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Thesis Title: The Role of Socio-economic Factors in Flood Vulnerability in Low-Income Informal Settlements: Case of Soche Hill Informal Settlements in Blantyre City, Malawi

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Summery

This study discusses the role of socio-economic factors in flood vulnerability of low-income informal settlements in Soche, Blantyre City, Malawi. It aimed at examining the dynamic relationship between socioeconomic factors and vulnerability to flooding, with the goal of offering suggestions to improve resilience within the study area.

Mixed research methodology was employed whereby quantitative and qualitative tools were used. The survey questionnaire and Flood Vulnerability Index were used as quantitative tools and the qualitative ones were focus group discussions and semi-structured interviews with key informants with technical knowledge about flood management issues of the study area.

Study results suggest that factors such as education level, household income, occupation and access to financial services have a significant influence on flood vulnerability of people in the study are based on the sample used. However, other factors like age, gender, access to flood risk information, family support system and flood perceptions did not indicate significant effect on flood vulnerability.

Due to socio-economic disparities in the study areas, further research was recommended to combine socio-economic, environmental, and physical components to understand how these components interact and affect flood vulnerability in the study area. The research raises issues about how policy and planning affect urban growth and service delivery. Given that urban expansion increases flood risk, how urban social economic services and projects are developed and managed may provide new practical insights.

The findings informed further recommendations in modifying the pressure and release model framework in order to prioritize socio-economic factors as the principal indicators of vulnerability and resilience. The integration of contextual factors, reinforcement of the feedback loop, and prioritization of long-term sustainability are essential considerations. It is recommended that community-based approaches be employed to address the unique requirements of low-income informal settlements. These approaches involve engaging local communities in decision-making processes and fostering bottom-up initiatives.

Through the incorporation of these adjustments, the paper enhances the scholarly discourse surrounding the socio-economic factors that underpin flood vulnerability within low-income informal settlements. The findings of this study offer valuable insights for policymakers, practitioners, and stakeholders who are involved in the development of strategies and interventions aimed at reducing flood risks and improving resilience in comparable situations.

Keywords: flood vulnerability, socio-economic factors, low-income informal settlements, pressure and release model, flood vulnerability index.

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To the residents of Soche informal settlements who wholeheartedly supported the study, to get a better knowledge of their vulnerability to floods.

To life, for so much personal and professional growth.

Foreword

This thesis dives into the critical problem of flood risk in low-income informal settlements, recognising how natural disasters disproportionately affect economically disadvantaged groups. The study demonstrates the current research gap, which has mostly concentrated on the physical components of vulnerability while ignoring the essential impact of social and economic issues. The research investigates the subtle interactions between flood susceptibility and several socioeconomic factors, with a special emphasis on Soche informal settlements in Blantyre City, Malawi. The study intends to guide the development of effective flood risk reduction and resilience measures by analysing the geographic distribution of flood-prone areas in relation to socioeconomic characteristics. Finally, the research hopes to provide useful insights into the multidimensional nature of flood susceptibility and argue for contextually relevant interventions that address the core causes of floods and lessen their effect on vulnerable populations.

Abbreviations

AHP	Analytic Hierarchy Process
BCC	Blantyre City Council
CBD	Central Business District
CI	Consistency Index
CR	Consistency Ratio
CCODE	Centre for Community Organization and Development
DTM	Digital Terrain Model
DoLS (S)	Department of Land Surveying (South)
FVI	Flood Vulnerability Index
GIS	Geographical Information System
IPCC	Intergovernmental Panel on Climate Change
ISDR	International Strategy for Disaster Reduction
MHC	Malawi Housing Corporation
MUBAS	Malawi University of Business and Applied Sciences
NSO	National Statistical Office
UNDRR	United Nations office for Disaster Risk Reduction
PDNA	Post-Disaster Needs Assessment
RI	Random Index

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1.0 Introduction

1.1 Background

It is a known fact that most of the time, people live in environments that feature both favorable and potentially dangerous conditions. Yet, studies have demonstrated that the distribution of these possibilities and risks is not even very close to being proportional (Wisner et al., 2004). Regrettably, individuals who are most financially challenged are frequently the ones that are forced to settle in areas that are more exposed to natural hazards, particularly in poor locations often densely inhabited, close to pollution sources, inadequately serviced, and hotbeds of social tension and crime because they lack the financial means or other resources to live somewhere else (Hoeven et al., 2015). The situation makes people disproportionately vulnerable to the aftereffects of natural disasters, which is a reality that has been extensively discussed and documented in most academic research (Smith et al.,2006).

The assertion that disasters are not inherently natural in nature. but rather a socio-economic construct is also explained by the increased number of poor people who are at risk, in both the south and the northern hemisphere. They often settle on marginal land, have substandard housing and infrastructure, do not receive early warning or, as in the case of Hurricane Katrina in New Orleans, are not able to leave the city (Bates, 2006). Disasters worsen poor and marginal living conditions, generating a vicious cycle of increased risk that frequently locks people in poverty (Wamsler, 2014).

It is generally accepted that socioeconomic factors also have a role in the occurrence of disasters. Across the world many poor and marginalized populations are mainly vulnerable, lack access to early warning systems and may be unable to evacuate before, during, or after a natural disaster because of their precarious location on marginal areas and their reliance on inadequate housing and infrastructure (Wamsler, 2014).

1.2 Thesis Outline

The study commences with an introductory section that emphasizes the study's relevance and outlines literature gaps. It analyses the conceptual framework of flood vulnerability and the socio-economic aspects that make people vulnerable to floods.

The methodology section details the study's research design, data collecting, and analytic methodologies.

The paper analyses the demographics and socio-economic variables of the Soche informal settlements and examines how various factors affect flood susceptibility. These factors include education level, access to flood risk information, family support systems, gender, age, flood perceptions, household income, occupations, and financial services.

Using Flood Vulnerability Index (FVI) the levels of vulnerability of the mentioned factors was assessed. The paper then discusses the results, compares them to the literature, and interprets them in terms of socio-economic variables affecting flood susceptibility.

1.3 Problem Statement

Urban poor are more susceptible to natural disasters due to their propensity for settling in riskier places for economic or land-related reasons. Notwithstanding the inherent risks, these high-risk places may provide economic possibilities, public services, and other benefits that attract residents. According to research by Hallegatte et al., (2020), high-risk regions are more desirable due to their increased output and wages. Patankar (2015) found in separate research

that families in flood-prone regions are aware of the dangers but accept them because of the area's advantages, such as proximity to employment, schools, healthcare facilities, and social networks.

Land and housing markets in urban areas, often force the poor to dwell in riskier places. According to Daniel et al., (2009), flood-prone areas may be much less expensive, thereby forcing poor people to live in such locations.

Blantyre City is the second largest commercial city of Malawi with urban population of 800,264, annual growth rate of 1.9% and urbanization rate of 17.7% (NSO, 2018). Soche Informal Settlements are located 5 kilometers from the CBD. It had a total population of 130,116, which is 16.3% of the city's population (NSO, 2018). Soche has endured repeated flooding in recent years including most recently in March 2023 where Cyclone Freddy caused high precipitation resulting flash flood and mudslide from Soche hill, where over 80 people from this informal areas died (Reuters). This has been exacerbated due to people living close and on the hill resulting in loss of life and property. Floods have also resulted in economic losses for low-income individuals, aggravating their already precarious living situations.

Based on the forgoing, Soche informal settlements offered an excellent setting for studying the role of social and economic factors in flood vulnerability. The settlement is home to a considerable population of low-income earners who are particularly susceptible to floods owing to limited infrastructure, poor living conditions, and restricted access to resources. The research centered on examining the distinct social and economic determinants that contribute to the susceptibility of the area to flooding. The objective was to gain insights into the area's level of vulnerability and anticipate forthcoming changes.

1.4 Relevance of the study

Ribot (2013), highlighted insufficient attention of literature to the social and economic aspects that has a significant and systematic contribution to vulnerability of the poor and marginalized people in low-income settlements in most urban areas. Furthermore, Kayulayula et al., (2015) agrees that many studies give more attention in forecasting physical effects of climate change and impacts using models whose results mostly uses assumptions to inform decision making and little consideration is given to contextual issues.

The study was therefore appropriate because it aimed at looking into the role of socioeconomic factors in making low-income communities susceptible to floods. The argument was that various families in a community are impacted differently by contextual factors, even if they are impacted by identical stresses, the intensity of effect is hardly the same. In the case of flooding, for example, the level of damage caused will be determined by the number of contextual variables at a household, the kind of factors, household coping techniques, household coping challenges, and even past flood coping experience. The study explored that the amount of impact flooding can have on a household is governed not just by actual exposure to flooding, but also by household contextual factors. This is especially true in Malawi, where prediction models are employed to provide averages for the Southern African area, while contextual factors are not exact on the ground. Thus far, few contextual vulnerability studies concentrating on informal settlements have been conducted in Malawi.

The study was therefore justifiable since it has added to a better understanding of the elements that influence flood vulnerability in literature.

1.5 Summary of the research gap

The existing body of research in the field of flood vulnerability has primarily concentrated on examining physical elements, such as the exposure to flood risks and the fragility of infrastructure. However, much as there has been comprehensive studies focusing on the role of socio-economic factors on flood vulnerability, scholarly research has frequently not properly taken into account the contextual factors and special characteristics associated with low-income informal settlements, which serve as residences for a substantial number of marginalized individuals like the case of Soche in Blantyre city (Ribot, 2013). Hence, it is imperative to acquire a holistic comprehension of the socioeconomic mechanisms that contribute to the susceptibility of low-income communities, specifically those residing in informal settlements. According to Kita (2017), the vulnerability of individuals with limited financial resources and land scarcity is exacerbated by their tendency to settle in high-risk areas.

Hence, it is necessary to comprehend the precise socio-economic factors that contribute to the vulnerability of low-income informal settlements to flooding in Soche. This understanding is crucial in contributing to the body of knowledge and formulating focused interventions aimed at reducing risks and enhancing resilience.

1.6 Research Objective

To investigate the role of socio-economic factors in flood vulnerability of low-income informal settlements.

1.6.1 Specific Objectives

1. To identify the socio-economic characteristics of residents in low-income informal settlements that are most strongly associated with flood vulnerability.
2. To measure vulnerability levels in relation to socio-economic characteristics
3. To understand how socio-economic vulnerability will affect the living conditions of people in the future.

1.7 Main research question

To what extent do social economic factors affect flood vulnerability at present and in the future in low-income informal settlements?

1.7.1 Research sub-questions

1. What are the social and economic factors that contribute to flood vulnerability in low-income informal settlements?
2. How to measure social-economic vulnerability to floods in low-income informal settlements?
3. What are the perceptions of people on the change of socio-economic vulnerability to floods in the future?

2.0 Literature Review and Hypotheses

This chapter provides an overview on theoretical literature in relation to socio-economic characteristics associated with levels of flood vulnerability, impact on living conditions of informal settlement dwellers with much focus on present and future. The last part of the chapter presents a theoretical framework upon which this research is basing its arguments.

2.1 Flood vulnerability in low-income informal settlements

The current trends of rainfall frequency and severity are predicted to keep on increasing in almost all regions of the world as a result of climate change (Myhre et al., 2019). This entails the increase in flood risks in many parts of the world (Connor & Hiroki, 2005). According to Wisner et al., (2004), location, population and infrastructure exposure, political and institutional frameworks, cultural and socio-economic conditions, and adaptation skills all affect people's climate risk and flood sensitivity.. Unfortunately, the most hit populations of these catastrophes in developing countries are the urban poor (Adelekan, 2011). Turner et al., (2003), argue that vulnerability analyses must include not just how vulnerable a system is to a given hazard, but also how well it can defend itself against that risk. The fragile condition of every urban community, especially the informal settlements, must thus be taken into consideration.

Multiple scholarly studies have demonstrated the relationship between the vulnerability to climate change-induced hazards and the urbanisation processes in cities in developing countries (Aboagye, 2012a). These studies primarily centre on flood hazards and underscore the fundamental factors that hold significant importance for the urban poor in said nations. According to Owusu et al., (2019), the vulnerability of individuals residing in informal settlements is notably influenced by their household assets and livelihoods. This scientific perspective suggests that although climate change may contribute to the emergence of hazards, it is primarily the socio-economic and political setting that renders the urban poor susceptible to the impacts thereof (Adams et al., 2023).

Furthermore, Dodman et al., (2012) concur that the presence of informality is a contributing factor to flood occurrences, with particular attention paid to this relationship. This phenomenon occurs when a greater percentage of individuals from lower socioeconomic backgrounds choose to reside in areas that are susceptible to natural disasters such as floods or landslides. This decision is often driven by the unavailability of safer land options that align with their financial means. The high concentration and densification of businesses within certain areas renders the inhabitants susceptible to various hazards, including floods (Douglas et al., 2008).

2.2 Socio-Economic Characteristics Associated with Flood Vulnerability

2.2.1 Education Level

It is a well-known truth that climate change is a reality, and the world should prepare for more changes to occur as a result of its unanticipated occurrences (Solomon et al., (2007). Many institutions and organisations have assessed that it is expensive to adjust to these changes, which are largely related to severe magnitude and frequency weather occurrences (Margulis et al., 2010). However, it is very difficult to make investments in resilience infrastructure since it is unclear what exact consequences will be like (Dessai et al., (2009). These incidents mostly have a significant negative impact on those who are most at risk and are living in challenging economic conditions, which leads them to live in areas prone to natural disasters like river flood plains (Wisner et al., 2004). Academic researchers Agrawal et al., (2009); McBean et

al.,(2010) and experts from the public sector (Shardul et al.,(2008) have suggested that the best adaptation investments might be those that optimise resilience and decrease people's vulnerability to environmental hazards rather than those that deal with specific impacts of climate change (Eakin & Patt, 2011). According to the research by Striessnig et al., (2013), one of the most important factors that has been discovered to have a significant impact on lowering susceptibility and losses from severe weather events is education.

There exist multiple rationales to anticipate that empowerment will transpire via fundamental literacy and, subsequently, through secondary education, thereby mitigating susceptibility to hazards associated with climate change. Improved education is often associated with increased access to pertinent information, such as emergency warnings for possible hazards conditions (Moser et al., 2010; Patt et al., 2010). Additionally, scholarly research suggests that education can improve mental capacity and promote a drive towards modifying hazardous behaviours, while concurrently expanding an individual's temporal perspective (Nisbett, 2009). According to Fuchs et al., (2010); Kc et al., (2010), there exists empirical evidence that suggests a positive correlation between education and improved health and physical wellness across various age groups and nations. According to scholarly sources such as Lutz et al., (2008), there exists a positive correlation between increased education and increased income levels at both the individual and household levels. Additionally, higher levels of education have been linked to increased economic growth at the level of the overall economy. All these factors suggest and establish that higher levels of education are in general associated with ability to access information such as early warnings, prepare for unforeseen environmental events and recover from disasters such as flooding.

2.2.2 Access to Information

Prior research on flood risk has established that individuals who live near or in flood-prone areas, demonstrate increased awareness of their vulnerability to flood risks. As a result, individuals are inclined to pursue additional knowledge regarding the matter owing to their perceived susceptibility (Kellens et al., 2012). Furthermore, Brody et al. (2004) assert that individuals who live near bodies of water are more likely to possess knowledge regarding the behaviour of these water bodies during flood events. Similarly, Botzen et al. (2019) established that individuals who reside in areas with higher flood risk demonstrate an increased desire to implement measures aimed at mitigating flood damage. This discovery aligns with prior studies conducted in this field. The ever-changing and complex nature of flood risk underscores the importance of current and accurate risk information, which is essential for individuals to effectively implement timely and suitable mitigation strategies. Given that risk status may change over time, the importance of obtaining up-to-date risk information is of utmost significance (Stephens, 2020).

Additionary, according to exposure theory by Hornik (2002), there exists a possibility that regions with higher susceptibility to flooding may exhibit a greater degree of dissemination of information pertaining to flood risk. The theory offers one possible explanation for this phenomenon that information exposure is a prerequisite for its impact on people. More importantly, this all depends on the frequency of exposure and the variety of channels and sources disseminating the message can influence modifying behaviour (Hornik, 2002).

2.2.3 Social Networks and Family Support Systems

Elliott & Pais (2006 p.300) underline that "people respond to disasters not as isolated individuals but as members of overlapping forms of social affiliation." The relations that exist within communities shape how well individuals can work together to respond to and recover from natural disasters which is an inherent part of adaptation processes (Adger, 2006). This

emphasises the critical significance of social capital/norms, networks, and trust of a particular community, in helping families mitigate and cope with natural events.

According to Cutter et al., (2003), the vulnerability of a community to various hazards, including flooding, is partially influenced by its social capital which generates value by means of the characteristics of social organisation, including trust, norms, and networks, which can enhance the effectiveness of society by enabling coordinated action (Babcicky et al.,2017; Putnam, 2000). Empirical evidence supports the association between social capital and adaptation, as demonstrated by research indicating favourable outcomes of social capital on the adaptive potential of communities during and in aftermath of disasters (Babcicky & Seebauer, 2017; Nakagawa & Shaw, 2004).

During flooding, individuals affected by floods may utilise social networks as a means of accessing assistance from their neighbours Moore et al., (2004), or to find temporary housing following evacuation. Furthermore, during the recovery period, the utilisation of private and public sector resources can be optimised through the contribution of social capital (Aldrich, 2011). According to Hawkins et al., (2010), social connections can have a positive impact on long-term survival and facilitate reconstruction efforts. Social connections can further 'function as a form of informal insurance, enabling individuals to access pre-established support networks for financial, informational, and emotional aid in times of need' (Kawachi et al., (2013 p. 17).

2.2.4 Gender and Age

Socio-economic vulnerability indicators among others are mostly associated with some aspects of demographic characteristics although scholars in most cases extend this association. Other scholars argue that although children fall among the most vulnerable group of the population, they are also very important drivers of resilience through their community groups (Walker & Burningham, 2011) which in a way provide support to their households during recovery period (Kuhlicke et al., 2011).

The condition of the elderly has a strong vulnerability factor as movements during emergency to get out of danger becomes a problem because they need special care which makes recovery difficult (Tunstall et al., (2006). The dependency status and physical condition of the old people and the young makes this age group more vulnerable to flooding hazard (Kuhlicke et al., 2011).

Socio-economic vulnerability is strongly associated with gender status where mostly women who have the whelm of family care responsibility becomes very burdened with limited access to resources, opportunities and rights. This extends to little pay in informal sector employment as compared to men (Rufat et al., 2015). Although this is the case, the impact of gender on socio-economic vulnerability to flooding is not direct because women are typically associated with strong commitment on risk knowledge, surviving capacities and community relationships (Rufat et al., 2015; Walker & Burningham, 2011). According to (Rufat et al., 2015), gender on its on cannot be a determining factor on socio-economic vulnerability as living conditions of women are different within the socio-economic standing, household level and locations (Ajibade et al., (2013). This is the case even in developing countries where most inequalities are reported. However, it is a known fact by scholars that households in the lower socio-economic status are consistently affected by floods and the impact is different by social class at all levels of pre-impact, response, recovery and rebuilding (Rufat et al., 2015).

2.2.5 Household Income

The state of being impoverished clearly enhances vulnerability. According to Ribot (2011), families living in poverty are unable to afford the necessary resources to both mitigate and rebuild from natural calamities. Theorists suggest that income inequality has a notable impact on augmenting vulnerability, in addition to its association with absolute poverty (Adger, 1999; 2006). According to Massey (2009), income inequality leads to the formation of geographic segregation based on income level. This results in high-income groups residing in secure and exclusive areas, while lower-income groups are compelled to stay in informal areas, typically on the outskirts of urban centres. Due to financial constraints, people end up constructing dwellings in hazardous locations rather than in more secure regions. It is worthy noting that exposure to flood hazards is not exclusively limited to low-income households. Certain affluent households opt to reside in areas that are susceptible to flooding. Nevertheless, it is worth noting that affluent households possess the financial means to erect their dwellings utilising cutting-edge construction materials and designs that are resistant to natural disasters (McGranahan et al., (2013). In the event of the destruction of their homes, such individuals possess the ability to engage in the process of reconstruction.

2.2.6 Occupation

As per the UN-Habitat (2016), an estimated 880 million people inhibited informal settlements located in urban regions of developing nations. These communities face various challenges, including limited access to basic amenities and uncertainties surrounding their land tenure. It is worth noting that a considerable segment of the urban population participates in informal labour. In the global south, it has been observed that informal employment accounts for a significant proportion of non-agricultural labour, specifically 82%, as reported by Chen (2014) and Chen et al. (2016).

Socio-economic factors are very crucial in flood vulnerability of people in informal settlements as they are also associated with increased creation of informality in cities due to rapid rural urban migration in search of good employment opportunities. Mostly in developing countries, this has pushed people to live in unsafe locations with no access to the urban services they dreamed of (Aboagye, 2012b). They end up living in a complicated situations in the most vulnerable areas close to their work places in the cities with no security tenure, or proper infrastructure that is ideal to provide urban services. As a result their capacity to respond in the event of disasters such as floods is very reduced to none (Gencer, 2013).

2.2.7 Access to Finance (Loan)

According to Gencer (2013), lack of security tenure to informal settlement dwellers which is the case in most developing countries, limits the communities to access credit services, ensure their own property or even get support the government. This is normally the case because they operate outside the formal urban planning regulation system. This social exclusion coupled with other factors such as poor educational background and limited employment opportunities exacerbate the flood vulnerability conditions of informal settlement dwellers creating one of the key urban policy gaps in the developing world (Amoako, 2018; Gencer, 2013; Zoleta-Nantes, Doracie B., 2002)

The lack of assets of many people living in informal settlements coupled with their inability to have savings means that in cases of emergency they will have to borrow money or do without. In most cases such people do not have where to access affordable financing to solve their emerging problems. As a result, they tend to land into informal borrowing which is normally associated with high interest rates. Such situations have systematically and chronically created

a vicious circle of poverty from which it is very difficult to come out from (Mitlin & Satterthwaite, 2013).

Adams et al., (2023), highlights the significance of lack of access to finance, which results in low-income urban residents being compelled to seek housing in precarious locations within and around the urban areas. Furthermore, Beukes (2015) concurs that residing in an informal settlement entails significant cost implications, as individuals must contend with limited resources and services while seeking accommodation. Under such circumstances, households that lack a stable income and financial resources face challenges in obtaining housing in areas that offer income-generating prospects within walking distance. Consequently, individuals find themselves residing at a considerable distance from their places of employment, incurring significant expenses for daily transportation, and bearing elevated costs for scarce resources and services (Walker & Burningham, 2011). According to Wisner et al., (2004), individuals who are affected by this condition are rendered susceptible, and in the event of a disaster, it becomes challenging for them to recuperate and resume their regular routine.

2.3 Flood Vulnerability

2.3.1 Measurements of Flood Vulnerability

The effects of climate change, unplanned urbanisation, and shifting patterns of land use are expected to bring about an increased flood frequency in the years to come. This condition poses a risk to the inhabitants of a great number of urban areas all over the globe, which are more likely to be exposed to the grave risk of flooding and a great number of other catastrophes connected to climate change (Balica et al., (2010). Actions need to be done in order to lower vulnerability across regions and raise their resilience and safeguard safety of the urban dwellers and the environment in which they live. According to Takemoto (2011), one of the very essential elements of this actionable process is measuring vulnerability in order to recognize the susceptible areas and undertake interventions.

On the other hand, Ahmad & Simonovic (2013) underline the fact that flood vulnerability also changes through time as a result of changing geographical landscapes, varied climatic circumstances, social cultures, and human activities. This is the reason why numerous assessment techniques of flood risk have been created over the years in order to broaden the knowledge and space in understanding about flood vulnerability and to give solid guidance to decision-makers.

Flood vulnerability assessments are designed to establish a definitive connection between theoretical hypotheses of flood vulnerability and the current administrative procedures (Nasiri et al., (2016). Scholars have devised various techniques to assess flood vulnerability. However, despite the implementation of awareness campaigns, flooding remains a persistent issue (Birkmann, 2007). The efficacy of the flood evaluation techniques and their influence on the mitigation and adaptation of flooding have been a subject of debate among scholars, as evidenced by the arguments presented by (Khan, 2012b). Nonetheless, as per the assertions made by Gao et al., (2007; Nasiri et al., (2016), the complexity of assessing vulnerability, in conjunction with the impact of various factors such as social, economic, environmental, political, among others, contribute to this phenomenon.

2.3.2 Flood vulnerability assessment methods

The complex nature of flood vulnerability necessitates the implementation of multidimensional methodologies that are contingent upon various vulnerability delineations. Huang (2012) has classified methods for vulnerability assessment into four distinct groups.

2.3.2.1 Indicator Based

This approach involves utilising existing data to construct a credible representation of the susceptibility of a particular location under consideration. In addition to its widespread application in flood vulnerability assessments, this approach is favoured by policymakers due to its ability to provide a clear and concise depiction of vulnerability patterns across different locations. This facilitates the prioritisation of risk response measures and planning efforts for specific regions or areas. This set of techniques employs intricate weighting and non-weighting indices in conjunction with standardisation, weighting, and aggregation methodologies. Nasiri et al., (2016) asserts that researchers in this group encounter challenges related to uncertainty due to the presence of multiple variables associated with any added factor. Lein & Abel (2010), suggests the utilisation of variable weighting to mitigate the effects of variable interdependencies and reduce their influence on the ultimate outcome. Khan (2012b), contends that this demography presents challenges in the quantification of certain social indicators during calculations. The utilisation of theory-based and data-based methodologies in selecting indicators facilitates a more comprehensive understanding of the susceptibility of a specific area or region (Füssel, 2010).

2.3.2.2 Vulnerability Curve Based

Papathoma-Köhle (2016) suggests that the correlation between flood risk and elements at risk can be examined through the utilisation of empirical damage or vulnerability curves. The methodology is primarily based on empirical evidence derived from extensively documented case studies, which are typically limited to residential structures within a specific geographic region. This methodology involves the selection of a subset of items from each designated category, followed by the organisation of a catalogue of potential subjects. The mean values of all samples belonging to each component class are computed, and subsequently utilised to generate step-damage curves. The following stage-damage curves pertain to potential damage, although analogous techniques may be employed to assess damages that occur in the immediate aftermath of a flood (actual damage analyses). The methodology relies on conducting a comprehensive damage survey, which necessitates a significant investment of time and resources. Furthermore, its applicability to other regions is limited, resulting in reduced reliability compared to alternative approaches (Nasiri et al., 2016).

2.3.2.3 Disaster loss data method

This methodology is based on the gathering of empirical flood hazard data and their utilisation as a guide for future events. However, (Papathoma-Köhle, 2016) further emphasized that although this approach is straightforward, it may be subject to some degree of imprecision due to the unevenness of the recorded data. Therefore, the outcomes of this methodology should be interpreted with prudence.

2.4. Future of Flood Vulnerability

Pecl et al., (2017) and Ramaswami et al., (2016) have identified climate change and urbanization as two of the most pressing global challenges of the 21st century. The impact of global climate change has resulted in floods becoming a significant hazard for numerous cities worldwide, as evidenced by research conducted by Fang et al. (2020), Hallegatte et al. (2013), and the IPCC (2014). According to the United Nations (2017), there is an anticipated 29% rise in the global population, reaching 32 billion by 2050. This growth is expected to result in a higher concentration of urban population and an increase in impervious surfaces, as noted by Chen et al. (2020). A lack of capacity for cities to adapt to the flooding brought on by future climate change is the result of considerable uncertainty in flood risk and urban expansion (Du et al., 2015; Fang et al., 2021; Tessler et al., 2015).

The projected trend of flood vulnerability on a global scale indicates a general increase, which can be attributed to various factors including climate change. According to the IPCC (2014), climate models indicate an increase in the frequency and intensity of rainfall events, which may result in elevated flood hazards in various areas. The vulnerability is further intensified by the inadequate infrastructure and the rise in urbanisation in developing nations, as stated by Kundzewicz et al. (2008).

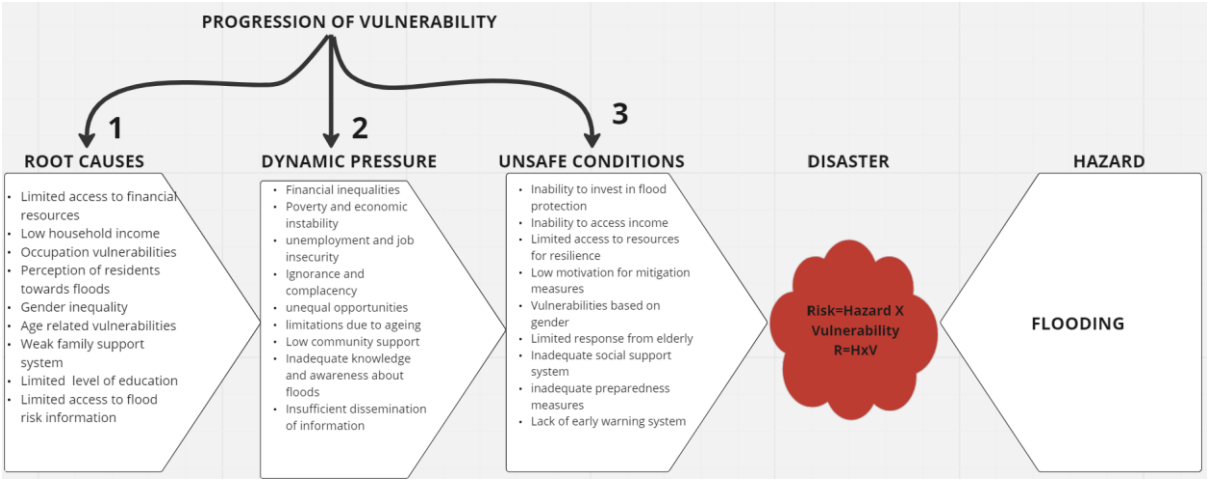
The global south, encounter distinctive obstacles with regards to their susceptibility to floods in the future. The regions in question are anticipated to experience heightened flood risks because of climate change, including altered rainfall patterns and elevated temperatures (Fekete et al. (2018). According to Pelling et al. (2016), vulnerability in the global south can be intensified by socio-economic factors such as poverty and restricted adaptive capacity.

Malawi as a country exhibits a significant susceptibility to flooding as a result of its geographical attributes and socio-economic circumstances. According to existing research, it is probable that Malawi will encounter heightened susceptibility to flooding in the near future. According to Kumwenda et al. (2019), climate projections suggest changes in precipitation trends, such as heightened variability and intensity. The confluence of deforestation, inadequate land management practises, and other factors has been identified as a significant contributor to the increased risk of flooding in Malawi.

2.5. Conceptual framework

The Pressure and Release (PAR) model was used as an analytical framework in this study to get a full picture of the wider factors that make people vulnerable to floods and the efforts to reduce those risks. The PAR model, which was created by Blaikie et al. (1994) and revised by Wisner et al. in 2004, is used a lot in flood vulnerability related studies. (Asgary & Halim, 2011); (Manyena, 2012); (Arnall, Thomas, Twyman, & Liverman, 2013)(Islam & Lim, 2015) (Nirupama, 2012) and (Kita, 2017) are just some of the researchers who have used the model in their work. The model is based on the idea that disasters aren't just caused by risks, but also by how risks interact with vulnerable populations and create pressure. The model says that pressure must be released to lower the risk of disasters. This means that both risk and vulnerability must be taken into account. The PAR model was useful for this study in two different ways. (Manyena, 2012) states that the model gives a way to look at the dangers and weaknesses that can lead to a disaster. Also, the model helps figure out if the steps that have been taken to reduce disaster risks are working or not. The PAR model says that vulnerability is built into the social structure, going from origin causes to dynamic pressures to unsafe conditions. By identifying these factors, the PAR model gives a full picture of the complex factors that contribute to vulnerability.

Figure 1: Pressure and Release Model (Adapted and modified from Wisner et al., (2004)



3.0 Research Design and Methodology

This chapter provides an overview of the process of operationalizing the principal concepts that have been identified for the purpose of data collection. Subsequently, the chapter expounds on the research design, encompassing the selection of data collection and analysis techniques.

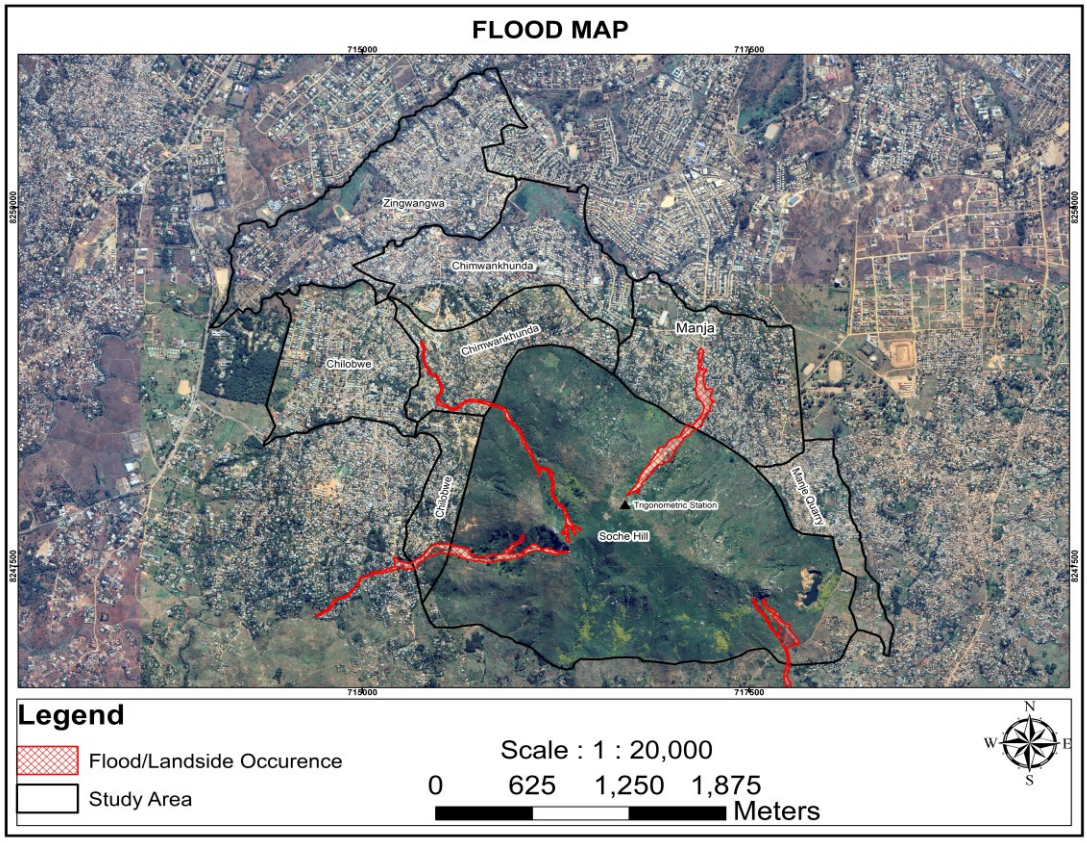
3.1 Research strategies

The study employed a mixed-methods approach, utilising key informant interviews, and focus group discussions to gather qualitative data, and a survey to obtain quantitative data. Quantitative data was subjected to chi-squared and correlation analysis, while qualitative data was analysed using the software, Atlas.ti. The integration of the findings has resulted in an in-depth understanding of the research topic, thereby providing significant insights that can be utilised for policy and practice purposes in the reduction of flood vulnerability in low-income informal settlements.

3.1.1 Data collection methods

The study area was purposively chosen because it was affected heavily by the flash floods and mudslides that came with Cyclone Freddy in March 2023. Primary and secondary data were collected.

Figure 2: Map showing coverage and impact of flash floods in the study area.



Source: Author (2023)

3.1.2.1 Primary data collection

3.1.2.1.1 Survey questionnaire

Purposive sampling was used in identifying forty respondents to the survey questionnaire. From these respondents 19 came from Misesa ward, 10 from Soche West ward and 11 from Greencorner ward. The number of respondents were determined purposively based on the most affected by cyclone Freddy in each ward. These respondents were identified from the 7,720 victims which represented 5.9% of the total population in the study area. It is important to acknowledge that the individuals involved in this study were non-technical in nature. Their perspectives were informed by their personal experiences and local knowledge of the flooding event that occurred in March of 2023.

Table 1: Summery of Primary Data collected.

Data Type	Data Description	Source
Primary	Audio recordings Filled questionnaires	Survey, Key informants, Focus group discussions

Source: Author (2023)

3.1.2.1.2 Key informant interview

Another set of primary data was collected through key informant questionnaires where eight experts were purposively chosen based on their experience and knowledge to respond to the questionnaire. Snowballing technic was applied where a respondent felt some one has more knowledge about the topic of discussion.

Table 2: Basic Information about the Key Informants

Name of Institution	Profession	Qualifications	Experience (yrs.)
UN-Habitat	Disaster, Climate Risk and Environment Expert	Doctor of Philosophy (PhD), Geography, Climate Change, Disasters and Resettlement.	10 years
Malawi Housing Corporation	Urban Planner	Masters in Sustainable Urban Planning and Development	25 years
Centre for Community Organization and Development	Service and Infrastructure Specialist	BSc Civil Engineering BSc Environmental Studies	11 years
Malawi University of Business and Applied Sciences	Urban Planner, Lecture	MSc International Planning & Sustainable Urban Management	13 years
Blantyre City Council	Civil Engineer	Master's Degree in Environmental Engineering	13 years
Blantyre City Council	Disaster Risk Management	Master of Science in Environmental Protection and Management	10 years
Blantyre City Council	Environmental Management	Bachelor of Science in Natural Resources Management	6 years
Regional Survey Department (South)	Land Surveyor	Master of Science in Geospatial Engineering	20 years

Source: Author (2023)

3.1.2.1.3 Focus group discussion.

The study employed focus group discussion to collect data from residents of the mentioned wards regarding their perceptions and local knowledge of the factors that contribute to their communities' susceptibility to flooding. Groups of nine community members affected by cyclone Freddy were mobilised from each ward for discussions. In May 2023, a trained research assistant deliberated the discussions using the discussion guide on site. The criteria for participation in these focus group discussions were that one must be chosen among the residents of the study area and was affected by Cyclone Freddy.

3.1.2.2 Secondary data collection

Secondary data from 2018 National Census was collected from NSO which provided population of the study area by gender and age ranges. Raster maps were sourced from BCC which was then used in GIS Software to produce flood vulnerability map. Literature was sourced from Scopus and Google Scholar.

Table 3: Summery of data collected.

Data Type	Data Description	Source
Secondary	Digital Terrain Model (DEM) obtained from USGS Earth Explorer. SRTM 1 Arc Second Global. 30m resolution, Copernicus Hub Landsat Image (10m-30m resolution)	Blantyre City Council
	Demographic data of the study area	National Statistical Office
	Literature	Scopus, Google scholar

Source: Author (2023)

3.1.2 Sampling and Selection

Purposive sampling was used in identifying the study boundary and targeted population. Because this study happened just after the disaster it was very difficult to reach all the targeted population in the city of Blantyre, it was decided to use purposive sampling to make the selection of specific wards to be studied. In order to reach with higher probability the target population on the wards, a specific criterion was employed which:

1. Have a higher number of seriously affected people by the cyclone Freddy.
2. Are located within informal settlements impacted by the cyclone.

Based on the criteria, three wards were selected to run this study (Figure 3) which were Misesa, Soche West and Green Corner, therefore, the study group are seriously affected people who have been residents of the area for not less than two years.

Misesa had 3,750 seriously affected people, Soche West had 1,840 and Green Corner had 2,130 making a total of 7,720. Due to time limitation and that data collection happened few days after the disaster, it was very difficult to get hold of people for they were rebuilding. As such a purposive sample of forty respondents was reached to respond to the survey questionnaire. From the sample size, 19 participants were from Misesa, 10 from Soche West and 11 from Green Corner wards.

3.1.3 Reliability and Validity

The concepts of reliability and validity are crucial in academic research. In order to enhance the dependability and accuracy of the study, a mixed-methods approach was utilised, which involved the integration of both quantitative and qualitative research instruments. Furthermore, cross-validation of the data was conducted across various sources, including secondary sources, that were considered in this study.

The process of selecting respondents was not reliant on the researcher's subjective judgement but rather on the study area based on the people who were affected by flash floods. The identification of this area was based on recent flash floods and mudslides that happened in the area. This serves to enhance the dependability and accuracy of the thesis.

3.2 Data Analyses Methods

The data collection tools employed in this study facilitated the utilisation of both quantitative and qualitative analysis methods for the purpose of data interpretation.

3.2.1 Quantitative Analysis

Includes the analysis of measurable data obtained from survey questionnaires. According to Van Thiel (2014), the questions were assigned necessary variables to facilitate and ensure responses that are logical and explicit.

Quantitative data from the survey was analysed by Stata 17 in ordinal and nominal terms. In order to comprehend the data that had been gathered based on research questions number one and three, quantitative approaches were used in the analyses.

3.2.1.1 Pearson's chi-squired test

In order to evaluate the influence of the independent variables on the dependent variable being studied, chi-square tests, commonly known as Pearson's chi-square test was used. This methodology is a statistical approach that does not depend on assumptions regarding the underlying probability distribution. It is utilized to assess the association among numerous categorical variables. The formulation of the chi-squared test is as follows:

$$x_c^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

Where:

O = Observed frequencies

E = Expected frequencies

C = Degrees of freedom.

The chi-square test is a statistical method that provides evidence through contradiction of Karl Pearson's null hypothesis $H0$. The null hypothesis suggests that if variables are not related to each other, then there is no relationship between the variables (Lyman & Longnecker, 2001). Stata software was utilized for conducting the test in this study. In order to establish a statistically significant relationship between two variables with a confidence level of 95%, the p-value derived from the chi-square test in Stata should be below 0.05. This implies that the likelihood of rejecting the null hypothesis while it is indeed true is below 5%. Moreover, a relationship of statistical significance is established at a confidence level of 99% when the p-value is below 0.01.

3.2.1.2 Spearman Correlation

Correlations were conducted to look at the relationship between the independent and dependent variables, including the magnitude and direction (positive or negative) of this relationship. Given that the data collected consisted of nominal and ordinal scales, it was necessary to conduct non-parametric Spearman correlations between the dependent and independent variables. This thesis utilizes a specific interpretation for both positive and negative relationships in order to interpret Spearman correlations.

Table 4: Interpretation of correlation values

Spearman correlation	Interpretation
>= 0.70	Very strong relationship
0.40 – 0.69	Strong relationship
0.30 – 0.39	Moderate relationship
0.20 – 0.29	Weak relationship
0.01 – 0.19	No or negligible relationship

Source: Leclezio et.al (2015)

3.2.1.3 Flood Vulnerability Index

The FVI was employed to address the second research question of the study, which centred on measuring the flood vulnerability of the study area. The FVI was formulated utilising a multi-criteria approach that integrates geographic overlays based on GIS. The index is derived from three discrete dimensions of vulnerability, specifically socio-economic, factors. The study utilised a multiple-phase methodology for the development of the FVI. The initial stage involved the identification of influencing indicators through the application of the AHP technique. Subsequently, the identified indicators were consolidated into a single element through normalisation. Subsequently, the evaluation of the score and normalisation for each indicator was undertaken, which was then followed by the computation of the FVI. Ultimately, a reclassification scheme was implemented to assess vulnerability.

3.2.1.3.1 Selection of Indicators

Based on the literature and collected data from key informants, the following indicators were used in the FVI: education level, access to flood risk information, family support systems, gender, age, residents' perceptions to floods, household income, occupation and access to financial services.

3.2.1.3.2 Determination of Weights from Indicator and Normalization

The AHP can be defined as a method for making decisions using multiple criteria that enables choosing the best options based on a independent evaluation built on individual options and generates quantitative weights (Saaty, 2001). According to Murari et al. (2013), the use of the AHP to assign weightings to flood vulnerability factors based on expert opinions has proven to be a valuable approach in determining vulnerability, as evidenced by multiple case studies.

Experts were chosen from among experts employed by institutions and organisations working in the study area that oversee managing flood disasters, including the UN-Habitat, BCC, MHC, CCODE, DoLS and MUBAS. The Key Informant questionnaire was completed by seven individuals responsible for disaster management within their respective institutions. The AHP involves a series of sequential steps, which are as follows:

1) Identification of the issue at hand and the subsequent specification of potential solutions. This is then followed by the creation of hierarchies, which typically include the establishment of a goal, the development of criteria, and the generation of alternative options.
2) Developing a pairwise comparison matrix utilizing scales, as outlined by (Saaty,2001).
3) Determining the proportional weighting of each parameter.

4) Evaluate the hierarchy's consistency as consistency ratio with a maximum threshold of 10%.

In the event that the ratio surpasses the established threshold, it becomes imperative to repeat the procedure. Equation (1) is utilized to compute the CR. According to (Saaty, 2001) the CI is a metric utilised to assess the consistency of assessments conducted in pairwise comparisons. In the context of AHP, experts are required to evaluate and contrast the relative significance of different criteria or alternatives using a numerical scale, typically ranging from 1 to 9. The CI evaluates if there are discrepancies or gaps in the comparisons or whether the judgements are internally consistent (Saaty, 2001). On the other hand, in order to determine if the CI value derived from the pairwise comparison matrix is acceptable, the RI, a reference value, is employed. The RI metric denotes the mean CI values obtained from random assessments. The degree of consistency may be assessed by comparing the CI value that results from the decision-maker's judgements to the RI value. The proportion between the RI and the CI is a significant metric.

$$CR = CI/RI \qquad \text{Equation (1)}$$

The calculation of the CR in Equation (1) is dependent upon the maximum eigenvalue (λmax) of the matrix. Equation (2) demonstrates the division of the utilized eigenvalue by the order of the matrix. The biggest eigenvalue of the pairwise comparison matrix is represented by the maximum eigenvalue (λmax), where n denotes the number of components that are being compared in that specific matrix.

$$CI = (\lambda_{max} - n)/(n-1) \qquad \text{Equation (2)}$$

3.2.1.3.3 Applying Normalized Weights

Equation (4) expresses the vulnerability index calculation for every indicator applying linear conversions in accordance with Equation (3), which correlates variables to positive and negative, as stated by Salazar-Briones et al. (2020).

$$X_i = \frac{Z_i - Z_{min}}{Z_{max} - Z_{min}} \qquad \text{Equation (3)}$$

$$X_i = 1 - \frac{Z_i - Z_{min}}{Z_{max} - Z_{min}} \qquad \text{Equation (4)}$$

In this context, Xi denotes the standardised measure of a socio-economic, parameter at a given location i. Meanwhile, Zi represents the actual value of the variable at the specific location i, whereas Zmax and Zmin correspond to the highest and lowest values of these variables across all areas.

3.2.1.3.4 Calculation of the Flood Vulnerability Index (FVI)

The vulnerability index for each component was computed using Equation (5), with the utilisation of normalized weights derived from AHP.

$$FVI_{SE} = \sum_{i=1}^{n} W_{SEn} X_i \qquad \text{Equation (5)}$$

The Flood Vulnerability Index (FVI_{SE}) is utilised to determine the vulnerability of each component. The weight (Wn) of each indicator is assigned a value between 0 and 1. Weight normalisation may also be facilitated by assigning weights that fall between the numbers 0 and 1. The normalisation process serves the purpose of standardising the weights to a common scale, thereby facilitating the meaningful consolidation of all the weighted indicators. The utilisation of scaling techniques aids in mitigating the potential influence of indicators with

higher numerical values, which may otherwise dominate the evaluation because of their larger scale or magnitude values lower than 0.01. Subsequently, the normalised composite vulnerability index is employed to compute the FVI by dividing the flood vulnerability index of all vulnerability indices by the number of influential components (m), as depicted in Equation (6).

$$FVI = VI_{SE}/m \qquad \text{Equation (6)}$$

Subsequently, the FVI is employed to ascertain the vulnerability zones within the study area. There are six different susceptibility levels: extremely low, low, medium, high, and very high. The categorization of vulnerability regions into 6 distinct groups stands determined by the ranges of the FVI value, which are as follows: very low (0.00-0.01), low (0.01-0.25), medium (0.25-0.50), high (0.50-0.75), and very high (0.75-1.00) (Balica, 2013).

3.2.2 Qualitative Data Analysis

Qualitative analysis methods were utilised for qualitative data. The data collected through focus groups and key informant interviews were analysed via ATLAS.ti, software which offers a systematic approach to data analysis and enhances effectiveness (Van Thiel, 2014). The collected data were carefully recorded, transcribed, and subsequently translated from Chichewa to English. The subsections were systematically encoded to facilitate their categorization based on the underlying conceptual framework.

Data from focus groups and interviews were classified through identifying relationship among the variables projected in the conceptual framework. This categorization was done in safeguarding legitimacy of the study results.

Table 5: Summery of data coding and interpretation process

Step	Action	Description
1	Importing Data	Importation of interview questionnaires, transcriptions from focus group discussions into ATLAS.ti, with each questionnaire or transcription representing a separate respondent.
2	Coding	• Create codes to represent meaningful themes. • Assign relevant text from the questionnaires to the appropriate codes
3	Refining Codes	Review and refine the codes, merging similar codes or splitting broad codes into specific sub-codes.
4	Analyzing Codes	Using the software analysis tools to explore the coded data, frequency counts and co-occurrences of codes
5	Interpretation	• Identify key themes and patterns from the findings that emerged from the interviews. • Develop narratives with supporting quotes from the coded data.
6	Reporting	Export the coded data for presentation.

Source: Author (2023)

3.3 Limitations for the Research

The data collection process for this study was conducted within few days after the flooding event. Consequently, the respondents were still experiencing shock, and any attempts to probe them could potentially elicit emotional responses. The restricted nature of the questions posed in the interview imposed a constraint on the depth of the inquiry. Additionally, the sample utilised in this study was based on 7,750 individuals who were impacted by the flash flood. Nonetheless, the circumstances in the field posed a challenge in achieving a bigger sample size. A total of 40 participants were surveyed from a population of 7,750. The incorporation of qualitative data via two focus group discussions and seven key informants served to address the deficiency in the level of coherence.

Due to time and resource constraints, the study was only conducted in the Soche informal community, one of several in the City of Blantyre. Furthermore, the methodology solely comprised interviews with a subset of organizations involved in addressing and managing flood-related challenges. Certain interviews, such as those conducted with key informants, were conducted remotely as a result of the researcher's inability to engage in fieldwork on-site. Consequently, there were delays in initiating interactions and building connections with prospective interviewees.

3.4 Operationalization of key concepts

Drawing upon the theoretical underpinnings presented in the literature review and the resulting conceptual framework, the study examined the relationship between socio-economic status as an independent variable and flood vulnerability as a dependent variable.

The study examined the independent variable from two distinct perspectives, namely social and economic dimensions, while the dependent variable was evaluated based on its adaptation dimension.

The selection of indicators for the independent variables was based on their anticipated ability to reflect the impact of said variables on the dependent variable. Following this, indicators pertaining to the dependent variable were chosen to ascertain whether the two independent variables are yielding a favorable outcome.

Considering the characteristics of the research, qualitative and quantitative methodologies was deemed as the more advantageous approach, entailing the gathering and examination of nominal data.

The operationalization of the independent and dependent variables has been carried out according to the specifications presented in the table provided below.

Table 6: Operationalization table

RESEARCH QUESTIONS	VARIABLES	DIMENSION	INDICATORS	DATA COLLECTION METHOD	DATA ANALYSIS METHOD	LITERATURE
What are the social and economic factors that contribute to flood vulnerability in informal settlement?	Socio-economic Status *(Independent)*	Social	1. Education level 2. Access to flood risk information 3. Family support systems 4. Gender 5. Age 6. Residents' perceptions	Primary data (Structured Interviews) Secondary data sources (projected demographic and economic data)	Quantitative (Descriptive and Inferential analyses) Qualitative (Flood Vulnerability Index)	Owizeye et al, (2020)
		Economic	1. Household income 2. Occupation 3. Access to financial services			Owizeye et al, (2020)
How should these factors be used to measure social-economic vulnerability to floods in low-income informal settlements?				Literature review on existing models, index		Belica et al., (2012)
What are the perceptions of people on the change of socio-economic vulnerability to floods in the future?	Flood Vulnerability *(Dependent)*	Adaptation	Flood Vulnerability Index (FVI)	Secondary data sources on the projected demographic and economic data	Quantitative (Flood Vulnerability Index)	Belica et al., (2012)

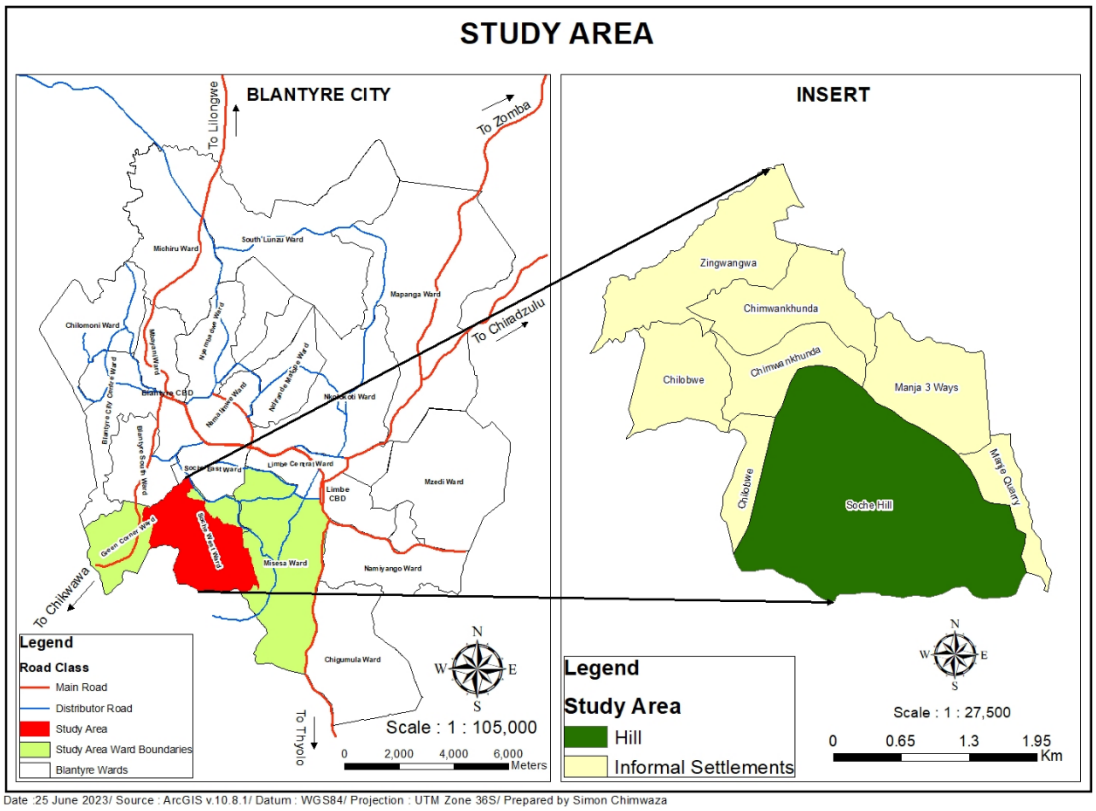
4.0. Case Study, Results, Analysis and Discussion

This chapter discusses and summarizes the research findings and results based on the information gathered and processed. The structure of the chapter starts with an analysis of the role of socio-economic factors in flood vulnerability in low-income informal settlements. Furthermore, the flood vulnerability of the study area is measured in relation to the identified socio-economic factors. This will be followed by an analysis of people's perceptions and views on future flood vulnerability. Finally, statistical findings of regression and correlations will be utilized to establish the link between the independent and dependent variables. The final section of the chapter examines the qualitative and quantitative results and provides an interpretation of the findings in the context of the underlying theoretical framework.

4.1. Description of the Case Study Area

Blantyre City, with an area of 250 square kilometers and a population of 800,264 according to the NSO 2018 report, serves as the primary commercial hub of Malawi and is the second largest city in the country. The urban area of the city is experiencing an annual growth rate of 1.9%, while the urbanization rate stands at 17.7%. Located at 15 degrees 47'10" S and 35 degrees 0'21" E, the city exhibits an elevation range of 750m to 1612m above sea level and is characterized by an undulating terrain that encompasses several hills. The climatic conditions prevalent in the urban center are notably impacted by its geographical positioning within the tropical region and its elevation. The city experiences a tropical continental climate characterized by two distinct seasons within a given year. The urban area undergoes precipitation between the months of November and April, with an average yearly rainfall of 1,222 meters. The geographical location of the study area within Blantyre City is depicted in Figure 3.

Figure 3: Map showing the Study Area



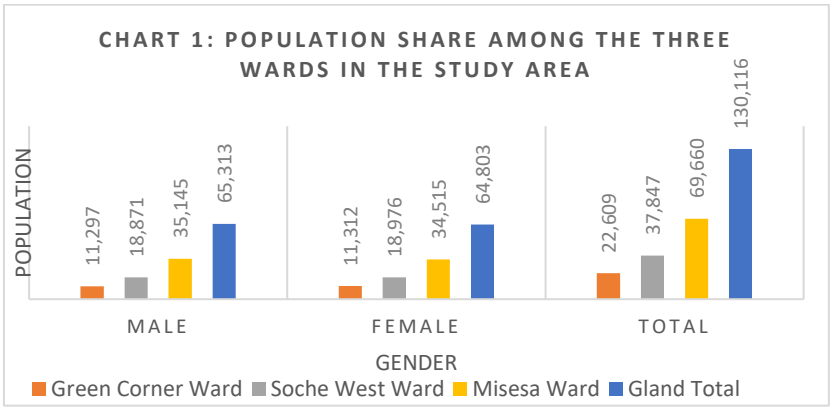
Source: Author (2023)

The ownership of land in the urban area is distributed among various entities, including the private sector, the central government, MHC, and BCC. As per UN-Habitat (2011), approximately 43% of the land is designated for planned residential purposes, while 22% is categorized as unplanned and 21% falls under the semi-rural classification. It is noteworthy that solely the demographic of medium and high-income brackets possesses the privilege of obtaining serviced land for residential purposes. The urban center presents various economic prospects; however, it faces resource constraints that hinder the execution of its strategies and the provision of essential social, infrastructure, and urban services necessary for the realization of economic growth (Ibid). Approximately 70% of the urban populace resides in informal settlements that encompass roughly 23% of the total land area. The poverty rate is currently at 24%, while the unemployment rate stands at 8%. According to UN-Habitat (2011), approximately 45% of the population in Blantyre is engaged in private sector employment, while 12% are employed in the public sector. Additionally, 36% of the residents are self-employed, and 7% work in the agricultural sector.

4.1.1 Cyclone Freddy and its Impact on Soche Informal Settlements

The three wards in Soche informal settlements encompass several informal settlements, namely Chilobwe, Quarry, Manje, Manja (part), Zingwangwa (part) and Misesa. According to the National Statistics Office's report in 2018, the collective populace of these three administrative was 130,116, constituting approximately 16.3% of the total population of the city, Chart 1.

Chart 1. Population distribution in the study area



Source: National Statistical Office, (2018)

In March of 2023, Malawi suffered damage by a severe tropical cyclone, which ranks among the most devastating on record. Tropical Cyclone Freddy resulted in significant precipitation over the southern region of Malawi. Several instances of flash floods and landslides, including debris landslides, were reported in Blantyre City and its adjacent districts in the aftermath of intense rainfall. According to PDNA (2023), the occurrence of these catastrophic events has resulted in adverse impacts on the populace's well-being, economic activities, and the nation's socioeconomic framework, thereby exacerbating the poverty situation.

The study area was subjected to this catastrophic event, rendering it the nation's most severely affected urban area. According to Reuters (2023), flash floods and mudslides resulted in the unfortunate demise of over 80 individuals from this locality. The impact of this disaster was influenced by various social-economic factors, among other variables, owing to its inherent nature. As per the PDNA (2023), the individuals who were primarily impacted by the disaster were those residing in the vulnerable areas surrounding Soche hill. This led to various adverse consequences, such as economic losses, fatalities, and damage to assets.

4.2 Characteristics of the Sample

The survey sample size comprises of n=40 participants from the total population of 7,720 affected people. The total affected population represent 5.9% of the population in the study area and 0.96% of the total population of the city. The participants exclusively consisting of permanent inhabitants of the Soche informal settlements, which serve as the focal point of the study. Comprehensive coverage of all informal areas within the study area was undertaken to ensure an equitable distribution of landscape features across all regions. The utilization of purposive sampling method hindered the attainment of a comprehensive representation of participants from all three wards. Consequently, certain wards exhibit a higher number of participants relative to others owing to the varying degrees of impact that the flooding event had on them.

Likewise, among the sample of 40 participants, 65% were male and 35% were female. The fact that this research took place at a time of disaster, when some individuals were in evacuation centers and others were reconstructing their homes with the help of available males, explains why there is this imbalance. The disproportionate representation of men in the sample can be attributed to their availability during the time of the interview and their status as heads of households. Additionally, the data indicates that a higher proportion of male respondents (24%) were unemployed compared to their female counterparts (21%) who participated in the survey.

However, in order to offset the sample, two focus group discussions were conducted plus seven key informant interviews. The graphical representation of the population characteristics can be obtained from Chart 1.

Conversely, the age distribution appears to be imbalanced across age cohorts, given the absence of respondents below the age of 24. All individuals involved in the study were aged 25 years or older. The educational attainment of the surveyed population is diverse, with a significant proportion of individuals (65%) having completed secondary education. A smaller percentage of respondents (18%) have completed primary education, while a minority (3%) have not received any formal education. Tertiary education has been attained by 15% of the respondents.

The monthly income per household exhibits a range of variability from 20,000 to 100,000 Malawi kwacha or higher. Respondents (35%) reported an income level of 100,000 Malawi kwacha or higher. In comparison to gender, it is observed that half of the female population earns a monthly income of less than 20,000 Malawi kwacha, whereas only 12% of men fall under the same income bracket.

4.3 Summery of Research Findings

This section offers significant perspectives on the socio-economic determinants that impact the susceptibility of low-income informal settlements to flooding. This study endeavored to investigate the influence of socio-economic factors on flood vulnerability in low-income informal settlements, utilizing in-depth analysis of data obtained from the local population. The results demonstrate a thorough comprehension of the socio-economic factors linked to vulnerability, covering variables such as age, gender, familial support structure, level of education, perception of flood vulnerability, occupation, flood exposure, financial accessibility, household income, and availability of flood risk information. Examining these factors underscores their importance in determining the degree of vulnerability in these communities. Through an analysis of the complex relationship between socio-economic variables and vulnerability to flooding, this study offers significant contributions to the field of policy-making and practical implementation. The findings can inform the development of focused interventions and approaches aimed at mitigating vulnerability and bolstering the resilience of impoverished informal settlements in the event of flooding.

4.3.1 Social and Economic Factors that Contribute to Flood Vulnerability in Low-income Informal Settlements.

This section examines the socioeconomic factors that substantially influence the susceptibility of low-income informal settlements to flooding. We acquire insights into the traits that specifically lead to higher vulnerability by examining each indication separately.

Table 7: Summery of the relationship between indicators and flood vulnerability

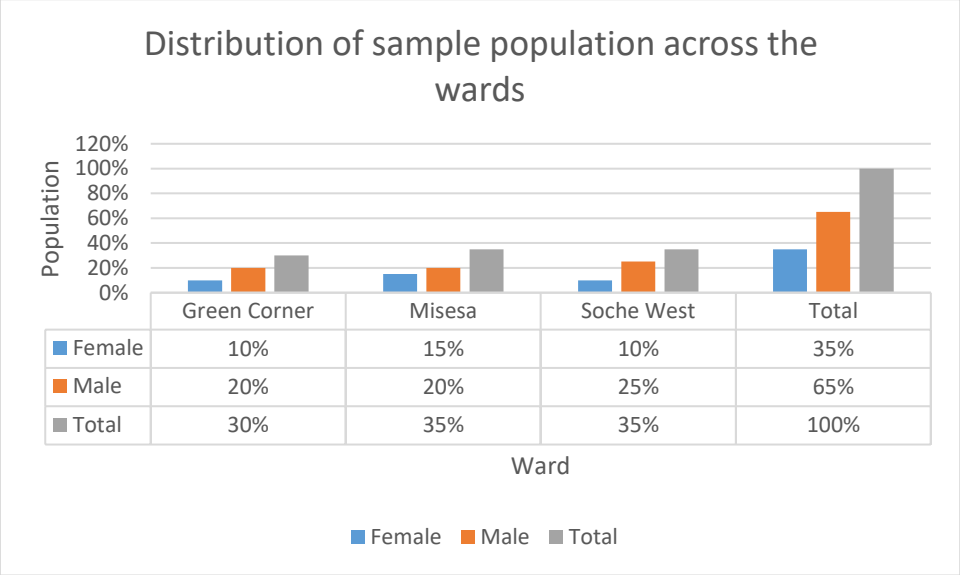
Indicators	Indicator representation	Relationship between indicator and vulnerability	Reference	P-Value	Correlation
Gender	Comparing vulnerability of men and women	Women may have more challenges recovering than men, making them more vulnerable.	Deepak et al., (2020)	0.368	Negative
Age	Vulnerable age group 55 and over	Elderly people are more vulnerable to floods	Deepak et al., (2020)	0.185	Negative
Level of education	Persons educated below secondary school level are vulnerable	There exists an inverse relationship between the level of education and both income and the capacity to understand flood recovery information	Fuchs et al., (2010)	0.0349**	Positive
Occupation	Unemployed populations are vulnerable	Lack of income sources influence vulnerability to floods	Chen et al., (2016)	0.0308**	Positive
Household income	Population earning MK50,000 and less are vulnerable	Insufficient income at household affect ability to adapt and recover from floods	Ribot, (2011)	0.0004**	Positive
Access to loan	People in need but never accessed loan are vulnerable	Inability to access loans when in need make people vulnerable to recover from flood event	Adams et al., (2023)	0.0007**	Negative
Access to flood risk information	People who rarely or never received flood risk information are vulnerable	The more frequently a person receive flood risk information, the more informed the person becomes in dealing with flood preparedness	Botzen et al., (2019)	0.1338	Negative
Household social support system	People with no family support system and those with weak and very weak support are vulnerable	The household support system is closely related to income. The weaker the support system the more vulnerable they are to flooding	Adger, (2006)	0.3040	Negative
Residents' perception to floods	People who feel very vulnerable and somewhat vulnerable to floods	The more people perceive themselves as vulnerable to floods the more they feel motivated tin mitigation measures	Balica et al.,(2012)	0.7084	Negative

Source: Author (2023)

4.3.1.1 Gender

According to the data, a notable gender distinction was observed with males dominating responses up to a total of 65% of the sample, while women made up 35%. This was the case due to the situations happening at the time of study as explained under sample characteristics. On average, the survey shows that the distribution of the sample population in relation to gender across the wards is normal with 10% of female from Green Corner, 15% from Misesa and 10% from Soche West. The same applies to men who share 20% in both Green Corner and Misesa respectively and 25% in Soche West. Chart 2 below shows more details.

Chart 2: Sample distribution in the study area



Source: National Statistical Office (2018)

To evaluate the influence of gender on the perceived level of flood vulnerability, chi-squired and correlation tests were applied between the two variables. In this case the null hypothesis was that there is no relationship between gender and level of flood vulnerability.

Table 8: Chi-squired test (P-Value) output between gender and level of flood vulnerability

Indicator	P=Value (Chi-Squired)	Correlation
Gender vs. Perceived level of flood vulnerability	0.368	-0.2288

Source: Author (2023)

The P-Value output indicates that in terms of gender, we fail to reject the null hypothesis at 5% confidence level. It implies that there is not enough evidence that gender and perceived level of flood vulnerability have a relationship. This is supported by the comment that was made in one of the focus group discussions:

" *as for me I do not think that it matters a lot whether you are a man or a woman to be vulnerable to floods because if all us were financially stable we would have already moved away from these dangerous places, anyone would want to live in a safer area". (Participant from Chilobwe)*

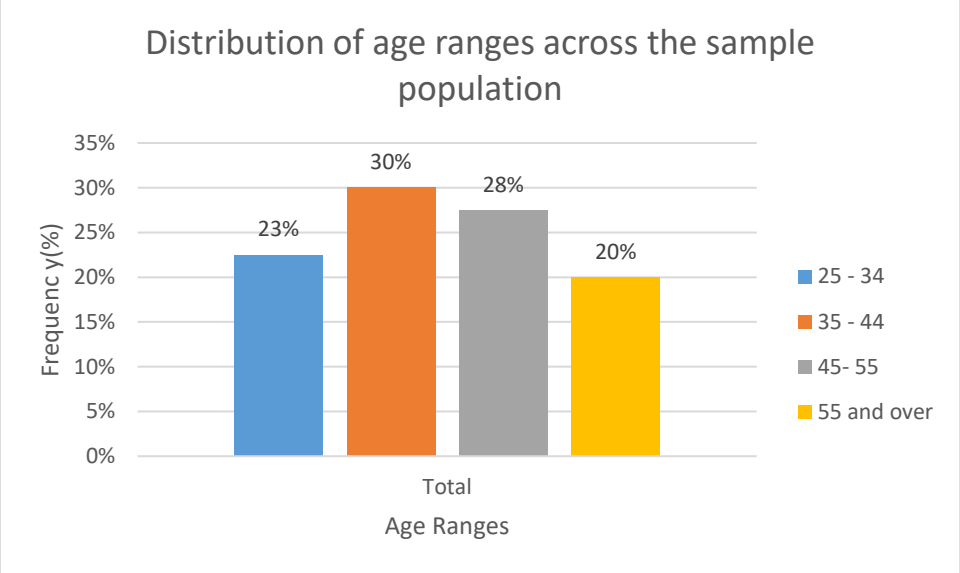
Furthermore, the variables present a negative weak correlation which implies that as gender fluctuates such as increasing from male domination to female, there is a tendency for the perceived level of vulnerability to decrease. Nevertheless, the correlation coefficient's

magnitude indicates a weak correlation, implying that the relationship between gender and perceived vulnerability lacks substantial strength.

4.3.1.2 Age

The results show that the majority, 30% of people interviewed, were of the age group 35-44 followed by 28% of the 45-55 range, 23% of 25-34 range and lastly by 20% of 55 and over range. Thes results were dominated by middle age ranges of 35-44 and 45-55 respectively. See chart 3.

Chart 3: Distribution of age range across the sample size



Source: Author (2023)

To evaluate if there is any influence of age on perceived level of flood vulnerability, chi-squired and correlation tests were used to test the variables.

In this test the null hypothesis is that there is no relationship between gender and perceived level of flood vulnerability.

Table 9: Chi-squired test (P-Value) output between age and level of flood vulnerability

Indicator	P=Value (Chi-Squired)	Correlation
Age vs. Perceived level of flood vulnerability	0.185	-0.1013

Source: Author (2023)

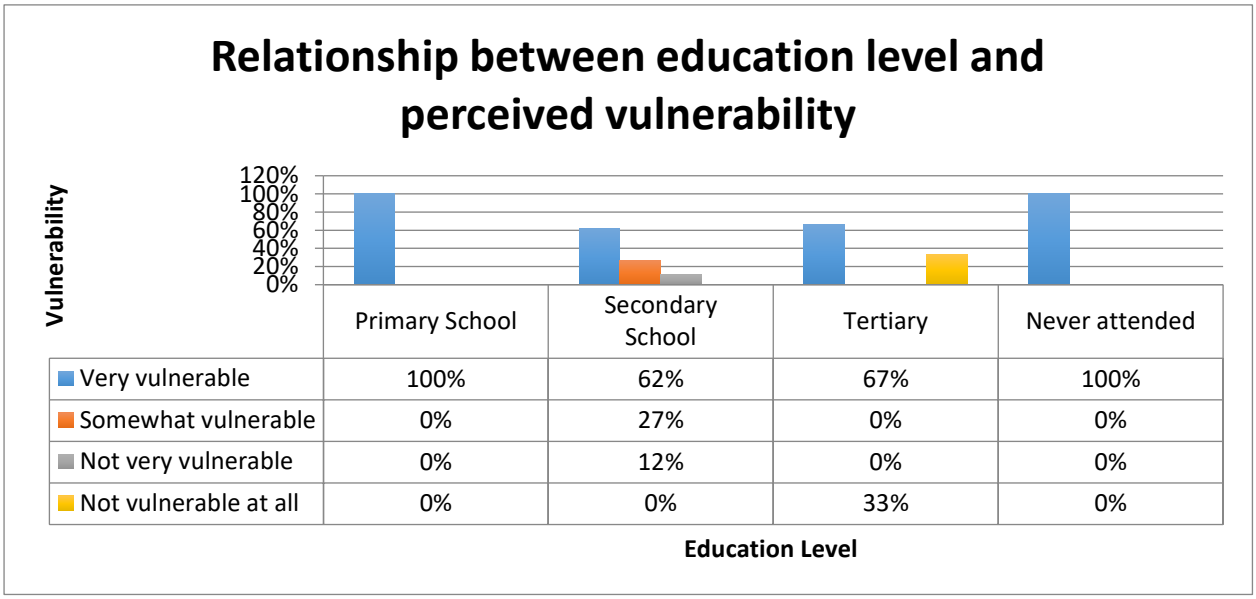
The P-Value output indicates that in terms of age, we fail to reject the null hypothesis at 5% confidence level. For this sample there is not enough evidence that can confirm the relationship between age and perceived level of flood vulnerability. The negligible negative correlation between the variables implies that age alone may not significantly determine perceived vulnerability to flooding in the study area based on the sampled population. Other aspects are likely to influence shaping the perceived vulnerability significantly. This result is like what was said in one of the focus group discussions on the connection between these two variables:

"I think this question can be answered same way we did with the other one you asked about gender, because what matters is financial capacity, if you are old and have money its easy to be resilient to these floods". (Participant from Chilobwe)

4.3.1.3 Level of Education

From the results on education level, 65% of the respondents completed secondary school, 18 % primary, 15% tertiary and 3% never attended. It can be seen from the data that all the respondents with primary school education and those who never attended education felt very vulnerable to floods. This scenario somehow applies to secondary school and tertiary respondents of which the majority 62% and 67% respectively felt very vulnerable. Chart 4 gives more details.

Chart 4: Relationship between education level and perceived vulnerability



Source: Author (2023)

In order to establish the assumed impact of education level on perceived level of flood vulnerability, chi-squared and correlation tests were conducted. The null hypothesis was that there is no relationship between education level and perceived level of flood vulnerability.

Table 10: Chi-squired test (P-Value) output between level of education and perceived flood vulnerability

Indicator	P=Value (Chi-Squired)	Correlation
Level of education vs. Perceived level of flood vulnerability	0.0349	0.2535

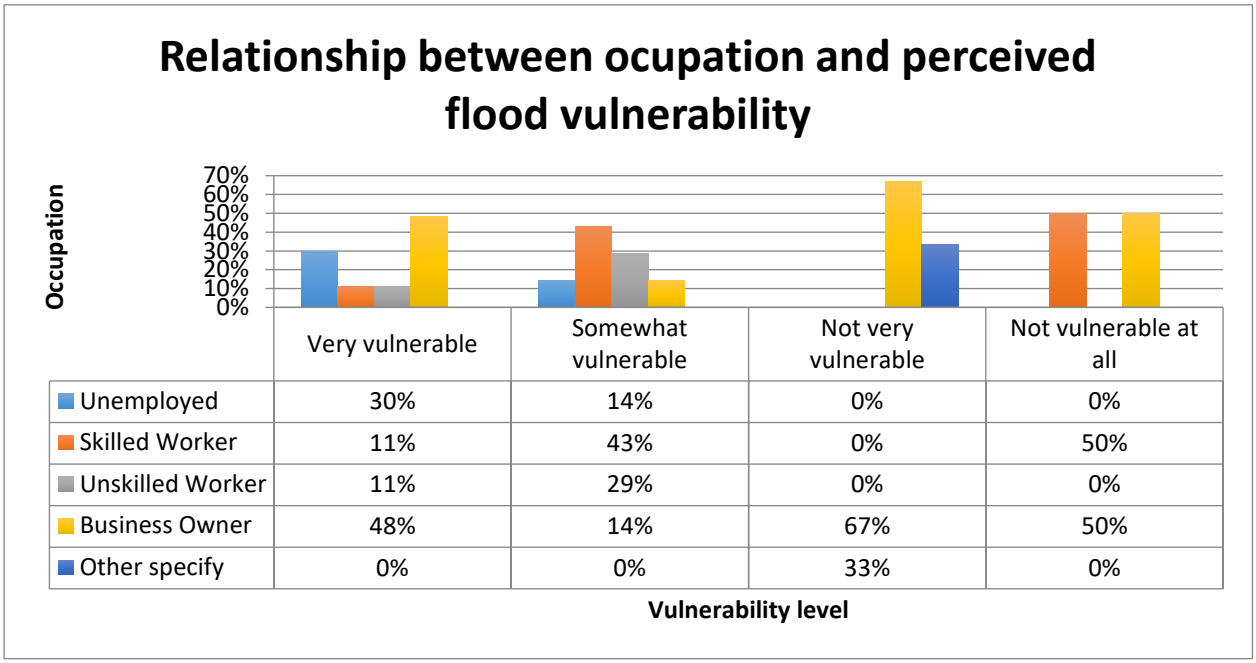
Source: Author (2023)

P-value result indicated that there is a strong statistically significant relationship between the two variables. This implies that there is evidence that education level has an influence on perceived level of flood vulnerability. As such, we reject the null hypothesis at 5% significant level. The correlation shows a weak positive relationship implying that when education level increases, perceived vulnerability also increases. Based on the sample and the study area, this indicates that as individuals attain higher levels of education, they are more likely to perceive themselves to be more vulnerable to floods due to acquired knowledge.

4.3.1.4 Occupation

The study investigated the assumption that income of people has a bearing in their vulnerability as indicated in chapter one and two. In order to establish this assumption, a series of questions were asked. 50% of skilled workers and business owners indicated not vulnerable respectively and 30% of unemployed were very vulnerable. Chart 5 below shows more details.

Chart 5: Relationship between occupation and perceived level of flood vulnerability



Source: Author (2023)

In order to evaluate the assumed relationship between occupation and perceived level of flood vulnerability, chi-squired tests and correlation were conducted. The null hypothesis was that occupation is not related to perceived flood vulnerability.

Table 11: Chi-squired test (P-Value) output between occupation and perceived flood vulnerability

Indicator	P=Value (Chi-Squired)	Correlation
Occupation vs. Perceived level of flood vulnerability	0.03087	0.1734

Source: Author (2023)

The P-value shows that there is a strong statistically significant relationship between occupation and perceived level of flood vulnerability, and we reject the null hypothesis at 5% significant level. This result implies that based on the sample size, the perception of people on their vulnerability is influenced by their occupation status. The negligible positive correlation suggests that there exists some positive relationship between certain occupations and high perceived vulnerability to floods. This result is in line with a quote from on key informant who said:

"most of these people have no skills to work on jobs that can give them enough financial support, as a result they end up cutting down trees in this hill to sell as firewood to make some money". (Local NGO Key Informant)

4.3.1.5 Household Income

Household income was one of the major factors that were assumed to have a strong relationship based on the literature. 35% of the sample indicated to make 100,000 Malawi kwacha or more and 25% make less than 20,000 Malawi kwacha in a month. When this data was run against gender, it showed that 23% of men make 100,000 Malawi kwacha or more against 13% of women in the same category. Furthermore, 13% of women makes less than 20,000 Malawi kwacha in a month against 8% of women in the same category. The results in general shows that men have an upper advantage in terms of income as compared to women. Chat 6 below was created merging the two variables of household income and perceived flood vulnerability. The results indicate that 50% and 25% of respondents whose income levels were much lower and lower indicated to be very vulnerable to floods respectively. On the other hand, 50% of respondents whose income levels were higher and slightly higher showed to be that said to be not vulnerable at all respectively.

To establish the assumed relationship between the two variables, Chi-squired and correlation tests were conducted between household income in relation to cost of living and perceived flood vulnerability. This was done with a null hypothesis that there is no relationship between household income level and perceived flood vulnerability. P-value result showed a very strong relationship between the two variables implying that higher household income is associated with reduction in perceived vulnerability to floods. As such we reject the null hypothesis at 1% and 5% significance levels. Furthermore, the moderately positive correlation signifies that in a positive response, people tend to feel less exposed to floods as household income rises. Nevertheless, the correlation is not particularly robust or straightforward, as there are likely other variables that exert influence in this regard.

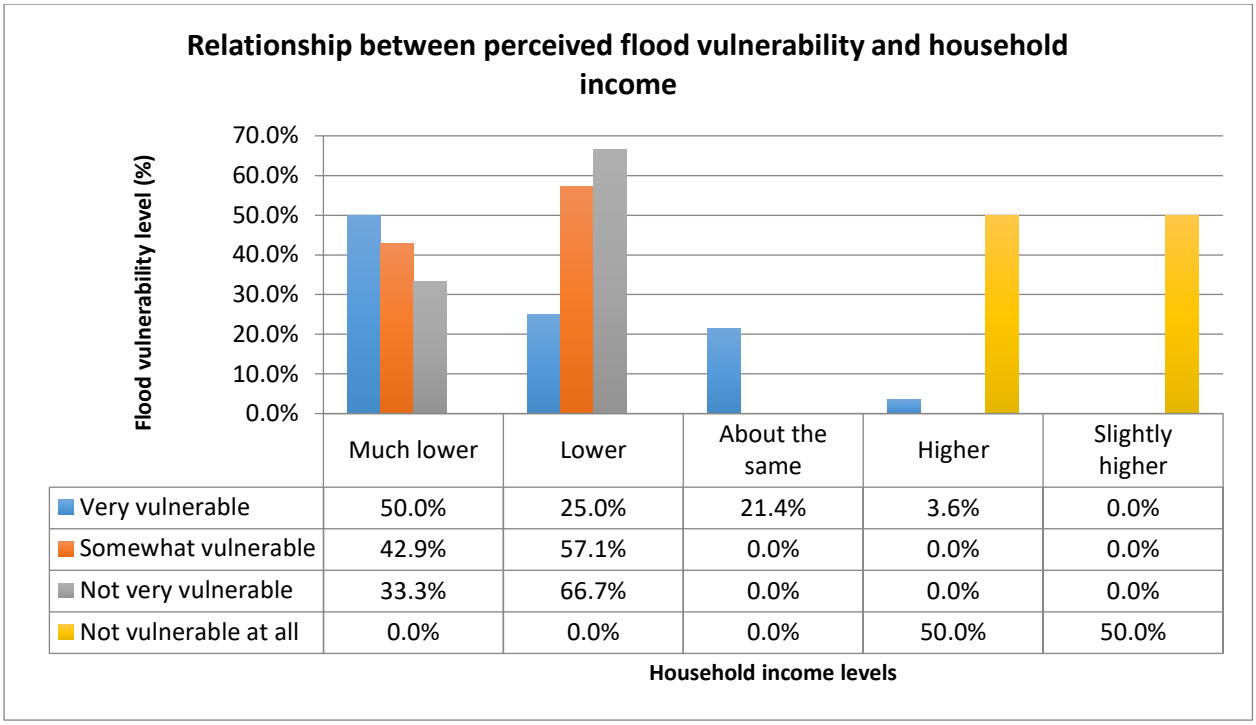
Table 12: Chi-squired test (P-Value) output between household income and perceived flood vulnerability

Indicator	P=Value (Chi-Squired)	Correlation
Household income vs. Perceived level of flood vulnerability	0.000475	0.3682

Source: Author (2023)

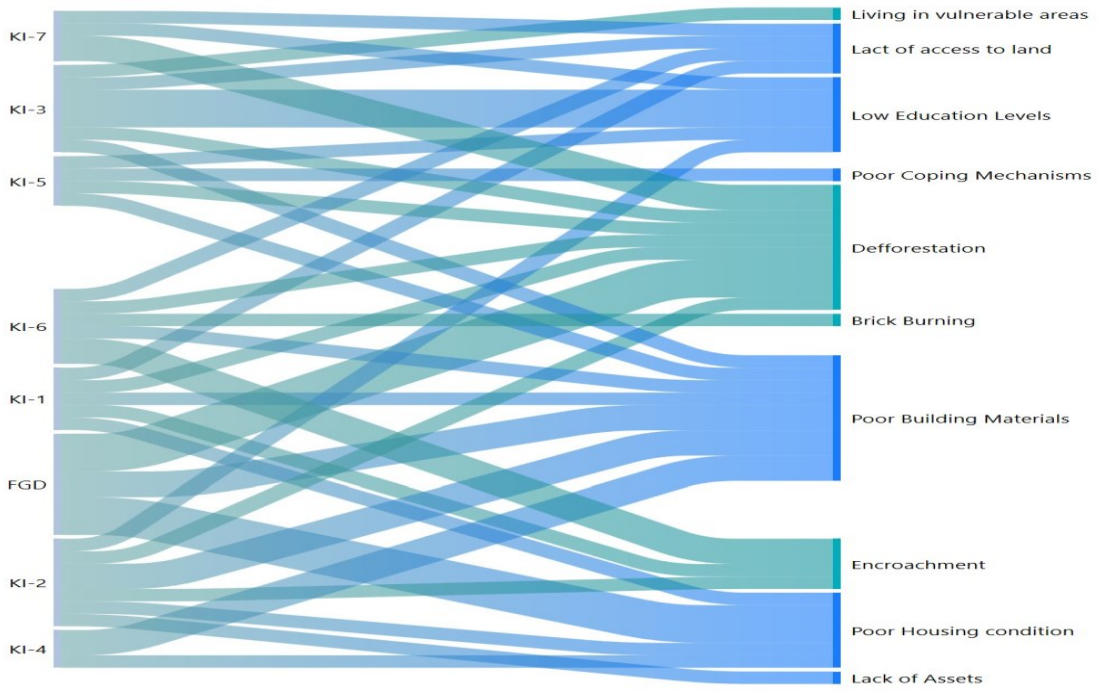
This result is in line with the results from key informants and focus group discussion that according to the results, those with a higher income may have better access to resources and ways of coping, which may help explain why they perceive themselves to be less vulnerable. On the other hand, lack of adequate income forces people in the study area to indulge in activities that further increase their vulnerability to floods such as deforestation etc. as shown on the sanky diagram 1 below.

Chart 6: Relationship between income and perceived flood vulnerability



Source: Author (2023)

Figure 4: Sanky diagram how lack of income triggers flood vulnerability

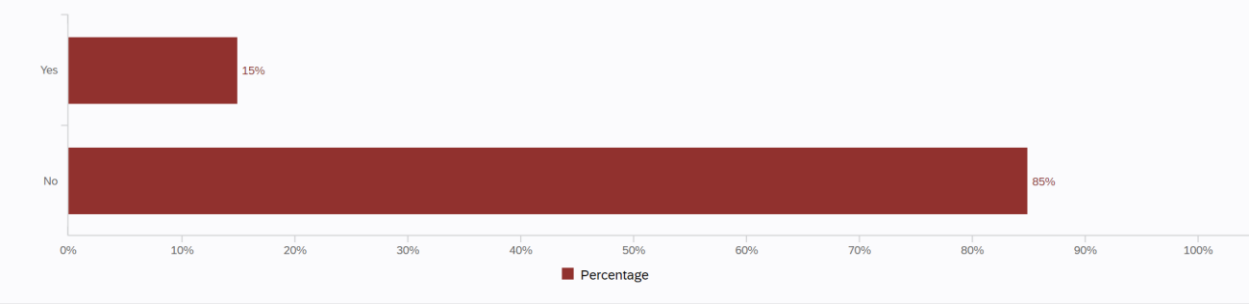


Source: Author (2023)

4.3.1.6 Access to loan

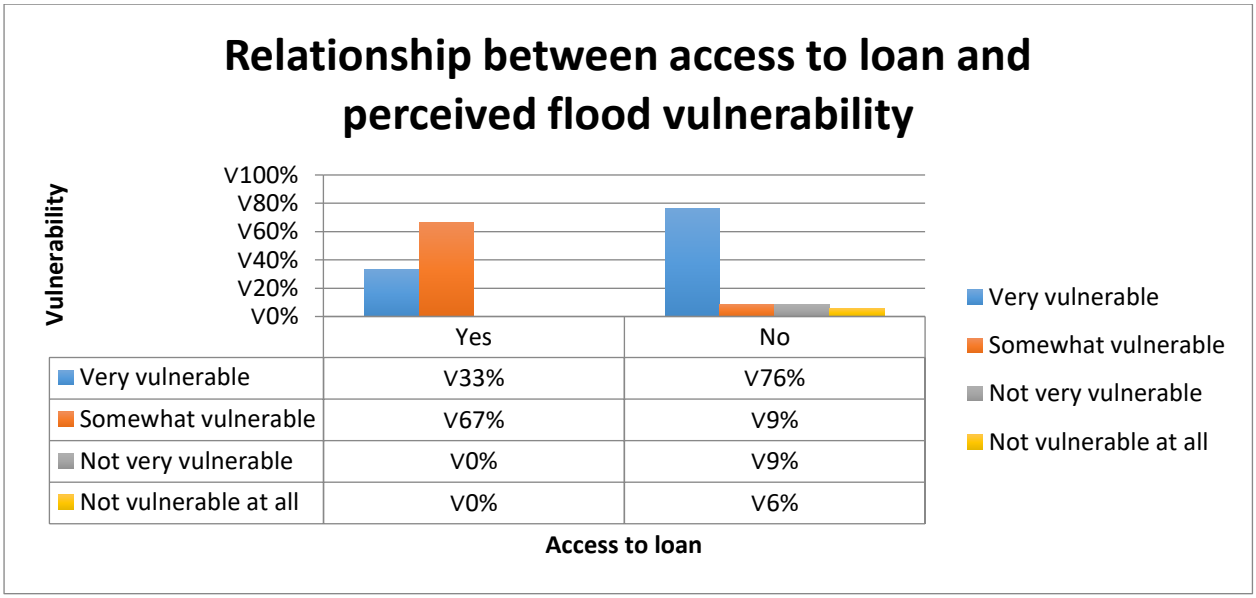
In order to establish the assumed relationship between the ability to access loan and perceived flood vulnerability, respondents were asked if they accessed loan related to flood damage maintenance. Chat 7 shows that 85% of the sample were not able to access the loan while only 15% were able to. Chart 8 further shows that 76% of respondents who indicated to have not access to loans perceived themselves as very vulnerable to floods. Chi-squared and correlation tests were applied. The null hypothesis was that access to loan has no relationship with perceived flood vulnerability. The P-value shows evidence of a very strong statistical relationship between the two variables as such we reject the null hypothesis at 1% and 5% confidence levels. The negligible negative correlation indicates that as access to loans increases, individuals are slightly inclined to perceive themselves as less vulnerable to floods due to access to resource and affordability to coping measures. However, based on the nature of the relationship it is plausible that additional factors could exert a more substantial impact on the perceived vulnerability to flooding within the study area.

Chart 7: Access to loan



Source: Author (2023)

Chart 8: Relationship between access to loan and perceived flood vulnerability



Source: Author (2023)

Table 13: Chi-squired test (P-Value) output between access to loan and perceived flood vulnerability

Indicator	P=Value (Chi-Squired)	Correlation
Access to Loan vs. Perceived level of flood vulnerability	0.00074	-0.0963

Source: Author (2023)

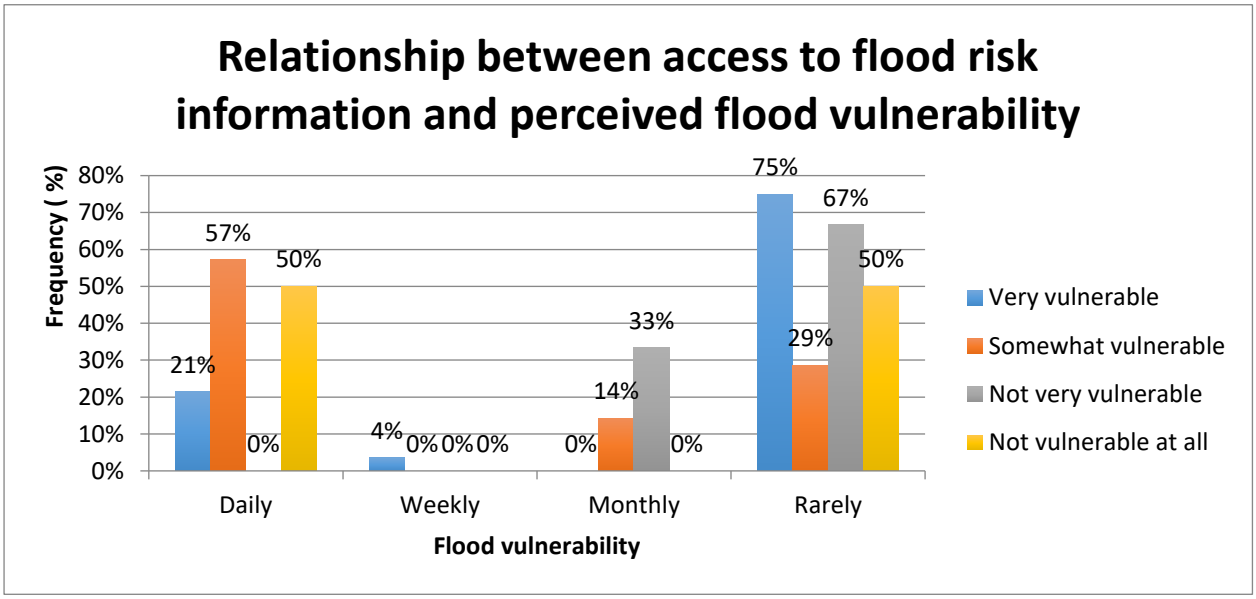
This result fall in line with a quote from one of the focus group discussions:

"*we are living in serious poverty, imagine if we cannot find food how can we find strong materials to build a strong house or live in a proper area?. Nobody cares for us, and no bank can even give us loans because we have no collateral. We are trapped my brother," (Participant from Manje)*

4.3.1.7 Access to Flood Risk Information

When responses on perceived flood vulnerability was crossed with frequency of access to information, 75% of those who indicated to perceive themselves very vulnerable to floods, accessed flood information as shown in chart 9 below.

Chart 9: Relationship between access to flood risk information and flood vulnerability



Source: Author (2023)

In order to establish if there is a relationship with perceived flood vulnerability, the chi-Squired and correlation tests were conducted see Table 14 below. The null hypothesis was that there is no relationship between access to flood risk information and perceived flood vulnerability. The P-Value shows that there is no statistically significant relationship between the two variables. As such we fail to reject the null hypothesis at 5% level. The observed negative negligible correlation between the variables indicates a slight tendency for individuals to perceive themselves as less vulnerable as their access to flood risk information increases. This is the case because access to information makes them aware and ready for disasters. This suggests that other variables significantly impact the perceived vulnerability to flooding in the study area.

Table 14: Chi-squired test (P-Value) output between access to flood risk information and perceived flood vulnerability

Indicator	P=Value (Chi-Squired)	Correlation
Access to flood risk information vs. Perceived level of flood vulnerability	0.1338	-0.1444

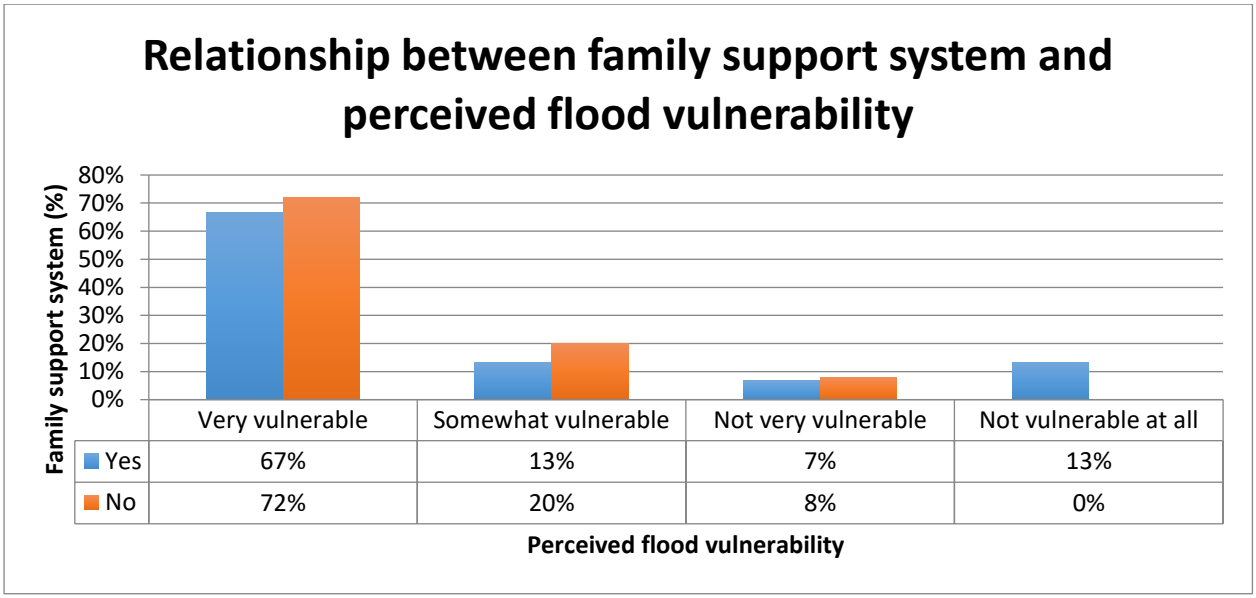
Source; Author (2023)

4.3.1.8 Household Social Support System

When asked if they have a family member or friend whom they can ask support from, 63% had no support as compared to 37% which had support. When responses on perceived flood vulnerability was crossed with household support system 72% of those without support system were found to be very vulnerable as compared to 13% of those who indicated to be have support system who were not vulnerable as shown in Chat 10, The chi-squired and correlation tests were conducted with the null hypothesis: there is no relationship between household social support system and perceived flood vulnerability. The P-Value shows that there is no statistically significant relationship between the variables so we fail to reject the null hypothesis at 5% significance level. This indicates that for the sample analyzed, household social support system has no relationship with the perceived flood vulnerability.

The observed negligible negative correlation between the two variables shows that as the level of family support increases, individuals are slightly inclined to perceive themselves as less susceptible to floods. However, the almost negligible relationship may be subject to various other factors that could significantly impact their perceived vulnerability to floods.

Chart 10: Relationship between family support system and perceived flood vulnerability



Source: Author (2023)

Table 15: Chi-squired test (P-Value) output between family support system and perceived flood vulnerability

Indicator	P=Value (Chi-Squired)	Correlation
Family support system vs. Perceived level of flood vulnerability	0.3040	-0.1775

Source: Author (2023)

4.3.2 Measurement of Flood Vulnerability in the Study Area

The socioeconomic factors associated with vulnerability were assigned weights in this study using AHP. The study gathered key informant data from professionals across various organizations, including UN-Habitat, BCC, MHC, CCODE, DoLS and MUBAS. A pairwise correlation matrix was constructed for all socio-economic indicators. The construction of the matrix was among others guided by a Disaster Risk Specialist from UH-Habitat who possesses extensive knowledge of the study area. The resulting matrix is presented in (Table 16). Subsequently, the calculation of the priority vector, which is a normalized Eigenvector derived from the matrix, was performed then employed as a weighting factor in the objective hierarchy (as presented in Table 17). The AHP methodology was utilized to identify the indicators that hold the most weight in determining socio-economic flood vulnerability. The results indicate that four indicators access to finance, household income, access to flood risk information and occupation hold the highest priority respectively, while the other five indicators flood experience, education level, perception, gender, and age, are of lower priority respectively. These findings are presented in (Table 19).

Table 16. Correlation matrix for socio-economic indicators

Matrix	Age	Gender	Education	Flood Experience	Family Suport	Access to FR information	Household income	Occupation	Perception	Access to finance
Age	1.00	0.33	0.33	0.17	1.00	0.17	0.12	0.20	0.33	0.11
Gender	3.00	1.00	1.00	0.17	3.00	0.17	0.12	0.20	1.00	0.11
Education level	3.00	1.00	1.00	0.17	3.00	0.17	0.12	0.20	1.00	0.11
Flood Experience	6.00	6.00	6.00	1.00	6.00	1.00	0.50	2.00	6.00	0.11
Family Suport	1.00	0.33	0.33	0.17	1.00	0.17	0.12	0.20	0.33	0.11
Access to information	6.00	6.00	6.00	1.00	6.00	1.00	0.50	2.00	6.00	0.11
Household income	8.00	8.00	8.00	2.00	8.00	2.00	1.00	8.00	8.00	0.50
Occupation	5.00	5.00	5.00	0.50	5.00	0.50	0.12	1.00	5.00	0.11
Perception	3.00	1.00	1.00	0.17	3.00	0.17	0.12	0.20	1.00	0.11
Access to finance	9.00	9.00	9.00	9.00	9.00	9.00	2.00	9.00	9.00	1.00
Total	45.00	37.66	37.66	14.35	45.00	14.35	4.72	23.00	37.66	2.38

Source: Author (2023)

Table 18 displays the Consistency Ratio (CR) values corresponding to socio-economic indicators. According to Saaty (2001), a Consistency Ration value that is below 10% is indicative of the reliability of each matrix. The vulnerability map for each indicator in ArcGIS was prepared by combining weights (W) calculated using the AHP approach with priority-based normalized rankings of each factor (Table 19, 20).

Table 17: Normalized matrix for the socio-economic indicators

Matrix	Age	Gender	Education	Flood Experience	Family Suport	Access to FR information	Household income	Occupation	Perception	Access to finance
Age	0.022	0.011	0.011	0.033	0.022	0.033	0.040	0.014	0.022	0.051
Gender	0.067	0.032	0.032	0.033	0.067	0.033	0.040	0.014	0.022	0.051
Education level	0.067	0.032	0.032	0.033	0.067	0.033	0.040	0.014	0.022	0.051
Flood Experience	0.133	0.194	0.194	0.194	0.133	0.194	0.161	0.135	0.133	0.051
Family Suport	0.022	0.011	0.011	0.033	0.022	0.033	0.040	0.014	0.022	0.051
Access to information	0.133	0.194	0.194	0.194	0.133	0.194	0.161	0.135	0.133	0.051
Household income	0.178	0.258	0.258	0.387	0.178	0.387	0.323	0.540	0.178	0.233
Occupation	0.111	0.161	0.161	0.097	0.111	0.097	0.040	0.068	0.111	0.051
Perception	0.067	0.032	0.032	0.033	0.067	0.033	0.040	0.014	0.022	0.051
Access to finance	0.200	0.290	0.290	1.000	0.200	1.000	0.500	0.608	0.200	0.465

Source: Author (2023)

Table 18: Consistency Ratio (CR) values for socio- economic indicators

Consistency Ratio	Value	Percentage (%)
Socio-economic	0.083	8.3%

Source: Author (2023)

Table 19: Weights based on pairwise comparisons.

Indicator	Priority (%)	Rank
Age	1.6	9
Gender	2.7	6
Education level	2.7	6
Flood Experience	10.6	3
Family Support	1.6	9
Access to information	10.6	3
Household income	20.8	2
Occupation	7.3	5
Perception	2.7	6
Access to finance	39.5	1

Source: Author (2023)

Table 20: Flood Vulnerability Index for each indicator

Number	Indicator	Normalized Value	Priority (%)	FVI Calculation per Indicator
1	Age	0.022	1.6	0.0352
2	Gender	0.0106	2.7	0.0286
3	Education Level	0.0106	2.7	0.0286
4	Flood Experience	0.0328	10.6	0.3477
5	Family Support	0.022	1.6	0.0352
6	Access to flood risk Information	0.0328	10.6	0.3477
7	Household Income	0.04	20.8	0.832
8	Occupation	0.0135	7.3	0.0986
9	Perception	0.022	2.7	0.0594
10	Access to Finance	0.0509	39.5	2.009

Source: Author (2023)

4.3.2.1 Socio-Economic Vulnerability

The level of socio-economic vulnerability differs along administrative borders the wards within the study area. There are four levels of socio- economic vulnerability as shown in (Fig.5). Using the priority column on (Table 19), vulnerability was categorized into four levels very low (0.00-0.01), low (0.01-0.25), medium (0.25-0.50), high (0.50-0.75), and very high (0.75-1.00) (Balica, 2013). The socio-economic vulnerability index in the study area as presented in (Fig. 5), shows a moderate level vulnerability.

The indicator vulnerability maps in appendix (1, 2, 3, 4 and 5) were generated using actual data obtained during the study. The maps employ a scale consisting of low, medium, and high to depict the distribution of indicators within the study area, based on the collected responses. The analysis of these indicator maps demonstrates that areas characterized as low are associated with higher levels of vulnerability, while areas identified as medium indicate a moderate level of vulnerability and high areas have lower levels of vulnerability, based on the specific indicators under analysis.

4.3.2.2 Justification of Flood Vulnerability Results

The FVI used a carefully selected set of indicators like education level, access to flood risk information, family support systems, gender, age, residents' perceptions to floods, household income, occupation and access to financial services. The selection of these indicators was informed by thorough research and a comprehensive review of relevant literature, as they have been widely acknowledged as significant determinants of susceptibility to flood events.

In order to account for the varying significance of each indicator, a weighting scheme was implemented within the FVI. The determination of the weights assigned to the indicators was

based on a combination of expert knowledge, stakeholder consultations, and data analysis. This approach ensured that indicators with a higher level of significance in contributing to overall vulnerability were assigned greater weights (Birkmann, 2007).

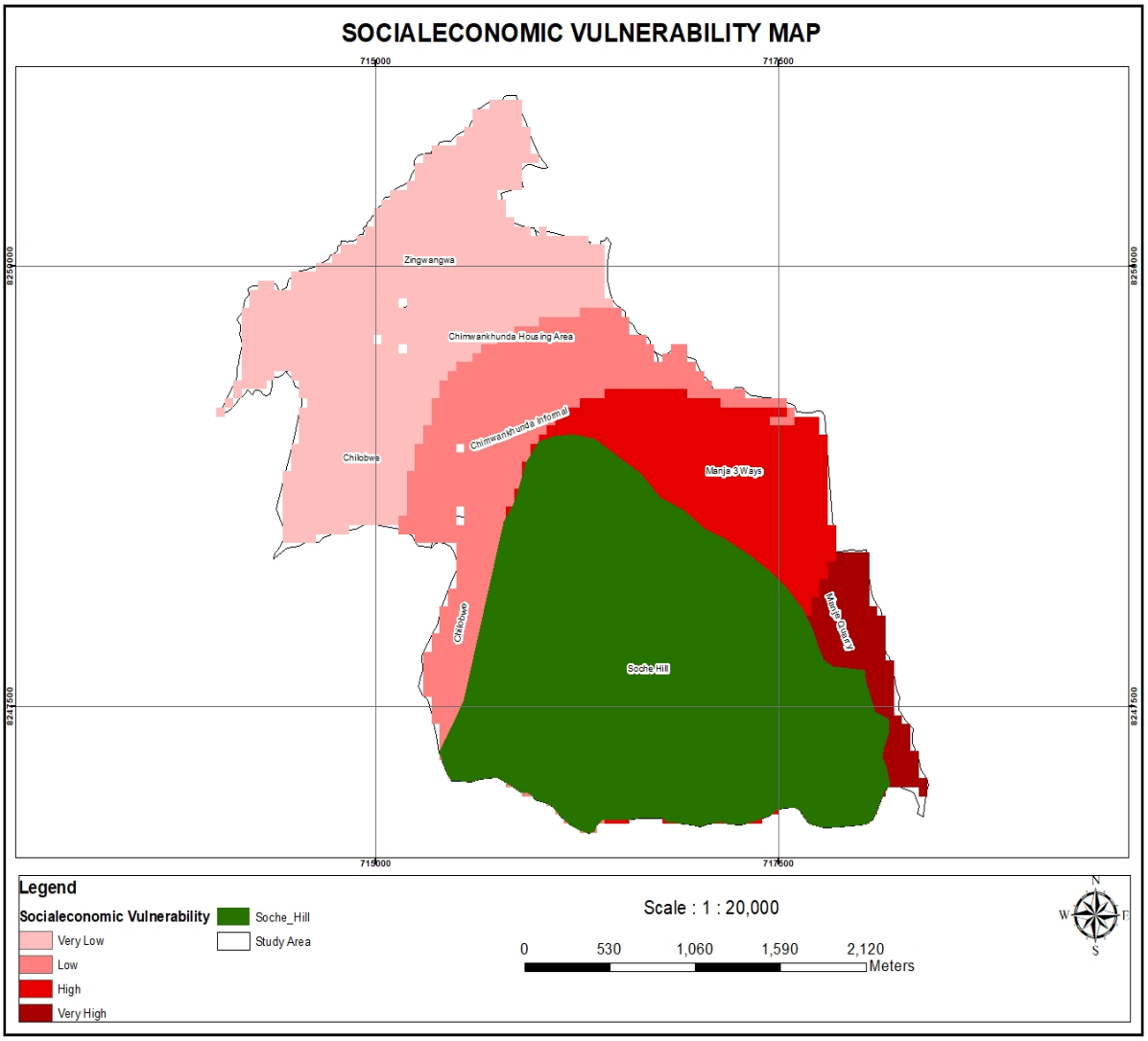
The collected data for each indicator underwent a normalization process to standardize them onto a common scale or range. The process enabled a significant and purposeful comparison and consolidation of the indicators, guaranteeing that each indicator made a proportional contribution to the overall index (Fekete, 2009).

The FVI utilized an aggregation technique that integrated the normalized values of the indicators, taking into account their respective weights. By simultaneously considering multiple indicators, this approach facilitated a comprehensive evaluation of vulnerability.

In order to enhance comprehension, the FVI has implemented an interpretive framework that includes pre-established classifications for levels of vulnerability. The determination of these thresholds was made by considering the specific context, available data, and expert judgement. Stakeholders were empowered to discern and give precedence to specific domains of intervention by considering the magnitude of vulnerability. The development of the FVI was undertaken with careful attention to the specific local context, achieved through active engagement with stakeholders and extensive consultations. This ensured the continued relevance and practicality of its use in evaluating the susceptibility to floods within the designated study area (Birkmann, 2007).

The rationale behind justifying the indicator selection, weighting scheme, normalization process, aggregation method, interpretation framework, and contextual considerations was to ensure the accuracy, validity, and practicality of the index. This supports the credibility and utility of this Flood Vulnerability Index (FVI) in informing decision-making processes, shaping policy formulation, and guiding targeted interventions pertaining to flood vulnerability.

Figure 5: Social-Economic Vulnerability Map



Source: Author (2023)

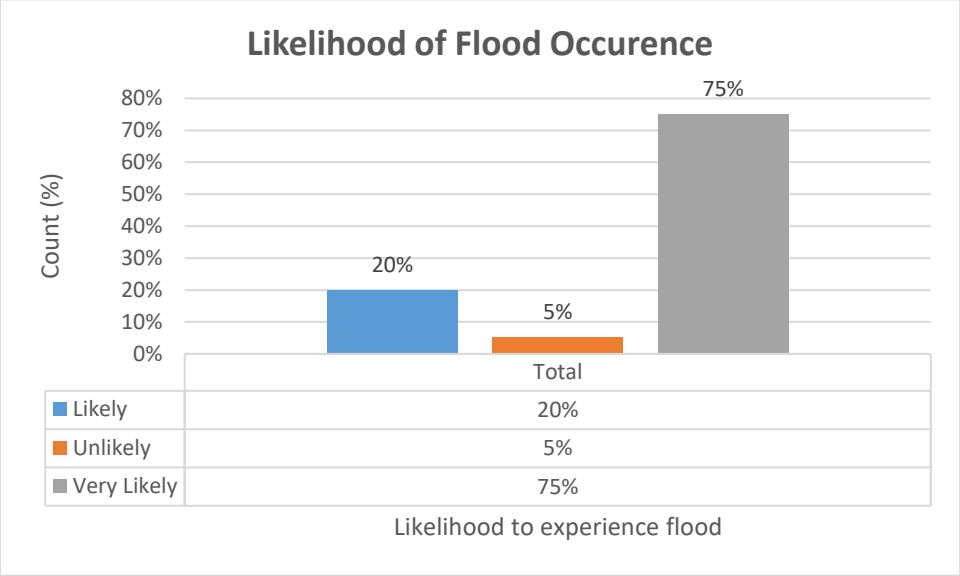
4.3.3 Perceptions on Changes in Socio-economic Vulnerability to Floods in the Future

The perception of flood risk is crucial in influencing individuals' decision-making regarding risk mitigation strategies. For instance, when an individual perceives the risk associated with a hazard to be minimal, their inclination to take action to mitigate their exposure to said hazard reduces (Martin, 2009). On the other hand socio-economic factors play a very big role flood vulnerability in shaping how the society perceive their future and safety from flooding events.

4.3.3.1 Likelihood to Experience Flooding

Chat 11 below shows the views of respondents on a question on likelihood that another flooding event will happen in the area. 75% indicated that it is very likely that flood will occur with just 5% of respondents who said it's unlikely for flooding to occur. This result implies that most of the people in the study area based on the sample used are aware of the risk they are in mostly because of the socio-economic vulnerability of the area they live in.

Chart 11. Likelihood of flood occurrence



Source: Author (2023)

The results pertaining to this question are consistent with focus group deliberations and key informants' interviews where significant responses indicated that they experience flooding annually with varying degrees of severity with the recent one being the worst.

To evaluate the level of preparedness, chi-squired and correlation tests were conducted. The null hypothesis in this test was that there is no relationship between likelihood of flood occurrence and level of preparedness.

P-value results show that there is no statistically significant relationship between these two variables therefore the null hypotheses were upheld see Table 21. The negligible negative correlation between the variables implies a negligible negative correlation between flood occurrence and the level of flood preparedness. These findings suggest that there is no or negligible correlation between the two variables based on the sample size.

Table 21: Chi-squired test (P-Value) output between flood occurrence and level of preparedness

Indicator	P=Value (Chi-Squired)	Correlation
Flood occurrence vs. Level of preparedness	0.4153	-0.0616

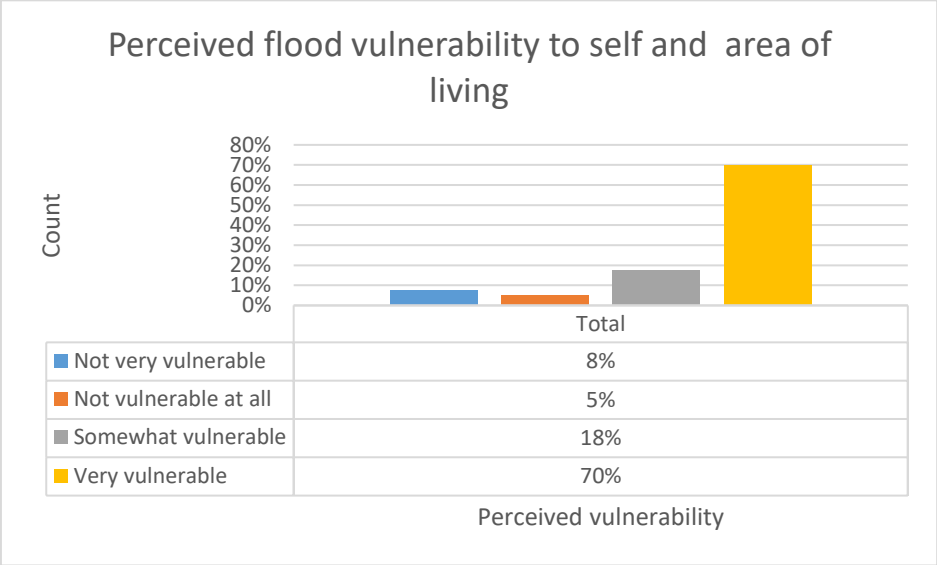
Source: Author (2023)

The results are consistent with what was discussed in the focus group: "*Don't think that we do not know that we are in danger, we are all aware the only is where can we go? We are people without any capacity to live outside this place because of poverty. We accepted that that's why you see although our relatives have died, we remain here because we have no where to go". (Participant from Manja)*

4.3.3.2 Perceived Vulnerability to Flooding

The perceived level of flood vulnerability was analyzed with the level of preparedness. Respondents were asked to indicate a range of responses based on their perception whether they feel very vulnerable, somewhat vulnerable, not vulnerable at all and not very vulnerable. 70% of the responses indicated their perception to flooding in the study areas as very vulnerable seconded by 18% who indicated somewhat vulnerable as shown in Chart 12.

Chart 12: Perceived vulnerability to flooding.



Source: Author (2023)

In order to assess if there was an effect of perceived level of flood vulnerability for the sample size and the level of flood preparedness, chi-squired and correlation was applied. The null hypothesis was that there is no relationship between perceived flood vulnerability to self and community and level of preparedness. Results showed no significant relationship between the two variables; thus, we fail to reject the null hypotheses at 5% significance level for the sample studied as shown in Table 22. The observed negligible negative correlation between the variables indicates an inverse relationship between the variables, meaning that a slight increase in level of preparedness to floods may not directly reduce flood occurrence.

Table 22: Chi-squired test (P-Value) output between perceived vulnerability and level of preparedness

Indicator	P=Value (Chi-Squired)	Correlation
Perceived vulnerability vs. Level of preparedness	0.7084	-0.0307

Source: Author (2023)

4.3.3.3 Perceived Level of Preparedness

This component was likewise analyzed by relating to ability to recover. From the mixed Chat 13, it shows that 57% of respondents who were not very prepared for floods was not able to recover and 20% of respondents who were not prepared at all are still recovering. A chi-squired and correlation tests were conducted with a null hypothesis that perceived level of preparedness has no relationship with the ability to recover.

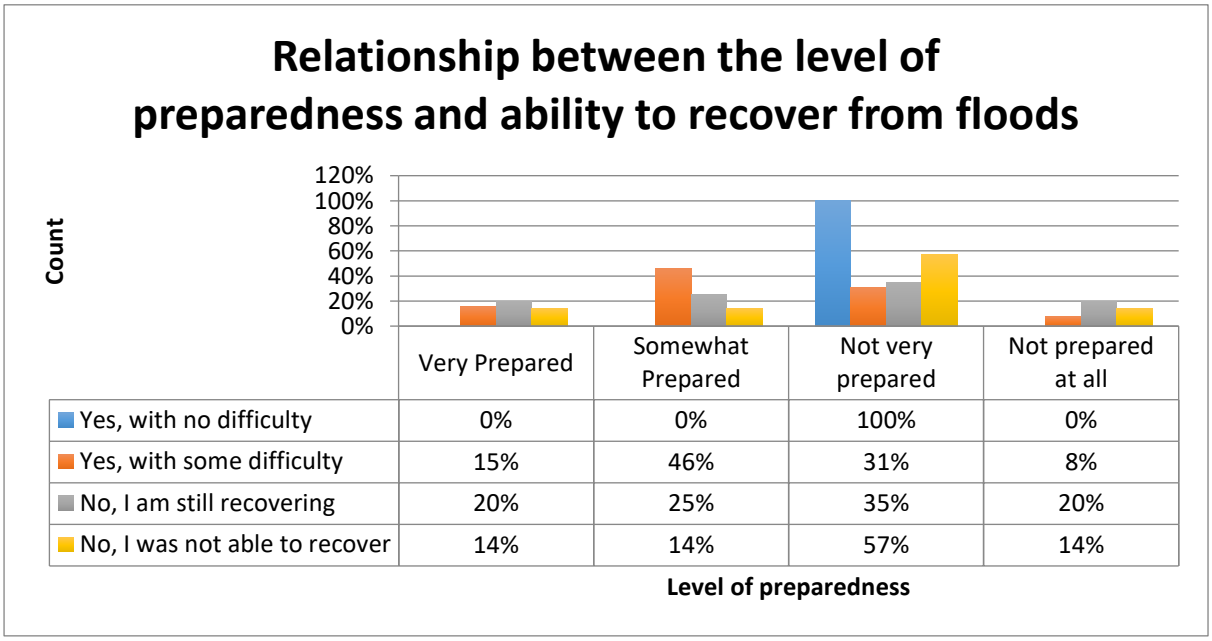
P-value in Table 23 shows that there is no statistically significant relationship between the two variables. As such we fail to reject the null hypothesis at 5% significant level. This means that the ability to recover from flood event has no meaningful relationship with how prepared people perceive themselves to be. The presence of a negligible negative correlation between the variables suggests that the degree to which people perceive to have prepared for floods may not always match their ability to recover when floods occur.

Table 23: Chi-squired test (P-Value) output between perceived level of preparedness and ability to recover.

Indicator	P=Value (Chi-Squired)	Correlation
Perceived level of preparedness vs. Ability to recover	0.8013	-0.0273

Source: Author (2023)

Chart 13: Relationship between level of preparedness and ability to recover.

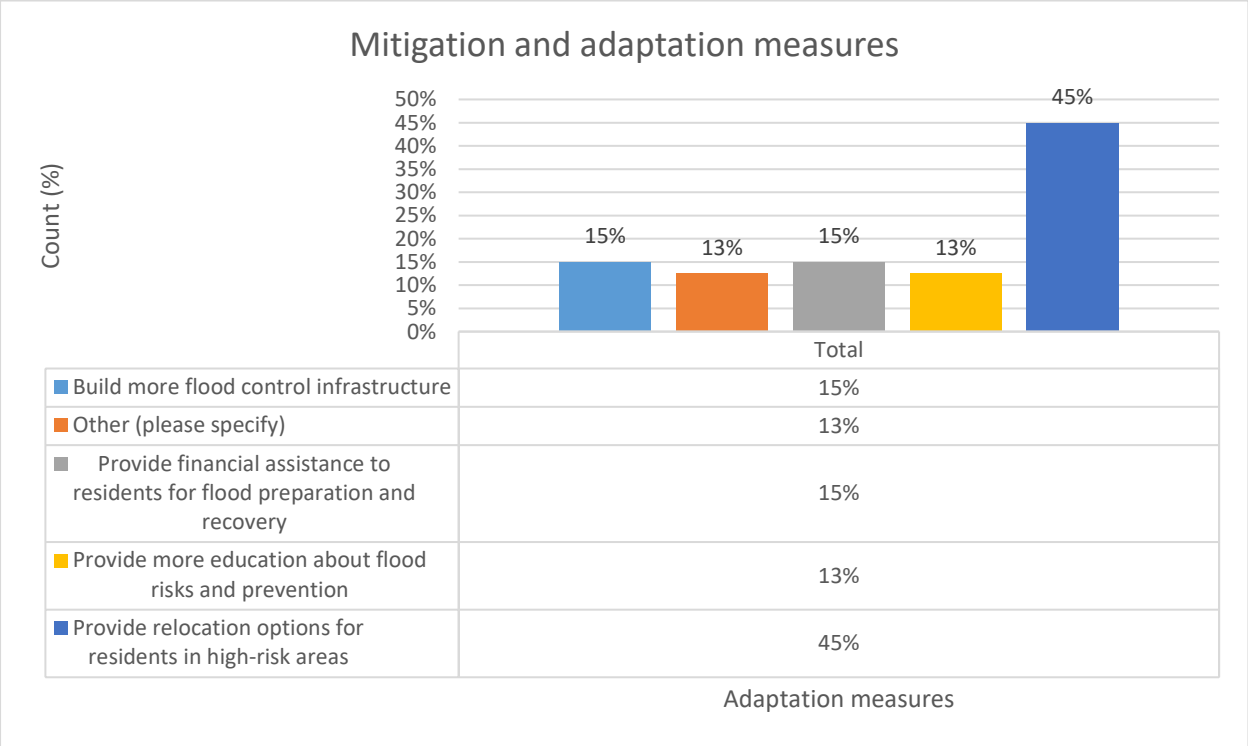


Source: Author (2023)

4.3.3.4 Proposed actions to be taken by government.

Chart 13 shows the list of proposed actions that respondents provided during data collection. They were asked to choose one measure which they think will help to reduce their flood risk in the study area. Based on the responses, 45% opted to relocate from the area to other safer locations, provide financial assistance to residents for flood preparation and recover and building more flood control infrastructure shared 15% respectively. Based on the sample size, the results imply that the sample population is aware of the looming danger in the areas that is why relocation is the best option for the majority that were interviewed. The Chart 14 below shows the share of the proposed measures in percentages.

Chart 14: Proposed mitigation and Adaptation measures



Source: Author (2023)

4.4 Interpretation of results

In general terms, this study has met most of the expected significances in interactions between vulnerable populations and the socio-economic factors used in this study. The socio-economic characteristics indicates that from the sampled respondents, indicators like household income, occupation, access to finance and level of education have a very significant determining factor in the socio-economic situation of the people for the sampled population. These factors determine where they can live within the area, their preparedness to flooding events and ability to recover from such events. Quotes from two key informants provide evidence on this:

"People in the settlement lack the resources and technical means to adequately prepare and cope with floods. They lack technical capacity to build resilient houses, they cannot afford to buy land in formal areas". (Key Informant 2)

"Those that are in poverty cannot access good sites for settlement and end up in marginal areas. In addition, the structures which they put up for shelter are out of rudimentary materials which do not withstand the harsh elements of weather". (Key Informant 1)

Based on the sampled respondents, indicators such as gender, age, access to flood risk information, residence's perception on flooding and family support system were not significant in the study suggesting that they are generally dependent on other factors for them to be effective, in this case the four indicators mentioned before acts as triggers or determinants in how they interact with each other to bring some impact in the socio-economic context. Such situations suggest to have people trapped in poverty cycles that exacerbate their vulnerability to flooding among others disasters. As illustrated in the quote from the focus group discussion when the participants were asked about family support:

"*many of us have nobody who can support, infact in our poor condition some people like me, my parents, nephews and cousins seek support from me yet I cannot support them because I do not have anything, my daughter has failed to go to school because I cannot afford her school fees". (Respondent from Misesa)*

In terms of measuring flood vulnerability, the results of the flood vulnerability index indicate that the study area is moderately vulnerable to flooding. It also indicates that reducing flood vulnerability cannot be accomplished by measuring and tackling a single socioeconomic component. Rather, all directly or indirectly interconnected elements should be assessed together. Resolving the environmental and physical factors is essential, as they contribute most significantly to flood vulnerability. Socio-economic vulnerability can be reduced by implementing a comprehensive management strategy at all levels, identifying local capacity, enhancing communication and awareness, and enhancing preparedness (Roder et al., 2017).

According to the sampled population, the quarry area located in Misesa ward exhibits the highest degree of socio-economic vulnerability. Access to finance is the most significant indicator of high socio-economic vulnerability, accounting for 39.5% of the total, followed by household income at 20.8% and access to flood risk information and flood experience shares 10.6%, respectively.

In terms of perceived change of flood vulnerability in future, the sampled respondents showed to know and understand their vulnerability and the likelihood of another disaster occurring in the future. However, they seem not prepared for such events due to poor socio-economic conditions they are living in. This is supported in a quote from focus group discussion:

"as for me I know we are in danger living here, but I have no financial capacity to change my situation, what can I do? I just ask God to protect us ".

5.0. Conclusions

This study was based on understanding the role of socio-economic factors in flood vulnerability in low-income informal settlements with a special focus on Soche hill informal settlements.

5.1. Answering Research Questions

5.1.1 What are the social and economic factors that contribute to flood vulnerability in low-income informal settlements?

The main hypothesis of this study was that social economic factors such as gender, age, level of education, occupation, household income, access to financial services, access to flood risk information, family support system and perceptions on flood vulnerability shape how people in low-income informal settlements become vulnerable to flooding events.

Based on analyzed responses from the survey respondents, key informants and focus group discussions, age, gender, access to flood risk information, family support system and flood perceptions did not indicate effect on flood vulnerability. However, the effect was shown with education level, household income, occupation and access to finance.

5.1.2 How to measure social-economic vulnerability to floods in low-income informal settlements.

The integration of AHP approach with GIS for assessing the degree of socio-economic vulnerability has shown to be a good methodology that effectively characterizes vulnerability. The efficacy of this approach could be further enhanced if the entirety of the data could comprehensively depict the state of the study area. The findings clearly demonstrate that Soche informal settlements exhibit socio-economic fragility, rendering them susceptible to flooding.

Hence, in order to mitigate the likelihood of flooding, it is imperative to formulate detailed land-use strategies that allocate substantial space for the establishment of vegetative areas that cannot be inhabited. It is imperative for the government to enact spatial policies aimed at mitigating settlement density such as relocation, particularly in areas that are prone to flooding.

5.1.3 How do the people perceive change of social-economic vulnerability to floods in the future?

According to the study, the sampled respondents showed to be aware of their vulnerability to flooding. However, statistical analysis results indicated no association between their altitudes and level of preparedness.

Based on the sampled respondents, the majority are aware that it is very likely that more disasters such as floods and mudslides will occur in the near future. However, the majority have limited options to deal with that fact because of their poor socio-economic status.

The perceptions from the sampled respondents in this study is in line with the conceptual Pressure and Release Model of which according to Wisner et al. (2004) and Adger (2006), individuals are susceptible to disasters due to a multitude of interrelated physical, social, economic, political, and environmental factors.

5.2 Societal and Scientific Contribution of this Study

Based on the study's findings, improvements and suggestions were proposed for the conceptual framework. Usually, flood vulnerabilities are predominantly associated with environmental and physical components. This study explored and validated socio-economic factors that are strongly associated with flood vulnerability levels in the context of Soche informal settlements in Blantyre city in Malawi.

Prominently, the study has revealed that household income, occupation, level of education, and access to finance are very important factors influencing the preparedness and ability to recover from flood events based on the sampled population. Furthermore, it is essential to incorporate contextual factors that are unique to the study area, such as socio-political dynamics and cultural influences, in order to enhance its applicability.

Enhancing the feedback loop within the framework is imperative, given the complex relationship between socio-economic factors, root causes, dynamic pressures, and unsafe conditions. The prioritization of long-term sustainability necessitates the implementation of interventions that emphasize the promotion of education, access to information, economic empowerment, social support systems, and community participation.

Integrating community-based approaches is crucial, as it highlights the significance of engaging local communities in decision-making processes and promoting grassroots initiatives to develop customized and situation-specific solutions.

Through the integration of these modifications, the framework has the capacity to offer a holistic comprehension of the socio-economic determinants that contribute to flood vulnerability. Furthermore, it can provide pertinent suggestions to tackle these obstacles within low-income informal settlements effectively.

5.3 Practical Limitations and Suggestions for further Research

The study's findings may be limited in their ability to be generalized to the entire city of Blantyre or other cities of similar nature, given that the data was solely obtained from three wards within the city. This assertion is predicated on the fact that various areas within Blantyre exhibit varying degrees of socioeconomic stratification, thereby potentially yielding divergent outcomes upon classification. However, the outcomes can be utilized to suggest theoretical frameworks in similar cases.

Considering the disparities of socio-economic aspects in Soche informal areas, further research could combine socio-economic, environmental and physical components in same study to see the bigger picture on how these components interrelate and influence flood vulnerability of the communities in the study area.

The study also prompts questions into the role of policy and planning in influencing urban development and provision of services. Given that flood risk goes hand in hand with urban growth, how choices on where social economic services and initiatives are implemented and managed in urban settings might provide fresh practical insights.

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Appendix 1: Research Instruments

IHS Making cities work Erasmus

Institute for Housing and Urban Development Studies of Erasmus University Rotterdam

Survey Interview Questionnaire

Hello, my name is **Simon McLloyd Chimwaza,** and I am a post-graduate student at Erasmus University Rotterdam pursuing a Master of Science in Urban Management and Development Majoring in Urban Environment, Sustainability and Climate Change. I am conducting this research in partial fulfillment of my studies at the university, and I am interested in understanding **the role of socio-economic factors in flood vulnerability in low-income informal settlements with focus to Soche Hill informal settlements.** The purpose of this survey is to gather information about the residents of these settlements and to measure their vulnerability levels in relation to socio-economic characteristics such as education level, access to information, social networks and support system, gender and age, household income, occupation, access to services, and access to finance.

The objectives of this research are **to identify the socio-economic characteristics of residents in low-income informal settlements that are most strongly associated with flood vulnerability, to measure vulnerability levels in relation to socio-economic characteristics, and to understand how vulnerable conditions will affect the living conditions of people in the future**. This information will be used to inform policies and programs that aim to improve the resilience of low-income informal settlements to flooding.

Your participation in this survey is voluntary and all responses will be kept confidential. The survey will take approximately 15 minutes to complete. Your answers will be invaluable in helping us better understand the challenges faced by residents of low-income informal settlements in relation to flooding.

Thank you for your time and participation.

SECTION 1: SOCIO-ECONOMIC INFORMATION

1. Gender

a. Male

b. Female

2. What is your age?

a. Under 18

b. 18-24

c. 25-34

d. 35-44

e. 45-54 f. 55 and over

3. What is your highest level of education completed?

a. Primary school

b. Secondary school

c. Tertiary education

d. None of the above

4. How many years of formal education have you completed?

a. Less than 5 years

b. 5-9 years

c. 10-14 years

d. 15 years or more

5. What is your current occupation?

a. Unemployed

b. Skilled worker

c. Unskilled worker

d. Business owner

e. Other (please specify)

6. What is your current household income?

a. Less than K20,000 per month

b. K50,000 per month

c. K80,000 per month

d. K100,000 per month

e. K100,000 or more per month

7. How does your current household income compare to the cost of living in your neighborhood?

a. Much lower

b. Lower

c. About the same

d. Higher

e. Much higher

8. How easily accessible are essential services such as healthcare and emergency services in your neighborhood?

a. Very easily accessible

b. Somewhat easily accessible

c. Not very easily accessible

d. Not accessible at all

9. Do you have access to emergency funds or savings in case of a flood?

a. Yes

b. No

10. Have you ever taken out a loan for flood-related expenses?

a. Yes

b. No

11. How often do you receive information regarding flooding risks and/or prevention measures?

a. Daily

b. Weekly

c. Monthly

d. Rarely or never

12. From where do you get information regarding flooding risks and/or prevention measures? a. Television

b. Radio

c. Social media

d. Word of mouth

e. Other (please specify)

13. Do you have friends or family members who could provide support in case of a flood?

a. Yes

b. No

14. How would you rate the strength of your social support network in case of a flood?

a. Very strong

b. Strong

c. Moderate

d. Weak

e. Very weak

SECTION 2: FLOOD VULNERABILITY

15. How likely do you think it is that your neighborhood will experience a flood in the future?

a. Very likely

b. Likely

c. Unlikely

d. Very unlikely

16. How prepared do you feel for a flood?

a. Very prepared

b. Somewhat prepared

c. Not very prepared

d. Not prepared at all

17. Have you ever experienced a flood in your current neighborhood?

a. Yes

b. No

18. How severe was the flood you experienced in your current neighborhood?

a. Mild

b. Moderate

c. Severe

d. Very severe

19. Were you able to recover from the flood you experienced in your current neighborhood?
a. Yes, with no difficulty

b. Yes, with some difficulty

c. No, I am still recovering

d. No, I was not able to recover

20. Have you ever relocated to another area due to flooding in your current neighborhood?

a. Yes

b. No

21. If you have relocated due to flooding, where did you go?

a. Within the same city

b. To a nearby city or town

c. To another region or state

d. To another country

22. How vulnerable do you perceive yourself and your household to be to flooding?

a. Very vulnerable

b. Somewhat vulnerable

c. Not very vulnerable

d. Not at all vulnerable

23. In your opinion, what should the government do to prevent flooding in low-income informal settlements?

a. Build more flood control infrastructure

b. Provide more education about flood risks and prevention

c. Provide financial assistance to residents for flood preparation and recovery

d. Provide relocation options for residents in high-risk areas

e. Other (please specify)

Key Informants

Hello, my name is **Simon McLloyd Chimwaza,** and I am a post-graduate student at Erasmus University Rotterdam pursuing a Master of Science in Urban Management and Development Majoring in Urban Environment, Sustainability and Climate Change. I am conducting this research in partial fulfillment of my studies at the university, and I am interested in understanding **the role of socio-economic factors in flood vulnerability in low-income informal settlements with focus to Soche Hill informal settlements.** The purpose of this survey is to gather information about the residents of these settlements and to measure their vulnerability levels in relation to socio-economic characteristics such as education level, access to information, social networks and support system, gender and age, household income, occupation, access to services, and access to finance.

The objectives of this research are **to identify the socio-economic characteristics of residents in low-income informal settlements that are most strongly associated with flood vulnerability, to measure vulnerability levels in relation to socio-economic characteristics, and to understand how vulnerable conditions will affect the living conditions of people in the future**. This information will be used to inform policies and programs that aim to improve the resilience of low-income informal settlements to flooding.

Your participation in this study is voluntary and all responses will be kept confidential. Your answers will be invaluable in helping me to better understand the challenges faced by residents of low-income informal settlements in relation to flooding.

Thank you for your time and participation.

SECTION 1: DEMOGRAPHIC INFORMATION

1. What is your occupation?

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2. How many years have you been working in your profession?

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3. What is your educational background?

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SECTION 2: FLOOD VULNERABILITY

5. In your opinion, what are the main causes of flooding in this area?

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6. How frequently does flooding occur in this area?

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7. How severe are the floods that occur in this area?

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8. What are the typical impacts of flooding on the community?

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9. In your experience, which households are most vulnerable to flooding in this community?

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SECTION 3: SOCIO-ECONOMIC FACTORS

10. In your opinion, which socio-economic factors are most strongly associated with flood vulnerability in this community?

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11. How do poverty and income inequality contribute to flood vulnerability in this community?

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12. In your experience, how do lack of access to sanitation and waste management facilities impact flood vulnerability in this community?

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13. Do you think housing conditions contribute to flood vulnerability in this community? If so how?

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14. Do you think access to services such as healthcare and education impact flood vulnerability in this community?

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15. Does age and gender has any influence to flood vulnerability of the households in this area? If so, how?

SECTION 4: FUTURE VULNERABILITY

16. In your opinion, how do you see flood vulnerability changing in the future in this community?

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17. How can the community prepare for future flooding events and reduce their vulnerability to them?

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18. Are there any current initiatives or projects in place to address flood vulnerability in this community? If so, can you describe them?

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19. In your opinion, what additional steps need to be taken to reduce flood vulnerability in this community?

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End of the questionnaire, thank you for your time!

Guide for focus group discussions

Hello, my name is **Simon McLloyd Chimwaza,** and I am a post-graduate student at Erasmus University Rotterdam pursuing a Master of Science in Urban Management and Development Majoring in Urban Environment, Sustainability and Climate Change. I am conducting this research in partial fulfillment of my studies at the university, and I am interested in understanding **the role of socio-economic factors in flood vulnerability in low-income informal settlements with focus to Soche Hill informal settlements.** The purpose of this survey is to gather information about the residents of these settlements and to measure their vulnerability levels in relation to socio-economic characteristics such as education level, access to information, social networks and support system, gender and age, household income, occupation, access to services, and access to finance.

The objectives of this research are **to identify the socio-economic characteristics of residents in low-income informal settlements that are most strongly associated with flood vulnerability, to measure vulnerability levels in relation to socio-economic characteristics, and to understand how vulnerable conditions will affect the living conditions of people in the future**. This information will be used to inform policies and programs that aim to improve the resilience of low-income informal settlements to flooding.

Your participation in this study is voluntary and all responses will be kept confidential. Your answers will be invaluable in helping us better understand the challenges faced by residents of low-income informal settlements in relation to flooding.

Thank you for your time and participation.

INTRODUCTION

1. Welcome the participants to the focus group discussion and introduce myself.
2. Explain the purpose of the focus group discussion and the topics that will be covered.
3. Ask participants to introduce themselves and briefly describe their experience with flooding in low-income informal settlements.

SECTION 1: FLOOD VULNERABILITY

1. In your experience, what are the main causes of flooding in this area?
2. How frequently do flooding events occur in here?
3. What are the typical impacts of flooding on you as the residents of this area?
4. Have you or anyone you know been directly affected by flooding here? If so, can you describe your experience?

SECTION 2: SOCIO-ECONOMIC FACTORS

5. In your opinion, which socio-economic factors are most strongly associated with flood vulnerability in this area?
6. How do poverty and income inequality contribute to flood vulnerability ?
7. Do you think lack of access to basic services like clean water and sanitation facilities contribute/impact to your vulnerability to flooding?

If so, how does it impact flood vulnerability?

8. How do housing conditions contribute to flood vulnerability?
9. How do access to healthcare and education impact flood vulnerability ?

SECTION 3: CURRENT INITIATIVES

10. Are there any current initiatives or projects in place to address flood vulnerability in low-income informal settlements? If so, can you describe them?
11. What are your opinions on the effectiveness of these initiatives or projects?
12. Are there any gaps in the current initiatives or projects that need to be addressed?

SECTION 4: FUTURE VULNERABILITY

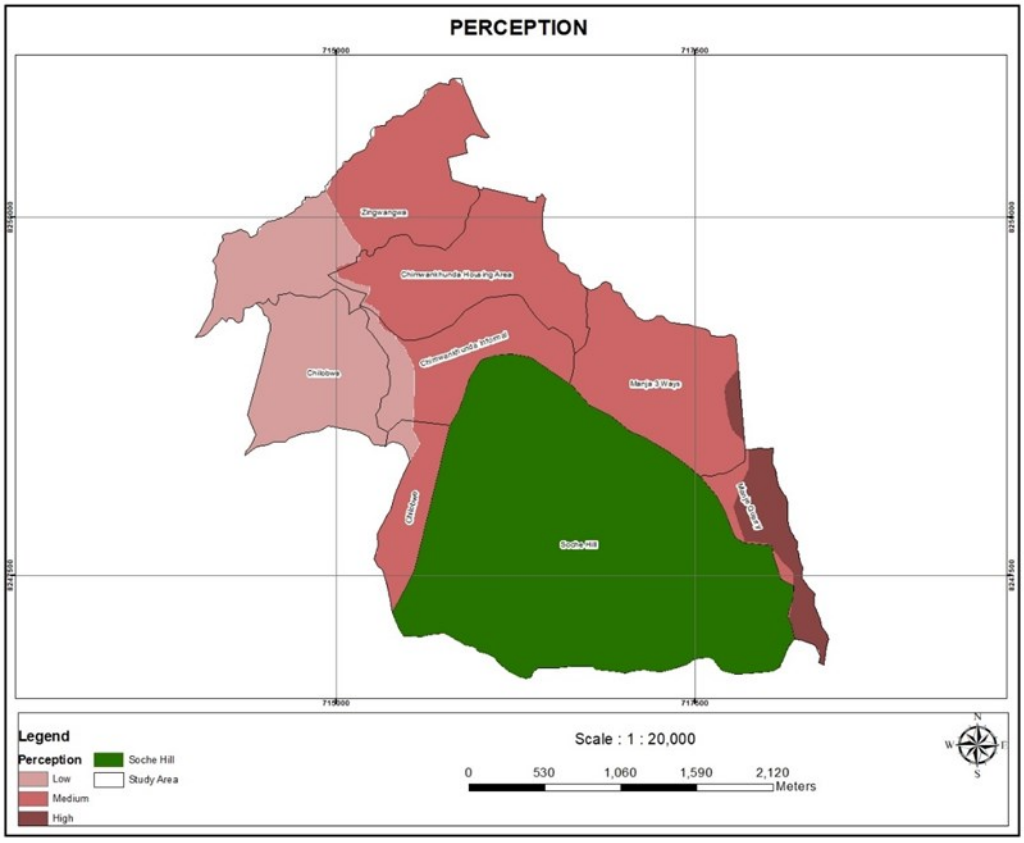
13. Can you describe any flooding events that you have experienced in this community? How did it impact you and your household?
14. In your opinion, how prepared is this community for flooding events? What measures could be taken to improve preparedness?
15. How do you think the vulnerability of this community to flooding might change in the future? Are there any factors that might make it more vulnerable?
16. Can you describe any measures you or your community have taken to reduce your vulnerability to flooding?
17. Are there any challenges to implementing these policies or initiatives? If so, what are they?

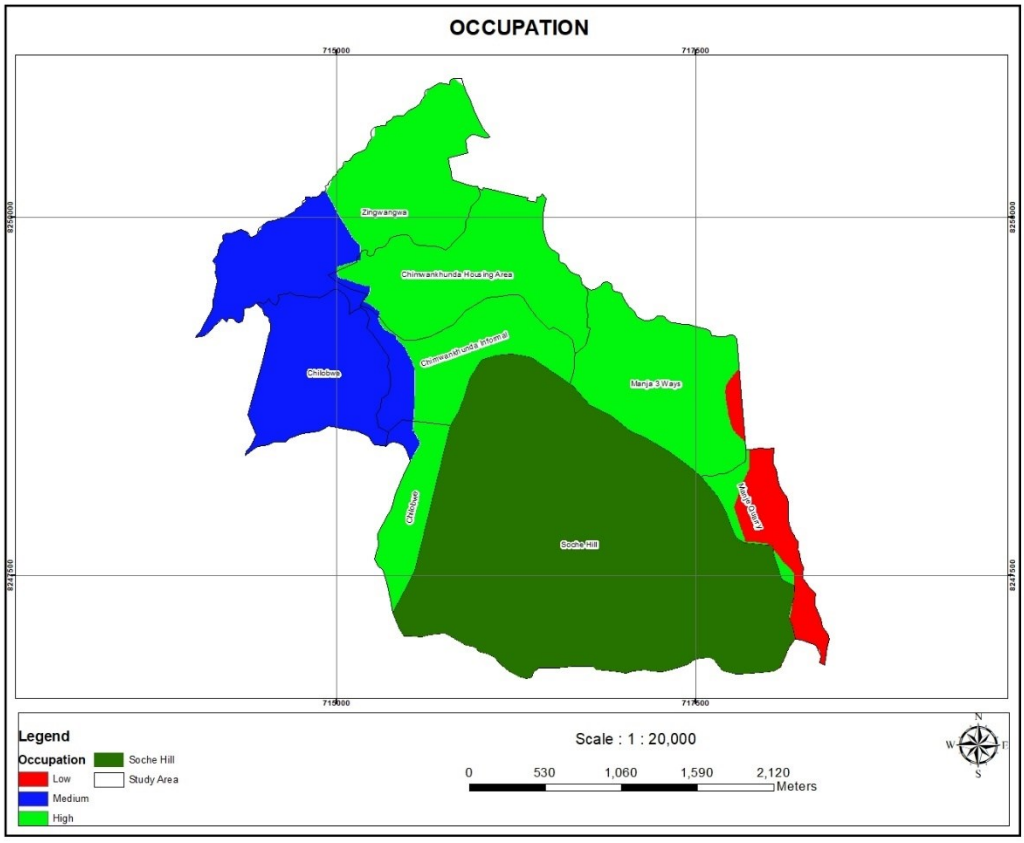
18. How can the government work with the community to reduce flood vulnerability in this area?

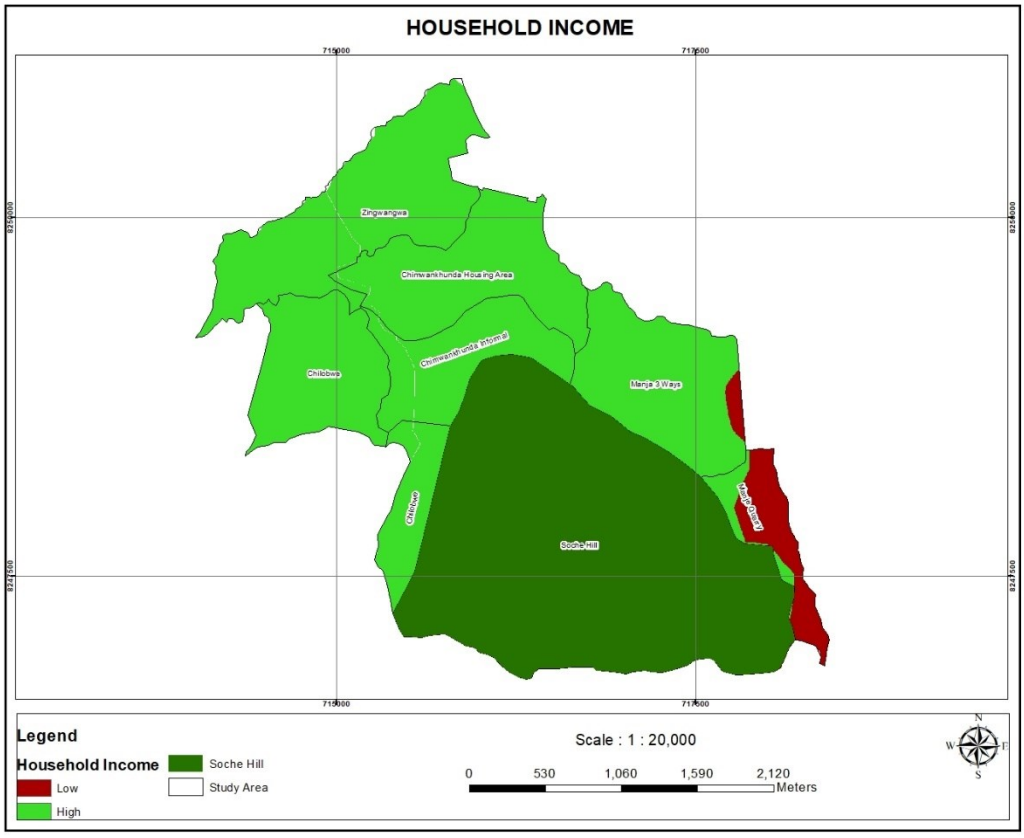
CONCLUSION

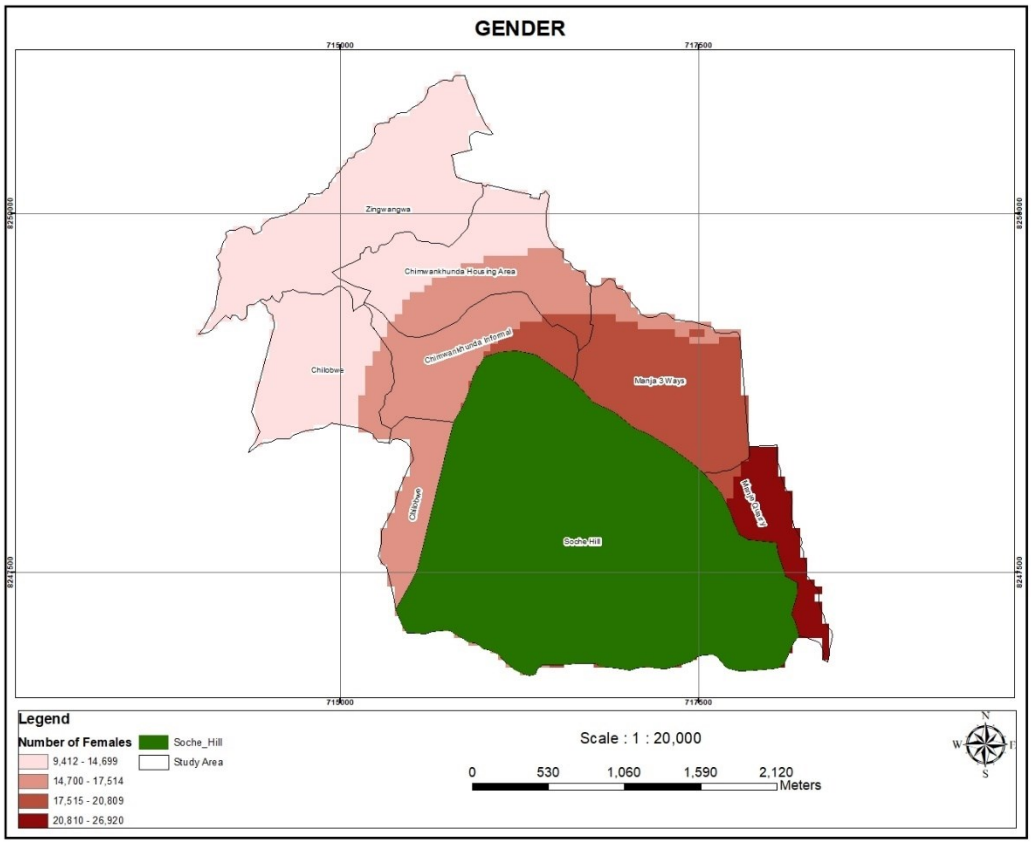
19. Thank the participants for their time and input.
20. Summarize the key points of the discussion and ask if anyone has any final comments.

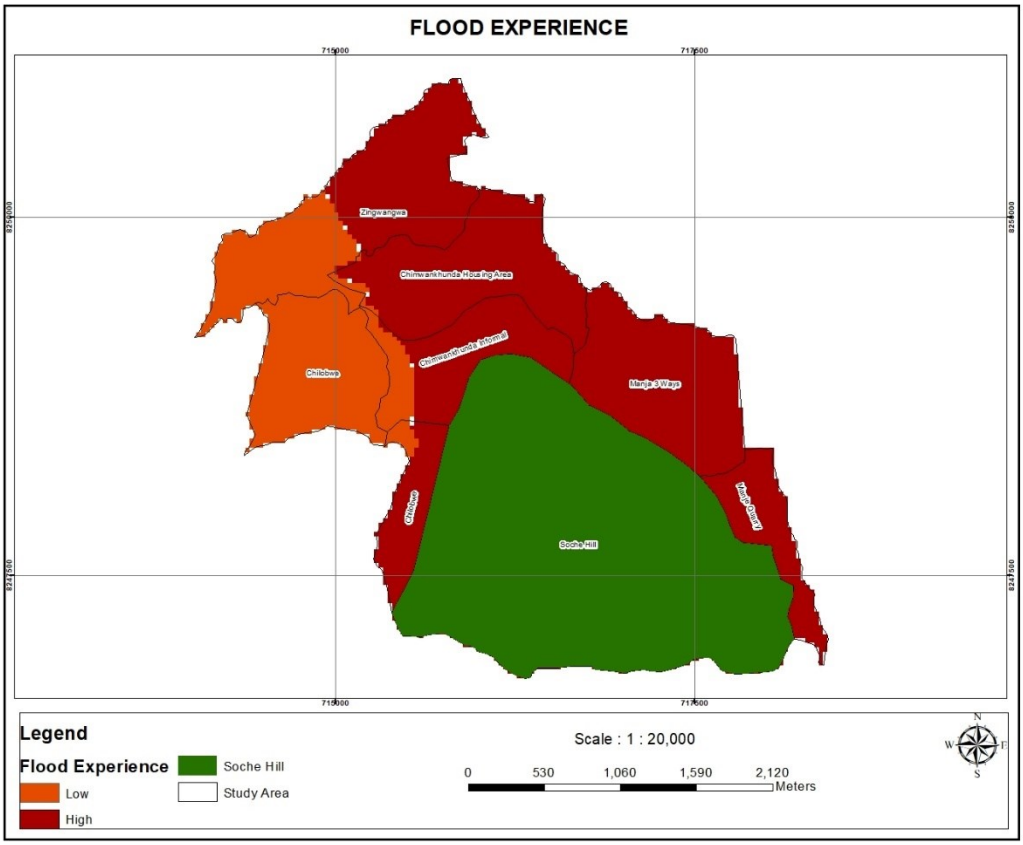
Appendix 2: Flood Vulnerability Index Maps

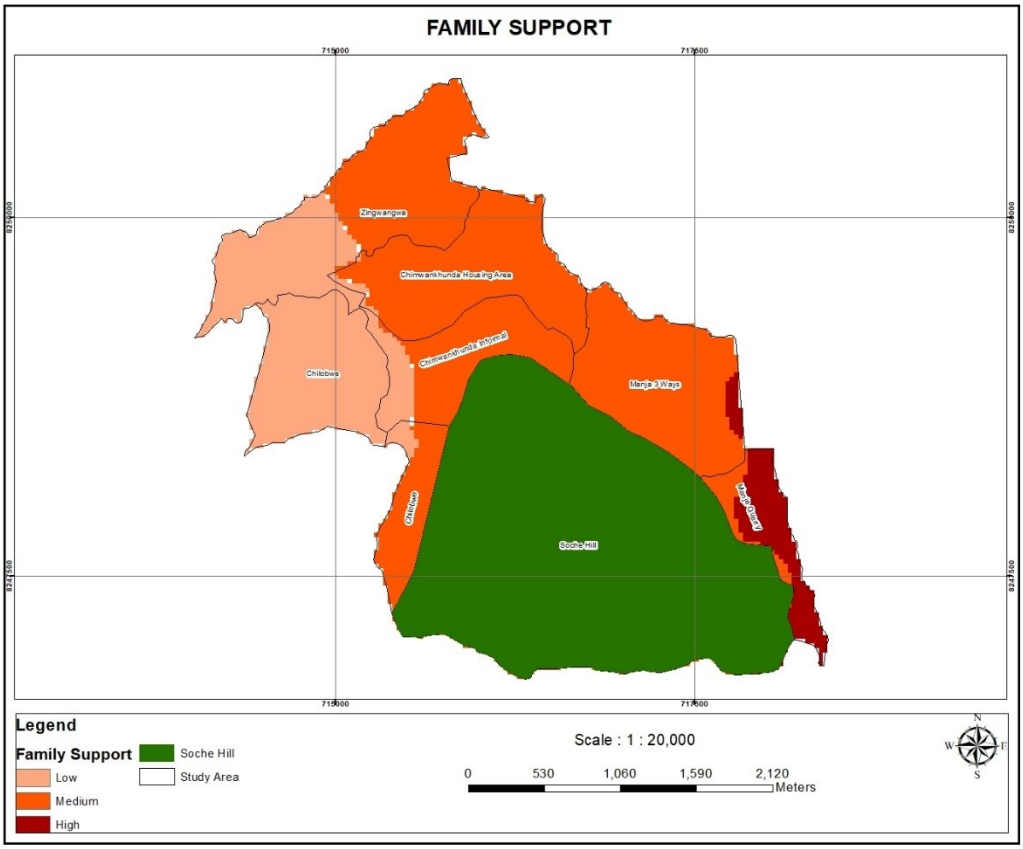


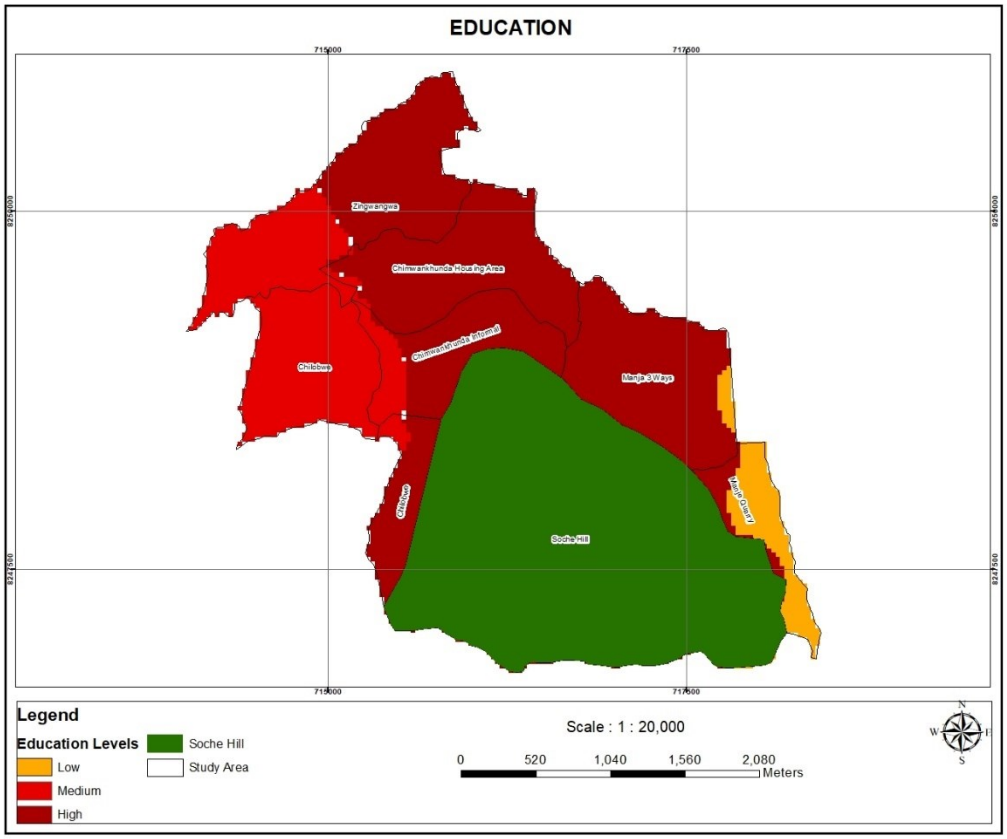

OCCUPATION
Zingwangwa
Chimwankhunda Housing Area
Chimwendi ndi a Yohimbe
Chilobwe
Manja 3 Ways
Soche Hill
Legend
Occupation
Low
Medium
High
Soche Hill
Study Area
Scale : 1 : 20,000
0 530 1,060 1,590 2,120
Meters


HOUSEHOLD INCOME
Zingwangwa
Chimwankhunda Housing Area
Chimwendi ndi a Yohimbe
Chilobwe
Manja 3 Ways
Soche Hill
Legend
Household Income
Low
High
Soche Hill
Study Area
Scale : 1 : 20,000
0 530 1,060 1,590 2,120
Meters


GENDER
715000
717500
8250000
8247500
Zingwangwa
Chimwankhunda Housing Area
Chimwankhunda Informal
Chilobwe
Manje 3 Ways
Chilobwe
Soche Hill
Legend
Number of Females
9,412 - 14,699
14,700 - 17,514
17,515 - 20,809
20,810 - 26,920
Soche_Hill
Study Area
Scale : 1 : 20,000
0
530
1,060
1,590
2,120
Meters
N
W
E
S


FLOOD EXPERIENCE
Zingwangwa
Chimwankhunda Housing Area
Chilobwe
Manja 3 Ways
Soche Hill
Legend
Flood Experience
Low
High
Soche Hill
Study Area
Scale : 1 : 20,000
0
530
1,060
1,590
2,120
Meters


FAMILY SUPPORT
Zingwangwa
Chimwankhunda Housing Area
Chilobwe
Manja 3 Ways
Soche Hill
Legend
Family Support
Low
Medium
High
Soche Hill
Study Area
Scale : 1 : 20,000
0
530
1,060
1,590
2,120
Meters


EDUCATION
715000
717500
8254000
8247500
Zingwangwa
Chimwankhunda Housing Area
Chimwankhunda Informal
Chilobwe
Manja 3 Ways
Manja Phase 7
Soche Hill
Legend
Education Levels
Low
Medium
High
Soche Hill
Study Area
Scale : 1 : 20,000
0 520 1,040 1,560 2,080
Meters
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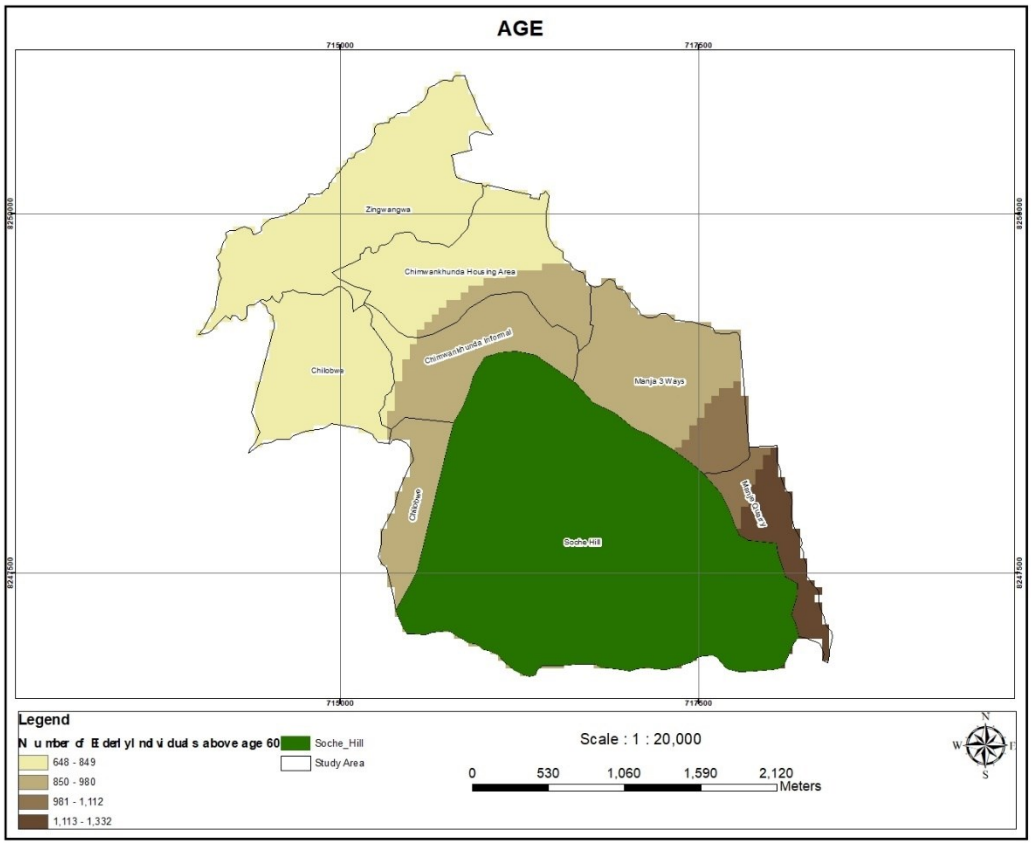
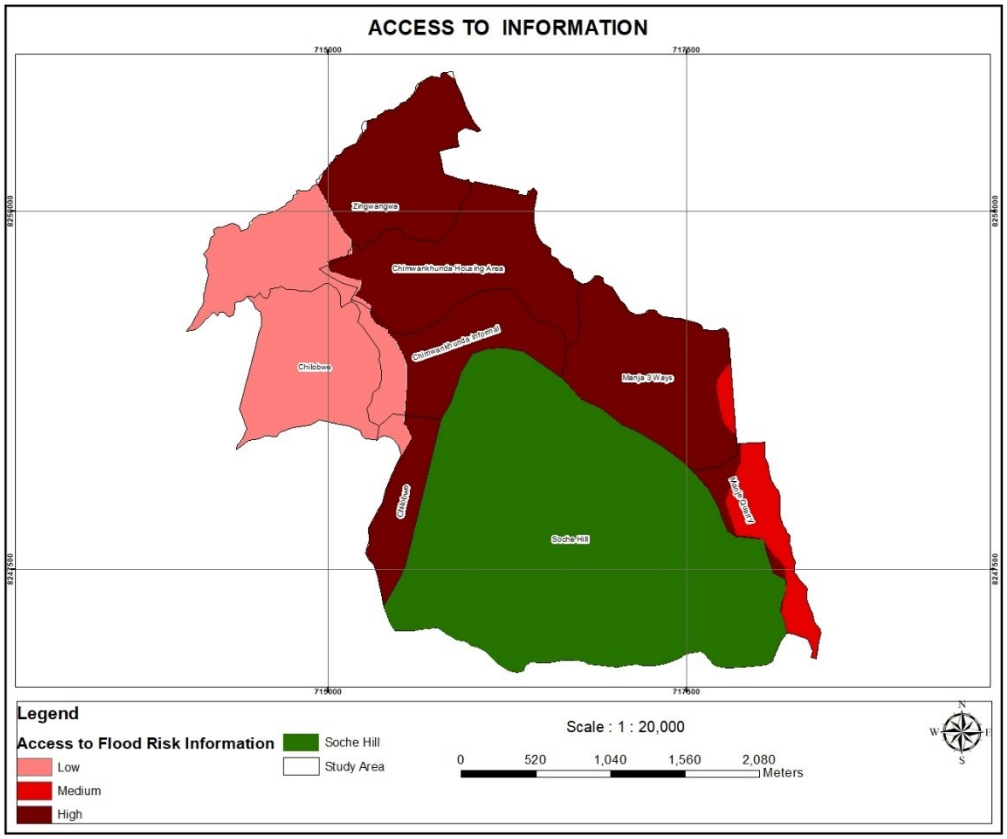
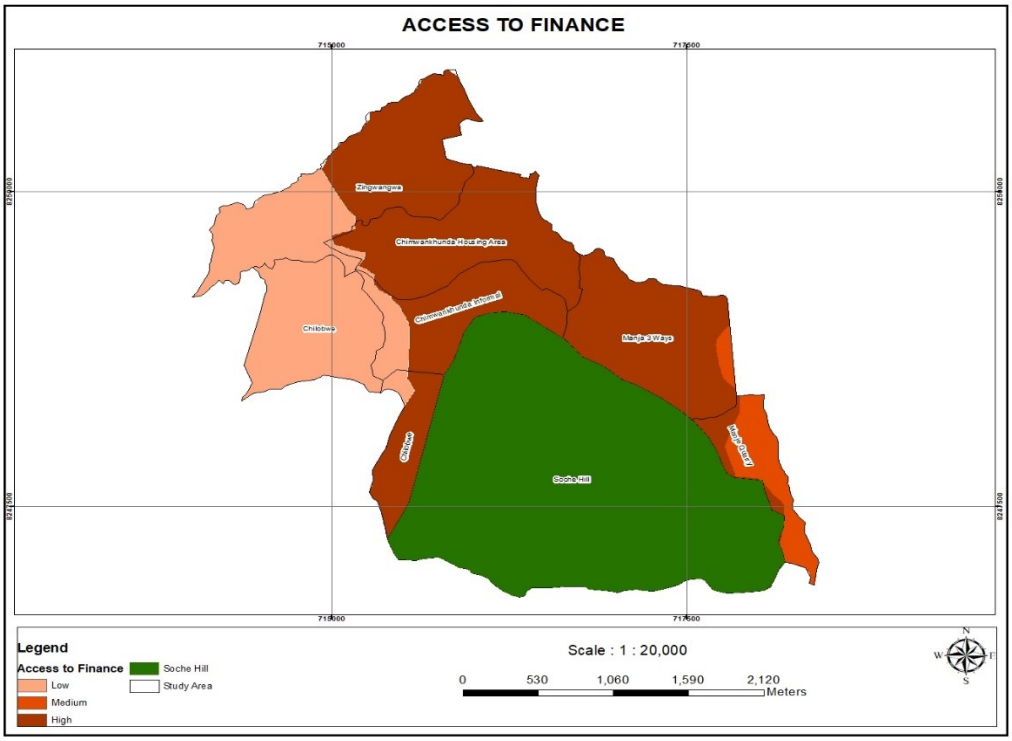

AGE
715000
717500
8254000
8247500
Zingwangwa
Chimwankhunda Housing Area
Chimwankhunda Informal
Chilobwe
Manja 3 Ways
Manja Phase 7
Soche Hill
Legend
N u mber of E derly nd vi dual s above age 60
648 - 849
850 - 980
981 - 1,112
1,113 - 1,332
Soche_Hill
Study Area
Scale : 1 : 20,000
0 530 1,060 1,590 2,120
Meters
N
W
E
S


ACCESS TO INFORMATION
Zingwangwa
Chimwankhunda Housing Area
Chimwankhunda Ethiopia
Chilobwe
Manja 3 Ways
Manja Phase 1
Soche Hill
Legend
Access to Flood Risk Information
Low
Medium
High
Soche Hill
Study Area
Scale : 1 : 20,000
0 520 1,040 1,560 2,080
Meters


ACCESS TO FINANCE
Zingwangwa
Chimwankhunda Housing Area
Chimwankhunda Ethiopia
Chilobwe
Manja 3 Ways
Manja Phase 1
Soche Hill
Legend
Access to Finance
Low
Medium
High
Soche Hill
Study Area
Scale : 1 : 20,000
0 530 1,060 1,590 2,120
Meters

Appendix 3: IHS copyright form

In order to allow the IHS Research Committee to select and publish the best UMD theses, students need to sign and hand in this copyright form to the course bureau together with their final thesis.

By signing this form, you agree that you are the sole author(s) of the work and that you have the right to transfer copyright to IHS, except for those items clearly cited or quoted in your work.

Criteria for publishing:

1. A summary of 400 words must be included in the thesis.
2. The number of pages for the thesis does not exceed the maximum word count.
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