4.7. Chapter summary

The three study areas frequently experienced floods. The factors determining flood vulnerability were a poor or lack of drainage system, and notably the topography in Nkowankowa. All the three study areas had equal levels of flood vulnerability; the difference was notable on their dimensions. The vulnerability level of Nkowankowa, Lenyenye and Ga-Kgapane Masakaneng was indicated as 'Vulnerability to Floods.' Even though these areas were entirely vulnerable to floods, respondents had ways of coping with the floods. Making 'Le-guba', sand-bags and furrow around houses and roads were applied more often than any other coping strategies. The findings of the study and recommendations are discussed in the next chapter.

CHAPTER 5: DISCUSSION OF THE FINDINGS

5.1. Introduction

This chapter discusses the findings of the study of flood vulnerability and adaptation study. The specific objectives were to assess determinants of flood vulnerability, as well as to measure levels of vulnerability and coping strategies to floods in Nkowankowa Section B and C, Lenyenye and Ga-Kgapane Masakaneng. It also includes related literature for comparison and validation of the findings. The relationship between the socio-economy, physical environment and extent of flood vulnerability will be thoroughly discussed. The mean rainfall and its variability from year to year are discussed in relation to flood vulnerability.

5.2. Vulnerability and Socio-Economic Profile

The relationship between the socio-economic profile and flood vulnerability shaped the flood vulnerability levels in this study. There is a link between natural hazards and demographic structure of the affected societies. Although the physical environment is the primary cause of floods, individuals with their socio-economic characteristics have a certain degree of control over flood damages (Botzen et al., 2009).

There are various demographic characteristics that exacerbate flood vulnerability such as: age, high poverty levels, illiteracy and lack of education, lack of employment, and level of household income. Gender is one of the most significant variables. A majority of the respondents in this study were female and they had low education level. Gender and the level of education of respondents in this study revealed that the three study areas were vulnerable to floods. This is because gender plays a crucial role on the vulnerability of individuals in a community. Walker (1994) stated that females are more vulnerable to floods in comparison with males. Women do not have equal access to resources as men and that decreases their resilience capacity.

This suggests that women are more disadvantaged than men. Muller et al. (2011) noted that women were also too emotional. During floods events women were likely to display emotions due to the probability of loss of life, damages to properties and others impacts of floods. Women are the most affected by disasters not just in their reproductive roles, but also in their roles as producers in the economy and providers for their families (Walker, 1994). Nevertheless, this does not spare men's vulnerability to floods.

This study also revealed that respondents who were severely affected by floods were females. However Ariyabandu and Wickramasighe (2005: 26) pointed out that even though women are often more vulnerable to disasters than men they are not just helpless victims as often represented. Women's strengths and capacity of coping with flood hazards have been overlooked. Thus ignorance of gender differences has led to insensitive and ineffective relief operations that largely bypass women's needs and their potential to assist in mitigation and relief work (Yande, 2009). The integration of men's abilities with women's strengths to resist floods can increase the resilience capacity of many societies against floods.

Yande (2009) noted that disability is an important factor affecting people's vulnerability. Vulnerability to any hazard is not just a natural construct but it is also socially constructed. It was found in this study that most of the respondents (84.33%) did not have disabled members in their households, and this slightly improved their resilience. This is because the more disabled members in a community, the more vulnerable the community is; disabled individuals face obstacles when it comes to coping with floods such as evacuating to a safer area, temporary relocation, building sand-bags and others. This was however not a major problem in the study area.

Education levels and age play are important determinants of floods vulnerability. A majority of the respondents in this study had low levels of education. Balica (2009) noted that low level of education or literacy increases vulnerability to a hazard. There is a great link between the level of education and social status; most educated people have better knowledge about natural hazards hence their abilities to mitigate and resist hazards. Munyai (2015) concluded that education level determines flood vulnerability; this conclusion was based on cross tabulation between respondents who were severely affected by floods in 2014 at Hamutsha-Muongamunwe in Makhado municipality. Most of the individuals without formal education were aged. However, one can argue that aged people should not be overlooked due to their age and lack of education. They are custodians of indigenous knowledge and have developed coping strategies to floods through experience; this a key tool to adapt and cope with floods.

A majority of the respondents were between 31 and 40 years old; this is an economically active group, which reduces their vulnerability to floods. The physical conditions and financial dependency of the aged and children exacerbate vulnerability to floods (Cutter et al., 2003; Haki et al., 2004; Schneiderbauer, 2007). Vulnerability was minimized in this study due to the majority of the respondents being middle aged.

Most of the respondents in this study (Nkownkowa Section B and C, Lenyenye and Ga-Kgapane) were single, constituting 75%; this included widows, singles, and widowers. This

finding shows that these three study areas were susceptible to floods. Rabalao (2010) noted that single respondents are vulnerable to floods because when floods occur they do not have a partner to turn to for assistance. The conclusion was based on the assistance required when immediate coping mechanisms were needed. Therefore individuals with partners are less vulnerable to floods.

Employment status of any given society is significant for economic growth and development. This also affects flood vulnerability in terms of response and recovery. The vulnerability levels of an unemployed person and an employed person vary; having more resources increases the capacity to cope. Therefore, high employment rate strengthens resilience of a society and low employment weakens the resilience of a society. Most of the respondents in this study were unemployed. A few members in the households were employed and employed individuals earned a low income: less than R1000 per month. Respondents were more vulnerable because any damage to their properties would be difficult to recover. Low income also means that one does not have enough resources or materials to prepare oneself before floods.

Dau (2010) noted that employment shapes the lives of individuals and groups as it also shapes the way of living due to financial strength or weakness. However, Dau (2010) was more interested in the employment status of individuals than their earnings. One can argue that financial advantage is when you are employed and earn a high income the disadvantages come when you are employed but earn a low income or you are not employed at all. This is because employment status and income are related to the ability of a household to save money and prepare for flood events.

The demographic structure of the respondents clearly shows that flood vulnerability is not only a naturally constructed issue but it is also socially constructed. Both natural and social vulnerability are significant in the assessment of flood vulnerability. Conditions of vulnerability are a combination of factors that include poor living conditions, lack of power, exposure to risk and the lack of capacity to cope with shocks and adverse situations (Yande, 2009). Most hazards are natural phenomena but disasters are socially constructed.

5.3. Determinants of flood vulnerability

There are various ways of assessing factors that determine flood vulnerability; they can be identified through field or social surveys. Both social and field surveys were used to identify determinants of flood vulnerability in this study. All four components of flood vulnerability should be considered when assessing determinants factors. Although floods are natural phenomena; the physical environment and socio-economic conditions play a crucial role to determine the effects of flood vulnerability. Human behaviour and uncontrolled activities with increased population growth worsen the damages that are caused by floods. It was noted from previous studied that most of floods were not supposed to be catastrophic, but the arrangement and human activities in rural and urban areas increased flood damages and vulnerability (Akukwe Thecla, 2014).

Flood vulnerability is expected to increase in the future due to human activities that determine vulnerability to floods. This is because throughout history human beings have been occupying and increasingly living on river banks, flood plains, coastal and lowveld areas and lake-sides. Run-off is a key aspect of rainfall and societies have aggregated flooding by reducing the flow of run-off. Instead of flood water flowing through rivers and proper channels, human constructions have distorted the normal natural flow.

In Ga-Kgapane Masakaneng five factors that determined flood vulnerability were identified; six in Lenyenye and Nkowankowa section B and C. Respondents were asked to rank these factors to assess the significance of each factor in vulnerability to floods. Ranking each factor is very significant because not all identified factors have the same influence on flood vulnerability. The best way of validating the ranking is by conducting a field survey. The most significant factor that determined flood vulnerability in the three study areas was 'unavailability or poor drainage system'.

Ga-kgapane Maskaneng did not have drainage system and this exacerbated its vulnerability to floods. This was because flood water did not have a proper flow path or channel, but water accumulated in residential zones and agricultural land. Some houses were affected to an extent that they collapsed. Lack of drainage was a prominent factor that determined flood vulnerability in Ga-Kgapane. Ngie (2012) found that lack of drainage system was the main cause of flood vulnerability in Diepsloot Township. The availability of a drainage system might reduce flood impacts and loss in a community.

"The community of Ga-Kgapane Masakaneng is located on a piece of land which was previously a dumping site, but community members occupied this place illegally due to shortage of land and increased population growth," said the storm water management in Ga-

Kgapane. The illegal occupation was also a key problem in the three study areas; especially Ga-Kgapane and Nkowankowa Section B and C. This might be the main critical reason why the local municipality or government did not construct a drainage system in these areas. It was also found that most of the respondents who lived on unauthorized land said that they did not receive any help when floods damaged their properties. Although occupying unauthorized land is not documented as one of the factors that determine flood vulnerability in the literature, it is clearly important from the findings of this study that the researcher should incorporate this issue as a determining factor.

Lenyenye had a drainage system but floods were worse in this community even with the availability of a drainage system (Figure 4.14). This demonstrates that even though there was an available drainage system, floods were still a major problem. The main problem about the available drainage system was that it was not properly maintained. Instead of floods water flowing through channels, water flow was hindered by stones and garbage inside the drainage channels.

The drainage system was supposed to reduce flood impacts and vulnerability but instead it exacerbated the damages and impacts of floods. Therefore any drainage system should be maintained properly to reduce and mitigate flood vulnerability. This means that the availability of a drainage system does not guarantee a reduction on flood vulnerability. However, other studies found that areas without drainage systems were more exposed and vulnerable than those that have a drainage system.

Cardona (2012) said, “high vulnerability and exposure are generally the outcome of skewed development processes, such as those associated with environmental mismanagement, demographic changes, rapid and unplanned urbanization in hazardous areas, failed governance, and the scarcity of livelihood options for the poor.” In this case, drainage systems were not well maintained. Nkowankowa section B and C experienced a similar problem with Lenyenye, the different was that some of the areas in Nkowankowa did not have a drainage system. The issue of drainage system should never be overlooked in the society. Ngie (2012) called the problem of ‘poor drainage system’ a ‘blocked drainage system’. It means that there is drainage but small stones and other materials have accumulated inside the channel and block the flow of flood water.

Nkowankowa Section B and C had another key determinant that was as significant as ‘poor drainage system’. This determinant was the topography (Nkowankowa is very plain or flat). There is a slight difference between the rank of the ‘poor drainage system and topography (flat) (Figure 4.15). “Flood water got inside houses and it was hard to remove water on this flat area of Nkowankowa because it takes hours to drain them” says the Storm-water

manager of Nkowankowa. It is also presented in chapter four that the municipal officers occasionally had to bring a draining machine to drain off water from houses and streets. One can conclude that even though respondents ranked a 'poor drainage system' as a main determinant of flood vulnerability, topography (flat) should be considered as important as 'poor drainage system.'

Other determinants of flood vulnerability in the three study areas were dwelling quality, employment status, rainfall, and education. In most cases, the determinants of vulnerability are contextual. The reason why these three study areas had similar factors was because they are located in the same municipality. However the ranking of those factors that determine flood vulnerability vary, for instance, the second significant determinant in Ga-Kgapane was 'dwelling quality' but in Lenyenye it was 'rainfall amount' and in Nkowankowa it was topography.

Some studies (e.g. Balica, 2012); Veenstra, 2013) and Samuel et al., 2009) found that rainfall and education level were the most significant factors that determined flood vulnerability. However, this was not the case in the current study, because education was the least significant factor in Nkowankowa Section B and C and Lenyenye. Rainfall was not the most significant either. This also proves how contextual these factors are concerning vulnerability to a hazard.

Flood vulnerability properties are primarily influenced by combination of rainfall characteristics including amount of intensity, duration, spatial distribution and rainfall variability (Enzel et al., 1993; Greenbaum et al., 1998; Cos and Shannon, 2008). Rainfall pattern is seasonal in these three communities, characterized by tropical storms, tropical lows and tropical cyclones. Previous studies (e.g. Greenbaum et al., 1998; Cos and Shannon, 2008; Paulson, 1991; Costa, 1987) noted that high intensity rainfall influences high magnitude flood events. However, it was found in this study that even low intensity rainfall may influences flood and vulnerability due to the socio-economic characteristics. Therefore both rainfall intensity and socio-economic characteristics play a key role in vulnerability to floods.

In other studies, factors that determine flood vulnerability emerged from socio-economic components without considering the physical aspects. Department of Rural Development and Land Reform (2013) and Pelling (1997) found that residential buildings, isolation, access to information, income level, age and economic dependency, health status and health care facilities, education, and even ethnicity were the determinants of flood vulnerability. Socio-economy aspects were considered more important in relation to floods than the physical

environment. However, some of their findings were similar to the findings of this study; dwelling places well as education were among the determinants.

Drainage system is the most important factor that should be considered for vulnerability reduction by households and municipal leaders. If the drainage system could be properly built in Ga-Kgapane and Nkowankowa Section B and C, vulnerability levels would be reduced. However, available drainage needed maintenance in Lenyenye and some parts of Nkowankowa Section B and C.

5.4. Extent of flood vulnerability

The main principle of flood vulnerability index is to measure the flood vulnerability levels of an area including the various dimensions. Flood Vulnerability Index needs indicator to be computed completely. Twenty six indicators were selected in this study but two could not be computed due to unavailability of information or data. Indicators are important for vulnerability because they represent a bigger picture of an area in a small package.

The scale of flood vulnerability was used in measuring flood vulnerability level. Zero (0) signifies low vulnerability while one (1) stands for high vulnerability to floods. The Flood vulnerability index of Nkowankowa Section B and C showed a 'vulnerable to floods' level, this vulnerability was exacerbated by the physical component. Even though there was an indication of high vulnerability to floods in the physical dimension, the general (mixture of social, economic and physical) flood vulnerability level did not change but reflected a 'vulnerability to floods' in both the social and economic dimensions. More focus and attention is required on their physical component than on social and economic components. The main cause of high vulnerability on the physical dimension was due to the topography, which is very flat or plain. Flat or low altitude areas exacerbate the vulnerability to floods since run-off from high altitude areas tends to accumulate in areas of low altitude or elevations (Ogbonna et al., 2015). Topography should be considered in Nkowankowa section B and C during construction of infrastructure, building and other development activities. Plain or flat slope areas are very prone to floods, while high elevations areas are free from floods.

In Ga-Kgapane Masakang, the physical dimension showed a 'small vulnerability to floods,' while the social dimension showed a 'vulnerability to floods' and the economic dimension had a 'high vulnerable to floods'. Although Ga-Kgapane was vulnerable to floods, the major influence was the economic characteristics. Unemployment, low income, poor dwelling and lack of a flood early warning system were key socio-economic aspects that played a crucial role in the levels of vulnerability. Lenyenye showed similar results with Ga-Kgapane but the key influences were both social and economic dimensions. The social and economic

dimensions had a similar influence in the flood vulnerability level of Lenyenye. However, that 'small vulnerability to floods' on the physical dimension does not mean they were not vulnerable, it just means the vulnerability was smaller. Any level of flood vulnerability is significant irrespective of the level. In this study, all three study areas had a 'vulnerability to floods' level.

There are some socio-political aspects that are very crucial in determining vulnerability such as allocation of stands. It was found in this study that there were some parts of the land that individuals were not authorized to occupy due to the risk of floods. However, there was poor collaboration between the municipality and households on the issue of stand allocation. This is because individuals insisted on occupying floods risk areas.

A high level of vulnerability to floods signifies a high probability of loss in any dimension; the social, economic and physical environment. The loss can be of property, people's lives, livelihood, environment and others. High vulnerability to floods or any hazards leads to catastrophes. "In social studies, high vulnerability is assigned where there is a high chance for loss of life while medium vulnerability is allocated in a case where medium potential of harm to people's lives and properties are apparent. A small vulnerability is assigned if there is only small potential of harm and damage to the socio-economy while very small vulnerability has to do with a very small potential damage and harm upon various system within a particular place" (Munyai, 2015).

Small vulnerability to floods is normally due to strong resilience of a specific community. Even though a community might be exposed and susceptible to floods, the strongest determiner of vulnerability is the resilience capacity. Areas that are characterised by small vulnerability to a hazard are composed of high resilience capacity.

According to the studies conducted by Piya et al. (2008), Kuhlicke and Steinführer (2010), Veenstra (2013), Chisola (2012), all levels of flood vulnerability are meaningful and have related impacts on the socio-economic and physical environment. The variation is on the amount of damages, magnitude and intensity of the impacts. There is a strong link between the dimensions of vulnerability, they do not operate or function independent of each other. A social problem affects the economic dimension as would the physical aspect. The best way of conducting a comprehensive vulnerability study is by including all the dimensions of vulnerability. This actually helps the decision and policy makers to know exactly where to concentrate in order deal with a hazard.

Vulnerability studies are very complicated. Many areas in the world were known as vulnerable areas but knowledge of the extent and level of such vulnerability were very

scarce, hence the development of indices both on the social-economic and physical environment. The incorporation of flood vulnerability designations is probably the most difficult of all variables to include in the vulnerability index (Balica et al., 2012).

5.5. Coping strategies against floods

The social survey revealed that the sampled households employed various coping strategies to deal with floods. Even though floods affected all the three study areas, there were immediate ways used by households to cope with floods. Identified coping strategies were also ranked to assess the preference of the households. Vulnerability is a concept that is incomplete without the capacity of the individuals to resist floods. Individuals can have same socio-economic and physical exposure but reflect different coping strategies. Coping capacity and adaptive competence are then the variables that modify the vulnerability to floods (Ngie, 2012).

In other studies, socio-economic characteristics played a vital role in vulnerability and there was also a significant relationship between socio-economic characteristics and flood vulnerability in this study. Cross-tabulation between preparedness and employment status and household income showed that most of the respondents who were unemployed or employed in low income- jobs of less than R1000 a month were not prepared for floods event. This reduced their ability to cope with floods compared to those who were employed and earned better income - more than R5000 per month.

High unemployment rate and low income played a major role on the lack of resilience in Nkowankowa section B and C, Lenyenye and Ga-Kgapane Maskaneng. The availability of resources in a community plays a key role in determining resilience levels and recovery. Munyai (2015) found that adequate resources led to lower vulnerability whilst a lack of resources made people more exposed and vulnerable to floods since it would take time for people to recover from damage.

The most prominent coping strategies in the three study areas were making 'Le-guba' around houses, sand-bags, making a furrow around houses and on roads and temporary relocation. In Ga-Kgapane and Lenyenye, the 'Le-guba' was the most preferred coping strategy. This is because it is easy to construct 'Le-guba' since it can be made by hands and does not take many complicated materials to build it. This coping strategy was adopted in almost every household. This coping strategy generally proves that these areas experienced a serious problem of floods. One of the female respondents in Lenyenye said that making Le-guba was no longer out of choice, because flood water could easily destroy your house if you did not have 'Le-guba'.

A majority of houses without 'Le-guba' were cracked and some of them had collapsed due to lack of protection on the slab and house's foundation. The survey also shows a house in Ga-Kgapane without 'Le-guba' and the foundation of the house is completely exposed to floods (Figure 4.20).

Though everyone can afford to build 'Le-guba', it needs maintenance so that it can remain strong and protect houses from flood water. In Nkowankowa, 'Le-guba' was also prominent but it was the second preferred coping strategy after 'making furrows around houses and on roads'. Since Nkowankowa is very plain or flat, furrows are necessary to direct water away from houses and streets. There were other coping strategies employed by households during floods in the three study areas but they were not preferred compared to the ones mentioned above. These include relocation to a safer area, building a protective wall and building a house with stones and cement.

It is noticeable that households in this study were not willing to permanently relocate to safer areas even though they experienced floods almost every rainy season. The Director of MDDMC also suggested that areas such as Ga-Kgapane Masakaneng and some parts of Nkowankowa households should be relocated. The main reason for relocating people was due to the recurrence of flood events in these communities. In most cases, temporary relocation was the fourth preferred coping strategy. Households were willing to go to their relatives, neighbours and municipal buildings for protection during floods but after the events, they wanted to go back to their respective domiciles.

Ngie (2012) found that relocating to a safe area and evacuation were the most practised coping strategies in the study that was conducted in Diepsloot Township. Preferences of households when it comes to coping against floods are not the same because of the cultural and ethics differences.

5.6. Chapter Summary

All the factors that determine flood vulnerability, levels of vulnerability and coping strategies have been discussed in this chapter. It is prominent that the socio-economic characteristics of the households made these three study areas more vulnerable to floods. In Nkowankowa, the physical characteristics played a greater role than the socio-economic characteristics. Even though all these areas were vulnerable to floods, households tried to cope with the hazard through various strategies. Finally, more efforts are needed to deal with their flood vulnerability levels.

Chapter 6: CONCLUSIONS AND RECOMMENDATIONS

6.1. Introduction

The study assessed community flood vulnerability and adaptation in Nkowankowa section B and C, Lenyenye and Ga-Kgapane Masakaneng. The objectives of the study were to identify and assess the contextual factors that determine flood vulnerability; to assess the level of flood vulnerability among the communities' households and to evaluate the community and municipal flood coping strategies. From the findings of the study, the following conclusions were made:

6.2. Contextual factors that determine flood vulnerability

Six factors that determine flood vulnerability were identified in Nkowankowa and Lenyenye and five factors in Ga-Kgapane. The determinant factors were: dwelling quality, poor or lack of drainage system, education levels, employment status, rainfall amount and topography. However, education was not identified in Ga-Kgapane Masakaneng. Respondents were asked to rank these factors according to their significance. In Ga-Kgapane, the most significant factor was the lack of drainage system, followed by dwelling quality, then rainfall and topography as the third significant factor, and the least significant factor was employment status. Lack of drainage system was the main problem in Ga-kgapane, this means that building a proper drainage might reduce their susceptibility to floods.

Lenyenye showed that the most significant factor that determined flood vulnerability was poor drainage system, the second was rainfall, topography was the third and employment status, dwelling quality and education were the least significant factors that determined vulnerability to floods. The key issue with drainage system was the maintenance, thus the drainage in this area was not properly maintained and that increased vulnerability to floods; because flood water was blocked within drainage. This was different compared to Ga-Kgapane, where there was no drainage system.

In Nkowankowa section B and C; poor drainage was the most significant factor, topography the second, employment status the third, dwelling quality the fourth, rainfall the fifth and the least significant factor that determined vulnerability was education. The weighting of drainage and topography were almost equal; the researcher concluded that topography was also very important in the vulnerability of Nkowankowa Section B and C.

6.3. Levels of flood vulnerability

The general or overall (social, economic and physical dimensions) level of flood vulnerability in the three study areas was indicated as 'vulnerability to floods.' However; the dimensions reflected different vulnerability levels. Ga-Kgapane Masakaneng had small vulnerability in the physical dimension, the economic dimension showed 'high vulnerability to floods' and social dimensions composed of 'vulnerability to floods' level.

Lenyenye reflected 'small vulnerability to floods' in the physical dimension while the economic and social dimensions indicated a 'vulnerability to floods' level. However, Nkowankowa section B and C showed 'high vulnerability' in the physical dimension and 'vulnerability to floods' level in both the social and economic dimensions. The physical aspects had more influence on the flood vulnerability of Nkowankowa section B and C. Chronologically; Nkowankowa was more vulnerable to floods than both Lenyenye and Ga-Kgapane Masakaneng. Relevant coping strategies and adaptations are required to match the vulnerability levels of each area and their dimensions.

6.4. Key Coping Strategies

Various coping strategies were identified and assessed in the three study areas. Even though these areas were vulnerable to floods, they had some resistance and coping capacity. Most of the respondents in Lenyenye and Ga-Kgapane Masakaneng preferred to build 'Le-guba' around houses in order to cope with floods. However, this was different in Nkowankowa section B and C; respondents preferred to make a furrow around houses and on roads.

Generally, these were all the identified coping strategies in the three study areas: making 'Le-guba' around houses; sand-bags; making furrows around houses and on roads; temporary relocation; relocating to a safer area; building protective walls around homes and terraces in fields and building houses with stone and cement. The social survey revealed an additional coping strategy in Nkowankowa called 'personal drainage system.' Although it was not preferred by many households in Nkowankowa, a few households applied it during floods. The primary reason for this lack of preference was because it is very expensive to build.

All the listed coping strategies have not improved the current flood vulnerability level; a lot of improvement is required to deal with the current flood vulnerability in the three study areas. The key problem that is reflected in Lenyenye and Ga-Kgapane is their socio-economic characteristics. This problem is also experienced in Nkowankowa even though their vulnerability is mostly influenced by their geographical topography which is flat or plain. Most

of the respondents were able to employ coping strategies that are affordable, this means that coping strategies that require money or other economic expenses tend to be difficult to employ.

6.5. Recommendations

Based on the key findings of the study, recommendations were made. This study recommends various mitigation and adaptation strategies that can be implemented to reduce flood vulnerability while minimizing adverse effects of floods in Nkowankowa section B and C, Lenyenye and Ga-Kgapane. The recommended mitigations and adaptation strategies will help the community leaders, municipal managers, disaster management sections, households and other stakeholders to reduce and mitigate vulnerability and effects of floods.

6.5.1. Public Awareness

It was found in this study that that most of the households were not aware of flood vulnerability. Therefore, there is a great need of public awareness campaigns and disaster management forums in the three study areas. This awareness effort should include knowledge about flood preparedness through which flood effects can be minimized in the households and communities' infrastructure. For instance, building materials should be more durable, especially for houses that are built on the plain areas of Nkowankowa Section B and C. Disaster management forums will also improve information about flood vulnerability and adaptation in the community. If community members understand flood vulnerability, it becomes easier to prevent flood effects.

Awareness and disaster management campaigns should not exclude households, but they should collaborate with the households, municipal leaders, traditional leaders and all stakeholders in these communities. This collaboration will increase sharing of responsibilities amongst households, community leaders, traditional leaders and municipal managers. When the communities become aware of floods and vulnerability, the knowledge will cement better strategies and preparedness.

6.5.2. Improvement on the socio-economy

The socio-economic characteristics of the three study areas played a key role in the flood vulnerability and adaptation. A great focus is required to for the socio-economic state of the households to improve management and adaptation of floods. This means that all households that are affected by unemployment, low education levels, disability and other disadvantages should receive special treatment and assistance from the government and local municipality when it comes to flood management. This will increase resilience in all

members of these communities. Community leaders and municipalities should develop programmes to insure resilience in these communities through incorporation of IDP (Integrated Development Planning) and flood management.

6.5.3. Incorporating Indigenous and Modern coping strategies

It is good to use modern floods mitigations and adaptations, but the best way to improve participation of the households is through integrating modern mitigations with local or indigenous knowledge. It was found in previous studies that societies have their unique ways of coping with and adapting to floods. The more experienced households are, the better their coping and adaptation strategies to floods. Community and traditional leaders, municipal and disaster managers should incorporate local knowledge with policy development to break the boundary between public participation and policy development (This is because households in the three study areas had been experiencing flood since 2000). This will improve collaboration and unity between municipalities and local people in dealing with flood effects.

6.5.4. Flood early warning system

The social survey indicated that there was no early warning system in these communities. Better risk prediction and improved flood forecast should be imposed in these areas; this will improve the preparation of households against floods. The early warning system improves disaster management by detecting hazardous flood events in advance. Therefore, communities can make necessary preparation before flood events approach. The primary reason of flood early warning system is to limit and prevent the exposure to floods. This means that a probability of shock is limited and sometimes eradicated. This tool would be very significant in these three communities; because floods damaged properties and there was massive loss of life. *“Flood warnings are a highly important adaptive measure where protection through large scale, hard defences, is not desirable or possible,”* (Mathhew, 2016).

6.5.5. Drainage system construction

The most significant factor that determined vulnerability in these areas was drainage system; in Ga-Kgapane proper drainage should be constructed by the local municipality, while Lenyenye needs maintenance on the available drainage system, the municipal and community members should work together to maintain the drainage. In Nkowankowa Section B and C, the municipality should maintain and construct drainage system for new emerging areas that do not have drainage systems. The availability of a drainage system is very significant because it allows flood water to flow and to be channelled to the right places and

not accumulate on roads and inside houses. Proper and well-maintained dams should be built by municipalities to store flood water.

6.5.6. Relocation

It was found in this study that some households were located on unauthorized areas and the effects of floods in these areas were severe. Municipal and community leaders should relocate households from these areas to safer RDP-built areas. The problem of occupying unauthorized land was very prominent in Ga-Kgapane Masakaneng, where houses have been built in an area which was once a dumping site. Nevertheless, this does not mean that Lenyenye and Nkowankowa did not have the same problem. This problem was common in all these areas. Floods cannot be prevented but their impacts can be reduced.

6.5.7. Flood insurance

There was no flood insurance for household properties in these communities because of low monthly household income. Therefore, the study recommends that there must be an introduction of mandatory insurance for households who are not willing to relocate; to counterbalance their losses during floods. This is recommended because it was found that most of the households were willing to relocate to safer areas. In a previous study, Rabalao (2010) concluded that every household that was not willing to relocate to a safer area should contribute towards insurance and these people should also receive a subsidy from government towards their insurance. To fund the disaster recovery, government has the option of using small amounts of private insurance, government reserves and international assistance (Kunreuther and Linnerooth-Bayer, 1999)

6.6. Chapter summary

This chapter concluded the key findings in Nkowankowa section B and C, Lenyenye and Ga-Kgapane Masakaneng. The key findings answered all the research questions in this study. The chapter also described the relevant recommendations that should be considered by the municipality, community leaders and households to cope with floods. All recommendations were emanated from the key findings.

6.7. Further Research

Flood vulnerability is very dynamic; it changes over time, thus there is a great need to for a continuous flood vulnerability assessment. During a period of three years, this assessment should be conducted at least once. Flood vulnerability is also site-specific. Depending on where it is conducted because places have different socio-economic and physical environments. This means that there is a need to do vulnerability assessment in all

communities. This study was conducted at community level without looking at the conditions affecting the whole Mopani District. Therefore there a need for a flood vulnerability assessment for the whole District of Mopani.

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APPENDICES

Appendix A: Permission Letter

 <p>Office of the Municipal Manager</p>	<p>MOPANI DISTRICT MUNICIPALITY</p> <p>Private Bag X9687 Giyani 0826</p> <p>Tel: +27 15 306 7010 Fax: +27 15 306 7299 E-mail: makgopap@mopani.gov.za</p>
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Ref: : A/A/T
Enq: : P.P. Makgopa

TO WHOM IT MAY CONCERN

DATE : 17 MARCH 2017

SUBJECT : LETTER OF CONFIRMATION : MR. RENDANI BIGBOY MUNYAI

This letter serves to confirm that Rendani Bigboy Munyai was accepted by Mopani Disaster Management Centre in August 2016 to conduct research on Disaster Risk Management challenges with regard to flooding in Lenyenye, Ga Kgapanne and Nkowankowa section B and C areas of our District .

Regards


D.D. SHILHANGU
ACTING MUNICIPAL MANAGER
MOPANI DISTRICT MUNICIPALITY

1

Appendix B: Household questionnaire

Demographic Information and socio-economic characteristics

1. Sex

Male	1	
Female	2	

2. Age

Under 20	1	
20-30	2	
31-40	3	
41-50	4	
50 and above	5	

3. Marital status

Single	1	
Married	2	
Divorced	3	
Widowed	4	

4. Are you the head of the house?

Yes	1	
No	2	

5. How many are you in your household?

Between 1 and two	1	
Between 3 and 5	2	
Between 6 and 8	3	
More than 8	4	
Alone	5	

6. Education qualification:

Degree	1	
Diploma	2	
Certificate	3	
Matriculate	4	

Grade 10 or 11	5	
Grade 8	6	
Other (specify)	7	

7. How many disables are in your family?

One	1	
Two	2	
Above three	3	
None of the above	4	

8. What is your employment status?

Employed	1	
Self-employed	2	
Unemployed	3	

9. What is the main source of your household income?

.....

10. Choose the range of your monthly income.

R 0-1000	1	
R 1000-5000	2	
R 5001-10000	3	
R 10001-15000	4	
R 15000+	5	

11. How many members of your family are working?

One member	1	
Two members	2	
Three members	3	
Four members	4	
None is working	5	

12. What is the average expenditure per month?

Less than R1 000. 00	1	
Between R1 000.00 and R5 000.00	2	
Between R5 000.00 and R10 000.00	3	
Between R10 000.00 and R15 000.00	4	
Above R15 000.00	5	
Other (Specify)	6	

13. How many dependencies are in your family?.....

1. Determinants of flood vulnerability

From the list below rank different factors that determine flood vulnerability in your area; the most apparent factors should be represented by number 1, then followed by the second and should be represented by 2 and on:

Factors	Rank
Infrastructure quality	
Education (level)	
Employment (status)	
Topography	
Dwelling quality	
Other (Specify).....	

2. From the rank above, explain why you consider such (e.ge soil moisture) factor/s as the most apparent factors in your community that determine flood vulnerability.

.....

3. Do you have any cultural heritage in your area? If yes, how is it affected by flood?

.....

Describe the nature of your cultural heritage.

.....
.....
4. Types of sanitation.

Flush toilet	1	
Non flush septic tank	2	
Pit latrine	3	

5. What type of house do you dwell in?

Masonry (bricks, cement and blocks)	1	
Metallic sheet (zinc, boards and woods)	2	
Cardboards and plastic bags	3	
Mud/dirt	4	
Other (specify)	5	

6. Of the following flood coping strategies indicate the ones your household adopted as a way to cope with flood.

Relocate to a safer area	1	
Be Evacuate to a safe place	2	
Approach local businesses and structure of government to help	3	
Building protective walls around home and terraces in fields	4	
Do nothing and wait for neighbours and government to help	5	
Building homes with durable materials	6	
Other (Specify)	7	

7. Are you always prepared for flood events? Explain please.

.....
.....
.....

8. Do you get any flood warning system or forecast?

Yes	1	
No	2	

9. Explain your answer please.....

.....
.....

10. Have you attended any Disaster Related Workshop? Explain things mentioned.....

.....

 11. Are you aware of any Disaster Management Organization? Explain please.

.....

12. Did any Local Government Leader Help? Explain please.

.....

13. Do you get financial flood support after floods events? Explain please.

.....

14. Do you pay for medical aid?

Yes	1	
No	2	

15. Did any of the household members get sick during the floods? Please describe the sickness and the condition.....

16. Do you get any help from the government or other institutions after the flood? Explain please.....

17. Do you have any flood insurance in your family? Explain please.

.....

18. Are you aware of flood risk? Explain your answer.

.....

19. Are you able to connect or get help from other communities to telecommunication? Explain.....

20. Are there any places where you can seek shelter during and/or after the floods?

Explain

please.....

.....

21. Does the district provide any protection measures? Explain please.

.....

.....

.....

22. How long does it take for your family to recover from floods?

One to two months	1	
Two to three months	2	
Three to four months	3	
Four to five months	4	
None of the above	5	
Others (Specify)	6	

23. Explain why it takes such long (chosen at 3.30) to recovery.

.....

.....

.....

24. Who else helped you and how?

.....

.....

.....

25. What is the rate of floods occurrence in your area?

Once in 10 years	1	
Twice in 10 years	2	
Thrice in 10 years	3	
Four times in 10 years	4	
Five times in 10 years	5	
Six times in 10 years	6	
More than seven times in 10 years	7	

26. Were you able to repair or replace the damaged items after flooding?

.....

.....

27. What is the overall estimated expenditure for replacement
R.....

28. Do you have energy supply after floods events? Explain please.

.....
.....
.....

THANKS FOR YOUR TIME

Appendix C: Key Informant interview



KEY INFORMANT INTERVIEW

Full name :

Title :

Position :

1. Mention the recent flood events, the year and their related impacts.
2. In your opinion, how badly was your community affected in terms of the socio-economic and environmental aspects?
3. Do you think that in your community people are vulnerable? Please explain.
4. List factors that determine flood vulnerability in your area according to their significance.

Predetermined Factors	Rank
Infrastructure (houses, etc.)	
Education (level)	
Employment (status)	
Rainfall	
Drainage system	
Topography	

5. What do you think are the root causes of floods?

6. How have floods affected your infrastructure in your community?
7. Which diseases are most likely to affect people during floods in your area?
8. Do you have Dams and Storage capacity, to assist in flood reduction? Please explain.
9. Are there any evacuation routes?
10. What is the nature of these evacuation routes?
11. Explain the nature of the emergency response that you get during floods.
12. Are you aware of flood risk? Please explain your answer?
13. What do you think makes/made some to be resilient to flood hazard/disasters?
14. Are you aware of the extent of flood vulnerability in your area?
15. Are the key stakeholders such as the government, farmers and community doing enough to address flood problems?
16. What would you recommend should be done to reduce vulnerability to floods?
17. Do you think there are ways of promoting resilience to floods in this area?
18. What would be your view about your community and floods?
19. Any further comments?