ASSESSING THE SOCIO-ECONOMIC EFFECTS OF FLOODS ON INFORMAL SETTLEMENTS: CASE STUDY OF EERSTE FABRIEK IN MAMELODI TOWNSHIP

By

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DECLARATION

I, **Nkoni Thabiso Selby Modiba**, hereby declare that this research paper is submitted as part of the fulfillment of the Master's degree in Disaster Management at the University of Free State. I confirm that the work has never before been submitted to any university and that the study is of my own efforts. I further declare that all sources cited in the paper are acknowledged and listed in the reference list.

Date:.../..../2021

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ABSTRACT

Floods affect Tshwane Metropolitan Municipality regions, with communities living on the flood line areas being the most vulnerable and, are in most cases, informal settlements. This research was carried out in the Eerste Fabriek informal settlement in the Township of Mamelodi, City of Tshwane (CoT), Gauteng Province, South Africa. The aim of the study was to assess the socio-economic effects of floods in informal settlements. The study's participants were 48 percent male and 52 percent female. The study adopted the quantitative research method to analyse and present the results. The study's findings highlighted gender disparities and the critical role they play in the context of flooding and its impact on informal settlements. Female respondents were found to be comparable to male respondents in terms of acquiring flood mitigation measures, though in some cases it was lower. Previous studies, on the other hand, were unable to establish a link between gender and the intention to take adaptive measures to mitigate flood damage. The study highlight the impact of climate shocks such as floods on education, as evidenced by low academic performance and higher absenteeism rates among flood victims. Factors such as marital status, house structure, education level, employment status, age, and access to social grants all have a significant impact on people's ability to deal with the effects of flooding on their livelihood. Although floods impacted access to health care facilities, floods had no effect on educational, recreational, or religious facilities in these communities. The findings indicate that homes in flood-prone informal settlements, such as those in the study area, have potential that could be used to strengthen local adaptation efforts, such as strong social networks between homes, which are essential for support, among other things. This study discovered that the existence of social networks through neighbors, relatives, friends, and various gender groupings is critical in providing immediate relief and support. In addition, findings indicate that important adaptation strategies were not implemented by community members due to a lack of capacity. As a result, policymakers should collaborate with community members to identify adaptation and mitigation strategies that can help community members build capacity through education or training. The findings also show that social grants through cash transfer programs have the potential to improve communities' ability to deal with floods. Given the high level of unemployment in these communities, policymakers may want to consider increasing the number and frequency of cash transfers to the most vulnerable members of the community while also providing employment opportunities to those who can work.

KEY TERMS: Floods, Social, Economic, Impact, Informal settlement

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LIST OF ACRONYMS/ ABBREVIATIONS

TMM	Tshwane Metropolitan Municipality
CoT	City of Tshwane
SDGs	Sustainable Development Goals
NDP	National Development Plan
DEA	Department of Environmental Affairs
DDR	Disaster Risk Reduction
NGOs	Non-Governmental Organizations
NDMF	National Disaster Management Framework
DMA	Disaster Management Act
GML	Generalised Linear Model
SPSS	Statistical Package for Social Sciences

PUBLICATIONS AND CONTRIBUTION

This dissertation has produced the following unpublished manuscript:

Modiba, NTS; Nyam, YS. Flood risk vulnerability assessment of urban informal settlers in South Africa. Case Study of Eerste Fabriek in Mamelodi Township. *African Journal of Science, Technology, Innovation and Development (under review).*

This dissertation is based on a one jointly authored manuscript (under review) (with potential of another being drafted). I performed most of the relevant tasks in this paper including, developing the concepts and design of the papers, participated in collecting data, analysing and interpreting data, and drafting the manuscript. Dr. YS. Nyam supervised and approved the final copy of the manuscript.

CHAPTER 1

ORIENTATION OF THE STUDY

1.1 Introduction

Recently, flood occurrences and damage has increased by both frequency and intensity (Zhou et al., 2018). It is estimated that in the past ten years (2010-2020), flood damage has amounted to 250 billion US Dollars (Tembata & Takeuchi, 2019). Furthermore, it is observed that flooding occur all over the world, with Asia more prone to floods when compared to middle eastern countries which are more dryer (Shah *et al.*, 2020). At a global scale, flooding is attributed to some of the following factors (i) rapid population growth and urbanisation, (ii) the increase in the vulnerability of structures; (iii) settlements in floods prone areas such as floodplains, and (iv) a change in the environment (UNISDR, 2015). Urban flooding ranks high in terms of the impact on people's economic, social and surrounding environment (Jha et al., 2011).

The world is experiencing a plethora of extreme weather events caused by climate change (Kuyper et al., 2019). These events are exacerbated by factors such as lack of resources, growing population and industrialisation (Tembata & Takeuchi, 2019). In addition, these human activity factors result in changes in weather patterns that manifest into climate change, causing extreme weather events like heavy precipitation resulting in flooding which negatively affects the lives of people and degrade the environment (McPhillips et al., 2018).

South Africa, like the rest of the world is susceptible to disasters largely triggered by climate change and associated extreme weather conditions caused by above-mentioned human activities (Jordhus-Lier et al., 2019). Therefore, South Africa's progress in attaining Sustainable Development Goals (SDGs) is threatened by these growing challenges and the impact of climate change which manifests in amongst others, frequent tropical storms and heavy precipitation that occur sporadically, causing floods (DEA, 2016). SDG targets make provision for the protection of the rights of people as well as building resilience against disasters and environmental protection (Ford et al., 2020). South Africa's 2019 SDG's country report indicates that the country's 2012 National Development plan is 74% aligned with SDGs, while there are challenges, this makes it easy for South Africa to respond and implement targets set by the Agenda 2030 of Sustainable Development (StatsSA, 2019).

Recently however, floods that are occurring frequently might derail the implementation of the SDGs because of social and economic issues that come with these floods. This study therefore focuses on assessing socio-economic effects of floods on informal settlement dwellers in the Eerste Fabriek informal settlement found in the township of Mamelodi, in the Gauteng Province of South Africa. The study looks at how floods affect this community socially and economically. This area was identified as one of the areas which were affected by the December 2019 floods caused by heavy rains in most Provinces of the country, including the Tshwane region.

1.2 Background of the study

According to the risk and vulnerability assessment report of the Tshwane Metropolitan Municipality (TMM), flooding is one of the hazards affecting the city's' regions. In 2015, floods were identified as one of the hazards that affected 6 regions in the TMM, where the township of Mamelodi is located (CoT, 2014). Climate change, land use management, urbanisation, rapid population growth and housing backlogs were reported as some of the factors that cause floods in the city (CoT, 2014). Moreover, other direct factors emanating from some of these underlying factors include illegal dumping of waste that causes blockage of sewer system resulting in flash floods. Illegal dumping of waste is a problem in bigger cities like Tshwane where rapid urbanisation is a major issue.

Ramokgopa (2018) reports that traditionally, property and infrastructure damage were the only variables included in the assessment of the impact of floods in the Tshwane Region. Social and economic elements at micro level were excluded from the assessment, and these are some of the issues low-income communities grapple with after floods (UN-HABITAT. 2018). Thus, this study focuses on socio-economic effects of floods on people living in the informal settlement of Eerste Fabriek in the Township of Mamelodi.

1.3 Study area

1.3.1 Geographic location

Mamelodi Township is part of the City of Tshwane (CoT), located in the Gauteng Province of South Africa. Eerste Fabriek informal settlement, where the study is demarcated to, is part of Mamelodi township (CoTIDP, 2014). According to StatsSA (2016) community survey, Mamelodi township has a population of approximately 337 577 people. Mamelodi's population is 90 percent African, 2.2 percent white, 2.1 percent Indian/Asian, and 6.6 percent coloured. Seventy-nine percent of this population is of working age. The dependency ratio, or the

percentage of people who rely on those of working age, is 39 percent (StatsSA, 2016). Mamelodi has a 24.2 percent unemployment rate. Furthermore, inequality is common in townships and informal settlements due to lack of economic activities.

The Tshwane Metropolitan Municipality (TTM) is home to South Africa's administrative capital city. The TTM is the third-largest city in the world in terms of land mass, covering an area of approximately 6 345km² and is the largest of the three metropolitan municipalities in the Gauteng Province (Johannesburg and Ekhurhuleni). (CoTIDP, 2014). By virtue of Tshwane being the capital city of the country, there is a problem with rapid urbanisation that results in the creation of illegal informal settlements, which are a problem when it comes to disaster exacerbation (Khanna, 2020). The CoT has a population of slightly more than 2.9 million people (StatsSA, 2016; CoTIDP, 2014).

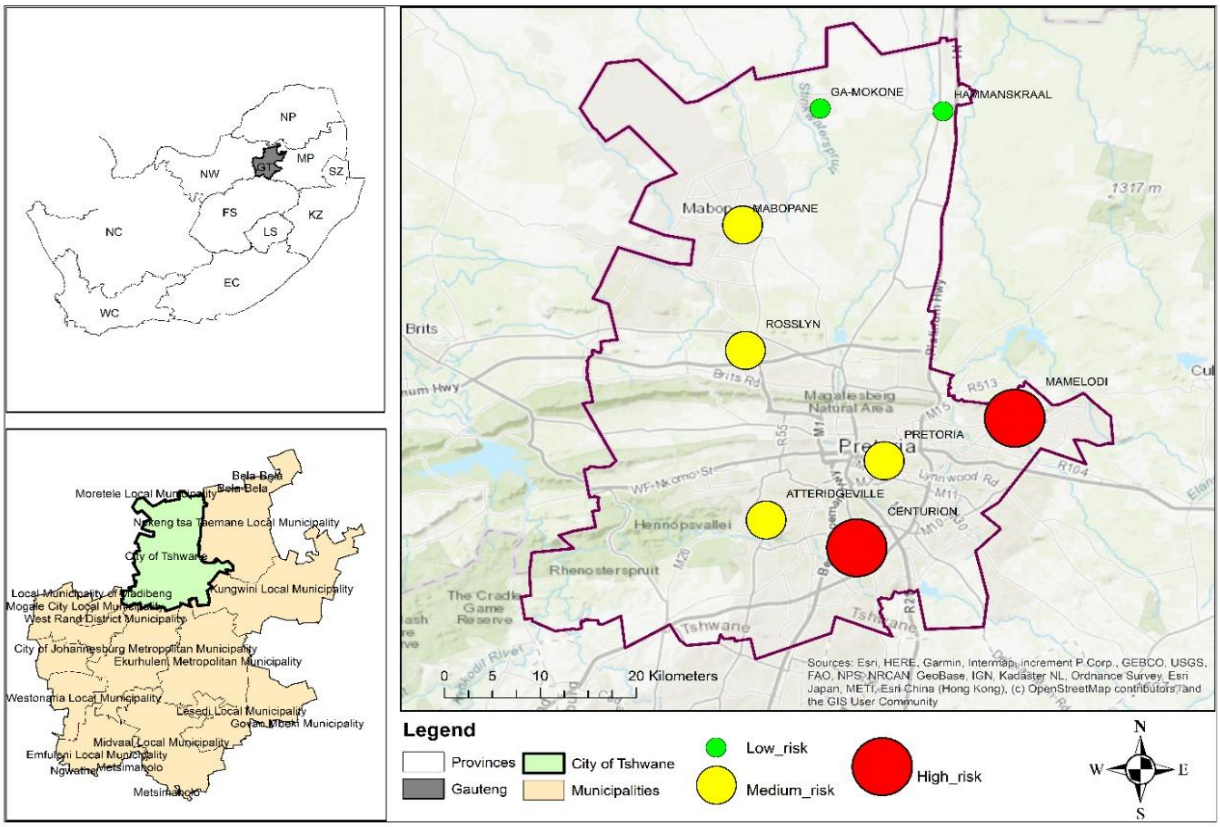

Figure 1.1 Map of South Africa and the City of Tshwane
(*Source*: CoT, 2020)

1.3.2 Socio-demographic information

According to Horn (2021), South Africa's Gauteng Province is seeing a tremendous increase in informal settlements as people migrate from largely rural areas to seek economic

opportunities in the big cities. The Province faces a significant housing shortage as due to this migration. The Tshwane region is not immune to this problem, as evidenced by a number of informal settlements communities in the city's seven flood-prone zones (CoT, 2014).

Tshwane has a Gini Coefficient of 0.63, according to Ramokgopa (2018), indicating that unemployment is at 24.2 percent (CoT, 2014). Inequality is particularly evident in the city's northern suburbs, including townships, informal settlements, and merging regions. The city, on the other hand, is one of South Africa's fastest-growing municipalities, with a Gross Value Added (GVA) of R275 billion in 2018.

The informal sector employs around 142 000 residents of Tshwane, and there are approximately 227 informal settlements throughout the city, accounting for 18% of all dwellings in Tshwane (CoT, 2014). Aside from the complex issues of rapid population and economic growth, the CoT has challenges to meet the needs of its citizens in the wake of climate change, which, in most cases, results in severe flood disasters, as shown in 2014 and 2020 Integrated Development Plans (IDP) (CoTIDP, 2014; CoTIDP, 2020).

1.4 Research problem

Flood disasters are a real problem worldwide, especially in developing countries as these disasters affect the socio-economic status of the affected (Echendu, 2020). For example, a study in Maputo reported that urban areas across the Global South are facing difficulties due to fast urbanisation, poor and inadequate infrastructure and climate change, coupled with frequent storms and flooding which overwhelms cities (Zehra et al., 2019). Floods by nature are more destructive and affect large numbers of the population when they occur as compared to other weather-related disasters (Ntanganedzeni & Nobert, 2020). It is worth noting that the mostly affected are the people living in low-income areas situated along the floodplains of cities (Zehra et al., 2019).Furthermore, these peoples' socio-economic status is most affected compared to other areas.

Another study in Pakistan reported that most townships and cities are regarded to be flood risk areas due to overcrowding and over population (Feng et al., 2021). Rapid urbanisation and unplanned migration of people from rural to urban areas in particular cities contribute to the strain on resources of the cities, and also leads to people settling on flood prone areas (Chen et al., 2015).

South Africa is also not immune to floods disasters (Milan et al., 2018). According to Floodlist (2019), the North and East parts of South Africa experienced flooding covering Gauteng, Northwest, Limpopo and Mpumalanga Provinces with a cumulative fatality of 32 deaths. The death of individuals due to any hazard will always be a problem that can affect socio-economic conditions. For example, the death of a bread winner can render the family of the deceased vulnerable to poverty and expose them to other social problems.

In December 2019, the Gauteng province and several other provinces, including KwaZulu-Natal, Eastern Cape, Northwest and the Free State experienced flooding as a result of heavy precipitation caused by the cyclone Idai (Bopape et al., 2021). Many people lost their belongings in the process. Hundreds of people had to be rescued after days of heavy rains which caused flooding. Public buildings such as churches, schools, halls and stadiums had to be opened to house displaced people in the Gauteng Province in particular (SABC, 2019).

Worst affected areas were in the in the outskirts of Pretoria in the TMM region 3 (Centurion area) and region 6 (Mamelodi township), in particular the Eerste Fabriek informal settlement. In Eerste Fabriek about 700 shacks were washed away due to the bursting of the Moretele riverbank in the area (SABC, 2019). This is a serious problem that warrants an investigation as socio-economic conditions of this community was affected by a flood disaster. Other affected areas included the Kaalfontein river stream in Ivory Park and the Stjwetla informal settlement along the Jukskei River in the Alexandra Township in Johannesburg, which are also part of the Gauteng Province.

Flooding happens when the normal flow of water or the catchment area is disturbed as a result of factors including human settlements near the flood line, the increasing urbanisation and industrialisation. Therefore, flooding is a worldwide problem that requires further research in order to make literature available (Tayyab, 2021). According to recent studies, informal settlements enhance the risk of flooding in two ways: first, because of their placement along riverbanks and catchment areas, and second, by the types of housing structures, which are typically shacks and mud-built structures that can be easily flooded (Kikwasi & Mbuya, 2019; Williams et al., 2018).

According to the Department of Environmental Affairs (DEA, 2016), South Africa is facing a plethora of environmental related challenges ranging from droughts, floods, land degradation and soil erosion. Climate change is affecting the country's ability to cope with extreme conditions (Trollip & Boulle, 2017). Almost all regions of Tshwane Metropolitan Municipality are affected by flooding, with the most affected being the people who live along flood lines,

which are in most cases the informal settlements (Loots & Smithers, 2020). Socio-economic vulnerabilities caused by flood impacts are greater (De Silva & Kawasaki. 2020). Challenges highlighted above make a study like this necessary as it enhances understanding of the impact of floods on vulnerable communities in South Africa and globally. Rapid urbanisation, housing backlogs and improper land use management give rise to informal settlements which tend to create environmental problems in risky areas such as river banks and floodplains (Feng et al.2021).

1.5 Research objectives

This study aims to assess socio-economic effects of floods in the informal settlement of Eerste Fabriek in the township of Mamelodi. This objective will be achieved by addressing the following sub-objectives:

- To determine causes of floods in the Eerste Fabriek informal settlement.
- To determine social effects of floods in the Eerste Fabriek informal settlement.
- To determine economic effects of floods in Eerste Fabriek informal settlement.
- To determine the flood disaster coping strategies employed by the community of Eerste Fabriek informal settlement.

1.6 Study questions

This study seeks to answer the following questions:

- What are main causes of floods in the Eerste Fabriek informal settlement?
- What are social effects of floods in the Eerste Fabriek informal settlement?
- What are economic effects of floods in the Eerste Fabriek informal settlement?
- What are flood disaster coping strategies employed by the community of Eerste Fabriek informal settlement?

1.7 Significance of the study

Although several studies have been conducted on floods in general, they did not focus on socio-economic effects of floods in informal settlements, in particular in the Tshwane Region (Amoako & Frimpong Boamah, 2020; Okaka & Odhiambo, 2019). This study is significant in that it seeks to understand how floods and related events affect social and economic activities of people living in Eerste Fabriek informal settlements. There is also a need for a more detailed analysis to develop appropriate policies and strategies to deal with mushrooming informal settlements in areas prone to floods to reduce the impact on the environment, social and

economic activities of communities (Sajor et al., 2017). This study will provide policy makers with information in order to deal with socio-economic issues brought about by floods.

Furthermore, the study will assist the TMM to better understand social and economic challenges caused by flooding in informal settlements to be able to incorporate response measures in their Integrated Development Plans aimed at eradicating informal settlements in risky areas such as flood plains (Le Roux et al., 2017. This research could also be used as a starting and point of reference for improving socioeconomic outcomes through policy and strategy formation, as well as the impact of floods on informal settlements in the studied area. The study will further contribute towards improving knowledge about the risks of residing in floodplain areas by demonstrating the impact on social and economic factors on the residents.

1.8 Research methodology

1.8.1 Research design

The research design is a method for combining the many components of the study in a cohesive and logical manner in order to successfully handle the research problem and answer the research questions (Leedy & Ormrod, 2015). Data gathering, analysis, and interpretation are all part of the research design process. The research problem informs the design of the study (Creswell, 2014). There are three types of research methods which are, quantitative, qualitative, and mixed method (Taguchi, 2018). A systematic analysis of phenomena using quantifiable data and statistical, mathematical, or computational approaches is known as quantitative research (Rutberg & Bouikidis, 2018). In this regard, data analysis involves descriptive or inferential data between variables (Creswell, 2014). A qualitative method on the other hand is a humanistic approach to understanding a research question by observing people's attitude, beliefs, experiences, interactions and behaviour (Rutberg & Bouikidis, 2018). It begins with the selection of the research area and progresses to the development of the theory (Belotto, 2018). The mixed research methodology brings together qualitative and quantitative methods for a more holistic approach (Leedy & Ormrod, 2015). This study utilised a quantitative research methodology to analyse socio-economic effects of floods in the Eerste Fabriek community. The quantitative research method was considered valuable in this study because it allowed for different statistics tools to be used to analyse the socio-economic effects of floods for easy presentation and interpretation both by experts and non-experts (Leedy & Ormrod, 2015).

1.8.2 Population and sampling techniques

The target population, according to Singh (2013), is the complete set of cases that satisfy the specified criteria. Social scientists have always been interested in the characteristics of a large number of people, things or cases (Watts, 2017). It is however not possible for them to accurately test all these variables; as a result, sampling is used. Sampling is a process used in research where a predetermined number of observations are taken from a larger population (Mouton, 2012). Furthermore, Mouton (2012) reports that a population is a group of persons or units upon which a study is based. The sample size is the number of analytical units that makes up a sample, a sample size has to be representative of the units or people in the population and be enough to give a meaningful statistical result (Leedy and Ormrod, 2015). Based on the above, a simple random sampling technique was chosen for this study. A simple random sampling technique ensures that every unit in the population has an equal chance of being selected in the final sample (Singh, 2013). This technique is suitable for this study because it gives everyone a chance to be sampled. The technique is also relevant for this study area to avoid bias. The Mamelodi community is known to be very volatile and should any techniques other than the one that gives everyone a fair chance to participate in the study be used, it might create problems within the community.

1.8.3 Sample size

A significant aspect of any empirical study in which the purpose is to make inferences about a population from a sample is called a sample size (Taherdoost, 2017). A random sample must be large enough to generalise from and avoid sampling errors or biases (Blaikie, 2018). In addition, Blaikie (2018) explains that when the population is too large, it is difficult to gather information from each unit in the population. As a result, collecting data from all of the units in a population is rarely feasible; instead, the researcher will gather data from a smaller group or subset that represents the entire population. In this study, a total of 50 people were chosen at random and interviewed.

1.8.4 Data collection

Data collection is the systematic gathering and measurement of information on variables of interest in order to answer research questions, test hypotheses, and assess outcomes (Leedy & Ormrod, 2015). When it comes to research, the data collection aspects do not vary, they are common in the different fields ranging from physics, anthropology and social sciences (Groenland & Dana 2019). The important task is to ensure the integrity and accuracy of the information. Primary data collected through the use of questionnaires was used for this study.

A survey questionnaire was designed for collection of primary data for this study to accommodate both structured and semi-structured questions.
The questionnaires were carefully designed to avoid ambiguity, sensitive and provocation questions (Leedy & Ormrod, 2015). A survey questionnaire is good for a study that involves humans (Kumar, 2019).

1.8.5 Data Analysis

Analysing data requires classifying it into themes, patterns, trends, and relationships that may be managed (Mouton, 2012). Data analysis is a technique for extrapolating, evaluating, and synthesizing data by examining the relationship between concepts, constructs, or variables to see if any patterns or trends can be identified or separated, or to establish themes in interpretation (2019, Kumar). The study's design, the type of data collected, and the features of the research problem, together with sub-problems and research questions, all influence the data analysis processes (Muthiah et al., 2020). For this study a quantitative research design incorporating both descriptive and empirical statistical analysis was used. Data cleaning and coding was employed to quality assure data for this study before analysing it (Tran et al., 2017). Data for this study was analysed using both Statistical Package for the Social Sciences (SPSS) and STATA softwares (Baarda & van Dijkum, 2019).

1.8.6 Data validity and reliability

The extent to which the collected data answers the study questions is known as data validity (Leedy & Ormrod, 2015). It entails making a logical connection between the study questions and objectives. According to Kumar (2019), validation of data for tangible concepts such as demographics, age and gender, which follows quantitative data methods are easier to validate whereas the less tangible concepts such as attitude, perceptions and feelings, which mainly follow the qualitative data collection method tend to be difficult to establish. Reliability is the degree of accuracy, consistency and stability of data produced through a research instrument (Leedy & Ormrod, 2015). It involves the process of testing the information several times using the same instrument under the same conditions and getting the same results. Data is deemed unreliable when the same process is repeated and provides different results. Thus, the process of assessing the trustworthiness, reliability, and consistency of the instrumentation and study results in terms of credibility, transferability, dependability, and confirmability is known as data validation and reliability (Kumar, 2019). This study although adopted a quantitative data collection method, it will had a few open-ended questions that encompasses

the perceptions of the study community. The Cronbach Alpha was used to test the reliability of the questions.

1.9 Limitations and delimitations of the study

1.9.1 Limitations

Limitations include challenges that may be encountered in caring out the study (Kumar, 2019). For the current study the envisaged limitations may included the following:

- **The unwillingness to participate in study.**

The Eerste Fabriek, like any other informal settlement especially in capital cities, is volatile with service delivery protests a common occurrence. Therefore, when doing a study about socio-economic impacts of a hazard that is believed to be caused by service delivery such as flash floods, known to be caused by blocked sewer pipes, or land and housing backlogs, this might cause problems in the community. The researcher informed potential participants that this study is for educational purposes and has nothing to do with the TMM.

- **COVID-19**

The COVID-19 virus has ushered in a new era in our lives. Townships and informal settlements are overpopulated and as a result are at high risk of the spread of COVID-19. Therefore when collecting data, there was a high risk of the researcher being exposed to COVID-19. The researcher practiced non-pharmaceutical precautions that included social distancing by maintaining the 1.5-meter distance from the respondents, the wearing of a mask at all times and sanitising frequently. In the process of data collection, the researcher ensured that interviews are conducted outside a housing structure of the respondents due to nature of the shacks, which are predominantly small without proper ventilation in the form of windows. The researcher also brought along a set of surgical masks and sanitizers for participants during interviews. The researcher also provided participants with one extra mask for use later. To avoid using one pen to respond to the questionnaire, the researcher read out questions for respondents and completed the questionnaire on behalf of participants.

1.9.2 Delimitations

Delimitations are study specific factors and characteristics that may limit and affect the scope and boundaries of the study (Leedy and Ormrod, 2015). They include factors such as geographic location, sample size and the setting where the study is taking place. The delimitations for this study will included the following

- **Scope limited to Eerste Fabriek informal settlement**

According to the TMM, many parts of Mamelodi Township and its informal settlements are prone to floods, however due to time and resource constrains in covering the whole of Mamelodi, the study focused on the Eerste Fabriek informal settlement. The December 2019 flooding mostly affected the Eerste Fabriek informal settlement with about 700 shacks washed away and therefore this study highlights some of the challenges faced by this community.

- **Scope limited to social and economic effects of floods**

Flooding can cause devastation especially in an informal settlement where there is no service delivery such as roads, housing, sanitation, water, electricity, storm water drainage and many others. There are many issues to look in to, however this study only focused on assessing social and economic effects of floods in Eerste Fabriek due to limited time.

1.10 Ethical consideration

In legal terms, it is a pre-requisite to obtain informed consent before conducting any research work (Kumar, 2019). Permission to carry out this study was sought from the University of Free State in order to obtain ethical clearance to conduct the research. Consent was also sought from people participating in the study and the ward councilor in the area using a written consent form that they were asked to sign as suggested by Leedy and Ormrod (2015). Care was exercised when seeking sensitive information so as to not embarrass or harm respondents/participants. For an example, in some instances questions may trigger traumatic memories due to floods. Complete confidentiality was maintained and assured (Kumar, 2019). There was no mentioning of names of participants in the final report. The researcher did not coerce or force the respondents to answer questions or complete the questionnaire for the study if they did not feel like it. Potential respondents/participants were advised to give information voluntarily. Unbiased and incorrect reporting of the findings was avoided. Humans

were at the center of this study for data collection and plagiarism was avoided by referencing all the literature used for this study in a reference list.

1.11 Chapter summary

Table 1.1: A summary of research chapters

CHAPTER	CHAPTER TITLE	CHAPTER CONTENT OVERVIEW
1.	The orientation of the study	This chapter provides an overview of the research: Introduction, background information, problem statement, purpose and objectives, and a description of the research area.
2.	Legislation and Theoretical Frameworks	This chapter outlines international, regional, national and theoretical frameworks underpinning the study.
3.	Literature Review	The chapter provides a theoretical literature review of textbooks, journals, and internet sources, as well as an empirical literature review of flood hazard analysis, definitions, coping abilities, and contributory factors.
4.	Research Methodology	The chapter presents the research methodology with a focus on quantitative approaches under the following headings: Introduction, research approach, data collections and analysis, data quality control, population and sampling techniques, reliability and validity ethical considerations.
5.	Research Results and discussions	The chapter presents discussion of variables used, analysis of preliminary data and presents data in a form of tables, statistical and narrative information.
6.	Conclusion and Recommendations	The chapter provide a summary drawn from the empirical literature review, theoretical literature review and recommend intervention measures.

CHAPTER 2

CONCEPTUAL, INTERNATIONAL AND NATIONAL LEGISLATIVE FRAMEWORK

2.1 Introduction

Many people in the Tshwane Metro are aware that flooding in informal settlements is a hazard which occurs annually in South Africa (CoTIDP, 2020). In spite of this knowledge, relevant stakeholders have made no contingency plans to aid inhabitants regularly affected by these floods. The Disaster Management Act (DMA) (Act No 57 0f 2002) makes specific pronouncements on the need for provinces to develop disaster management frameworks and implement them to mitigate these disasters. It is a specific requirement to make an effort to avoid these disasters as much as possible and mitigate them continuously (Dalu et al., 2018; Williams et al., 2018). It is worth noting that communities in informal settlements who have experienced flooding tend to use sandbags to mitigate the effects of flooding as a standard response. Lack of proper planning and adaptation strategies in the metros has led to these affected communities to find themselves residing in these type of areas. There are conceptual frameworks that have been used in flood related studies such as sustainable livelihood framework, community capital frameworks, PAR model and flood vulnerability assessment framework (Rehman et al., 2019; Tran et al., 2021).

Natural disasters such as heavy rain, storms, and cyclones can cause floods, but human actions such as development and settlement planning can also play a role in flood events. (Doocy, 2013; Douglas, 2017). Climate change, on the other hand, has emerged as one of the leading causes of floods, since rising global temperatures are predicted to bring severe flooding in numerous parts of the world. This unprecedented shift is linked to weather and climatic variability, such as the El-Nino Southern Oscillation (ENSO). In South Africa, the annual probability of flooding is 83.3 percent, with a high level of susceptibility due to economic factors and geographic location (Zuma et al. 2012; Munyai et al., 2019; Pour et al., 2020). Between 1980 and 2010, 77 flood disaster incidents were documented in the Eastern Cape, KwaZulu-Natal, the North-West and Limpopo provinces of South Africa, according to Prevention Web (Prevention Web, 2011). As a result, floods are by far the most prevalent of all natural disasters. Floods have wreaked havoc on a number of places around the world. Flood danger is a global concern that necessitates international, national, and provincial planning and preparation.

2.2 Sustainable Livelihood Framework

The term livelihood consists of a mixture of resources utilised and activities carried out in order to survive (Dinku, 2019; Su et al., 2019). These resources might consist of the assets or capitals, that is human, natural, financial and physical capital. For example, a livelihood strategy that includes reducing the impacts of hazards such as flood, drought could consist of:

- Someone's skill in reducing or building copy capacity in an event there is flood (human capital);
- Their access to natural land that no one else is using (natural capital);
- Funds from family or neighbours (natural capital from a social network);
- Support received from NGOs, which provides advice, relief and skills training (social capital).

The word livelihood strategies refers to a wide range of activities and decisions that people choose and execute in order to attain their livelihood goals, particularly in terms of reducing and managing hazards. In order to meet their needs, people tend to combine and diversify their activities at different times. Straddling is an example of this, when different members of the household live and work on separate techniques to cope with or recover from natural and man-made calamities. (Kasie et al., 2017). Study has highlighted a number of strategies used by poor households in informal settlements such as surviving through pressing and threat situations from formal or informal employment, complemented by strategies such as keeping good relations with family and neighbours in order to get solutions when needed, such as reducing impacts of disasters on the community or individuals. Using a sustainable livelihoods strategy to provide assistance aims to get a thorough and realistic understanding of people's vulnerability (or stresses) and how they can cope with flood threats (Le Dé et al., 2018; Abedi et al., 2019; Azam et al., 2021). The livelihoods approach is thus concerned first and foremost with people.

The livelihoods approach is primarily centred around people. The strategy is based on the notion that people require a diverse variety of assets in order to attain positive livelihood outcomes. There is no single asset category that can provide all of the various livelihood outcomes that people desires. This is especially true for the impoverished, who have very restricted access to any given category of assets. Therefore, people must look for innovative ways to manage threats and combine what assets they do have to assure survival during disasters (Letsoalo, 2019).

These limitations and opportunities are influenced by a variety of factors, ranging from global or national patterns and structures over which individuals have little control and may not even

be aware, to more local norms and institutions, and finally, the assets to which families or individuals have direct access (Mazibuko, 2017; Özçürümez et al., 2020).

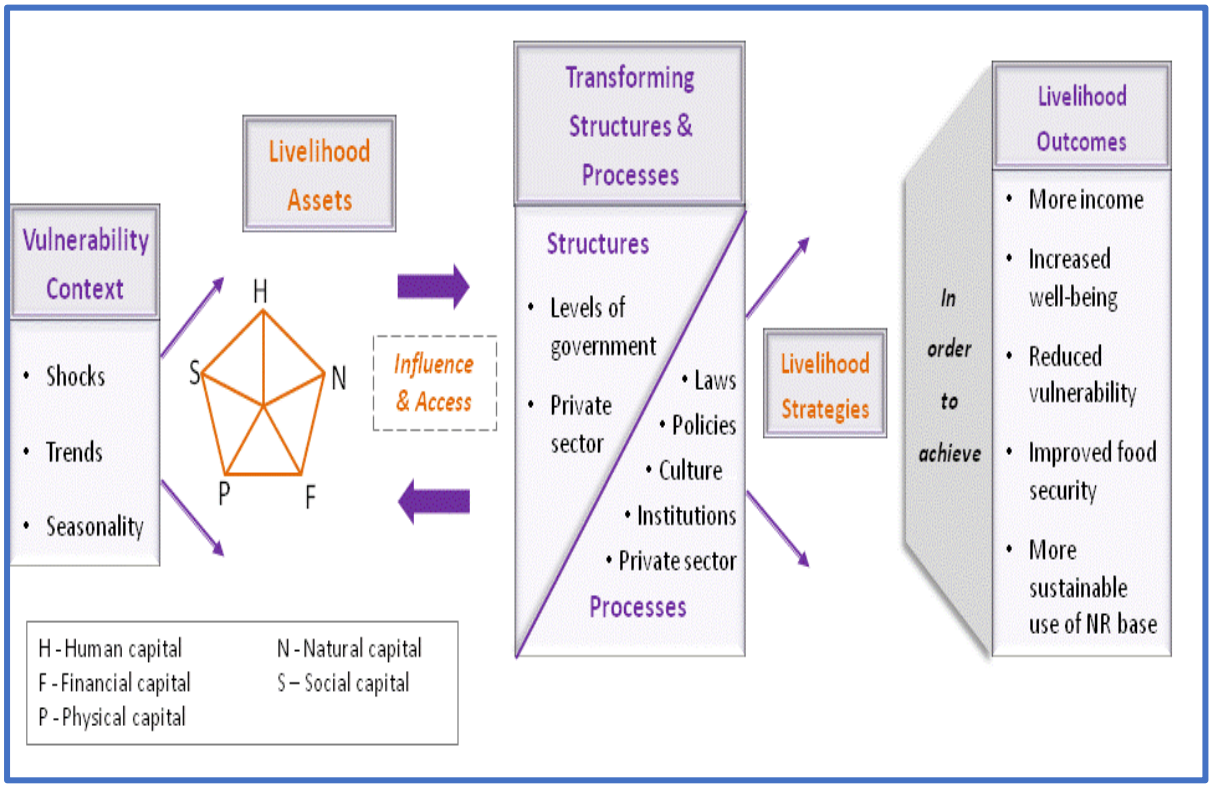

Figure 2.1 Sustainable livelihoods framework (Harper & Harper, 2020)

In the sustainable livelihoods framework, the vulnerability context refers to the external environment in which people live. Seasonality, shocks (such as disease or death, violence, and weather), and trends (such as national or global economic trends, changes in available technology, and political systems) are all examples of this (of event, occurrence cycles). Vulnerability is important because the three aspects have a direct impact on the ability of poor people to make a living today and in the future. (Serrat, 2017; Harper and Harper, 2020). In a community, disasters (flood) may deprive households of a large source of income and force them to sell key assets that they have built up or worked for over time, depending on the economic conditions. (Serrat, 2017; Sarker et al., 2019; Azam et al., 2021). Seasonal disasters and hazard events are some of the factors that might influence a community's ability to plan ahead for any hazard event, including floods.

The assets context is critical to the approach to sustainable livelihoods. Rather than viewing poverty in informal settlements as simply a lack of money, the sustainable livelihoods approach takes into account assets that poor people require in order to maintain a sufficient

level of income. Poor people living in informal settlements have a variety of livelihood strategies - actions and choices - that impact their livelihood results in terms of decreasing or controlling floods disasters, based on such assets, influenced by the environment of vulnerability, and modifying structures and processes (Serrat, 2017; Harper and Harper, 2020). Poor people, as previously said, are frequently obliged to adopt a range of strategies in order to merely exist; individuals may engage in a variety of activities, and members of a household may live and work in different regions. (Serrat, 2017; Harper and Harper, 2020. If everything goes well, they may get more income, better health, reduced vulnerability, and increased food security, all of which will eventually build an enabling environment for them. When poor people participate in less risky and hence lower-income activities to reduce their sensitivity to shocks, one result might sometimes have a negative impact on another. (Satterthwaite et al., 2018; Satterthwaite et al., 2019). If all goes well, they may obtain more income, improved well-being, less vulnerability and higher food security, all of which will gradually create an enabling environment for them. When poor people engage in less risky and lower-income activities in order to be less sensitive to shocks, one consequence can sometimes have a detrimental impact on another (Satterthwaite et al., 2019; Harper &Harper, 2020). The more assets a household has, the less exposed it is to the negative impacts of above-mentioned trends and shocks, as well as seasonality, and the more secure their livelihoods (Mthethwa & Wale, 2021). Increases in one type of capital frequently lead to increases in other types of capital. For example, as people gain education (increase in human capital), they may be able to obtain a better job that pays more money (increase in financial capital), allowing them to upgrade their home and facilities (increase in physical capital) in combatting hazard related threats. There are instances however when one sort of capital declines while another rises (Harper & Harper, 2020).

2.3 Sustainable livelihoods framework Shortcomings

In recent years, development practitioners and scientists have criticised the sustainable livelihoods framework for focusing too much on micro-level (five capitals) and neglecting the 'higher'- levels of governance, policy environment, national and global economic growth, and so on (Serrat, 2017; Quandt, 2018). This has resulted in a limited grasp of how markets work and how procedures that are far removed from the lives of impoverished people have a huge impact on their ability to earn a stable livelihood. Of course, these issues are addressed in the broader sustainable livelihoods framework, particularly in the transforming structures and processes and the 'vulnerability context,' but in practice, many people have focused on the five capitals rather than the connections between them and the larger environment in which people live (Schlosberg et al., 2017; Gao and Wu, 2017; Nagoda & Nightingale, 2017). It's

critical to remember that the larger environment has an impact on not only assets which people have access to, but also what they can do with those assets. The paradigm for sustainable livelihoods has also been chastised for failing to include power relations such as those relating to gender.

While such dynamics are included in the framework, they have been overlooked in practice (Sene-Harper et al., 2019; Harper & Harper, 2020). In particular, social capital has been viewed as a positive thing,' despite the fact that social networks may be both inclusive and exclusive, with the weakest and most vulnerable generally excluded. They also frequently feature hierarchical and coercive interactions, which limit options for people at lower levels, even when relationships are more horizontal than vertical, reciprocal relationships can entail onerous commitments.

All of the aforementioned objections and limitations of the sustainable livelihoods strategy are unquestionably correct. The method aims to condense enormously complex and diverse causes of poverty as well as options for alleviating it, into a single set of diagrams and concepts. Inevitably, when utilised in practice, it becomes cumbersome, and certain components were highlighted more than others based on the users' preferences. Nonetheless, flood vulnerability assessment was considered in this study for encompassing micro-level specifics of poor people's livelihoods and for thinking about the larger framework.

2.4. Community Capital Frameworks

Changes in social and economic conditions are reshaping informal settlement communities, necessitating a better knowledge of community dynamics (Mattos, 2015; Gordillo et al., 2019). The study and design of policies and programs aimed at positively changing rural areas are of interest to community development practitioners. The Community Capitals Framework (CCF) is one of the most extensively utilised community development and analysis research tools. Flora and Jan Flora (2013) developed this framework as a different way to strategic planning and measurement, and it has since been applied in a number of studies. (Mattos, 2015).

2.4.1. The Framework

CCF is a systemic way to analysing communities and community development initiatives. Jan and Cornelia Flora (2013) discovered that communities that were effective in supporting economic development concentrated on seven categories of capital in their research:

- **Natural capital**: Refers to the environment, rivers, lakes, woods, wildlife, soil, weather, and natural beauty of a community
- **Cultural capital**: Includes things like ethnic festivals, a bilingual population, traditions, heritage, and a strong work ethic. Cultural capital influences which voices are heard and listened to, which voices have influence in which sectors, and how creativity, invention, and influence emerge and are nourished (Lowry et al., 2014; Saja et al., 2019).
- **Human capital**: Residents' abilities and talents, as well as their access to outside resources and knowledge, are all aspects to examine in order to improve comprehension and identify promising methods (education, health, skills, and youth). Human capital also addresses leadership's ability to lead across divides, focus on assets, be inclusive and participatory, and be proactive in shaping the future of the community or group.
- **Social capital**: This reflects the connections among people and organisations or the social glue that makes things happen.
    - Bonding social capital refers to those close ties that build community cohesion.
    - Bridging social capital involves weak ties that create and maintain bridges among organizations and communities.
- **Political capital**: This is the power to influence standards, rules and regulations, as well as the enforcement of those standards, rules and regulations. It reflects access to authority and influencers, such as government officials, as well as leverage with a regional firm.
- **Financial capital**: Financial resources available to invest in community capacity building, underwrite business development, encourage civic and social entrepreneurship and accrue capital for future community development are all included.
- **Built capital**: Telecommunications, industrial parks, main roadways, water and sewer systems, highways and other infrastructure sustain the community. The focus of community development activities is frequently on built capital (Saja et al., 2019; Colina Neri et al., 2021).

Rural communities invest their communal resources in a variety of ways to attain community economic, social, and environmental sustainability all over the world (Mattos, 2015; Gordillo and Santana, 2019). The impact and outcomes of these investments are numerous.CCF includes the capitals (assets) that make up the initial community conditions, as well as investments in community development and the outputs and repercussions of such

investments. By examining investments in each of the capitals and the consequences induced by those investments, the framework allows community researchers and practitioners to begin to comprehend the impact of community development policies and programs on rural people and places. Using the Community Capitals Framework to describe tactics and outcomes gives strong evidence of asset growth and illustrates the interplay among the capitals that can lead to an upward spiral of good community change.

Although communities may not have an adequate supply of all of the distinct capitals, literature on the CCF suggests that investing in important resources (human, social and financial) can have a good impact on other capitals (Emery & Flora 2006; Flora et al., 2018; Stone and Nyaupane, 2018). Community developers and evaluators can use CCF to see how an investment in one capital affects other capitals. For example, a program to improve people' computer abilities (human capital investment) could have a financial capital impact if locals use their new skills to obtain better/new jobs.

Members of the program create links among themselves and many groups with whom they interact, which has an impact on social capital. The program may encourage the integration of representatives from various community groups, thereby increasing cultural capital. The original investment may also have an impact on remaining capitals. One of the shortcomings of CCF is that it is more concerned with a community's assets than with its needs and deficiencies. These assets could either be unused or invested to generate more assets. When community resources are left underused, they deteriorate, resulting in the community's deterioration unless there is a catalyst to alter course.

2.5. Flood Impact assessment

Flood vulnerability is defined as a community's or an individual's sensitivity to flooding, taking into consideration socioeconomic, environmental, and physical aspects (Sayers et al., 2018; Wing et al., 2020). Understanding flood susceptibility components and variables may be aided by an assessment of these components. Floods are one of the most dangerous natural calamities, taking the lives of many people every year (Zorn, 2018; Soens, 2018). Flood damage is often reduced by the use of both structural and non-structural flood mitigation methods, such as the construction of dams and dikes. Flood frequency has been increasing every year, according to Drogue et al. (2004). Flooding has become more common, resulting in the death of individuals, damage to property and infrastructure and degradation of the natural environment. Studies by Turner et al. (2003:3) and Salami et al., (2017) proposed a conceptual framework in which vulnerability is defined as a function of exposure, sensitivity and adaptive capability (Figure 2). This concept was adopted for this study due to its inclusion

of more than three conceptual frameworks such as sustainable livelihoods framework, community capital framework and PAR models.

Vulnerability is defined by three factors: exposure, sensitivity and resilience. The term exposure refers to a change in the operational system that occurs outside of its regular operating parameters (Munyai et al., 2019). A system is exposed to the state and change in external pressures, according to Judy et al. (2011). The system is currently prone to cause harm; this is due to current ecological conditions as well as societal factors.

Susceptibility refers to the possibility of a flood danger having an impact on a system or a person. According to Samuels et al. (2009), referenced in Munyai et al. (2019), susceptibility is the possibility of negative flood consequences for the ecosystem and civilisation. Hazards may have an impact on both the socioeconomic and natural environments. The ability of a community to adapt to changes in a risky environment by modifying itself to a structural and functional level that is acceptable is referred to as resilience (Galderisi et al. 2005; Galderisi et al., 2013). This implies that the people living in informal settlements (study area) must recover from threats as a result of flood events, that is, the capacity to maintain the system's operation and function is resilient (Munyai et al., 2019; Ajodo & Olawepo, 2021).

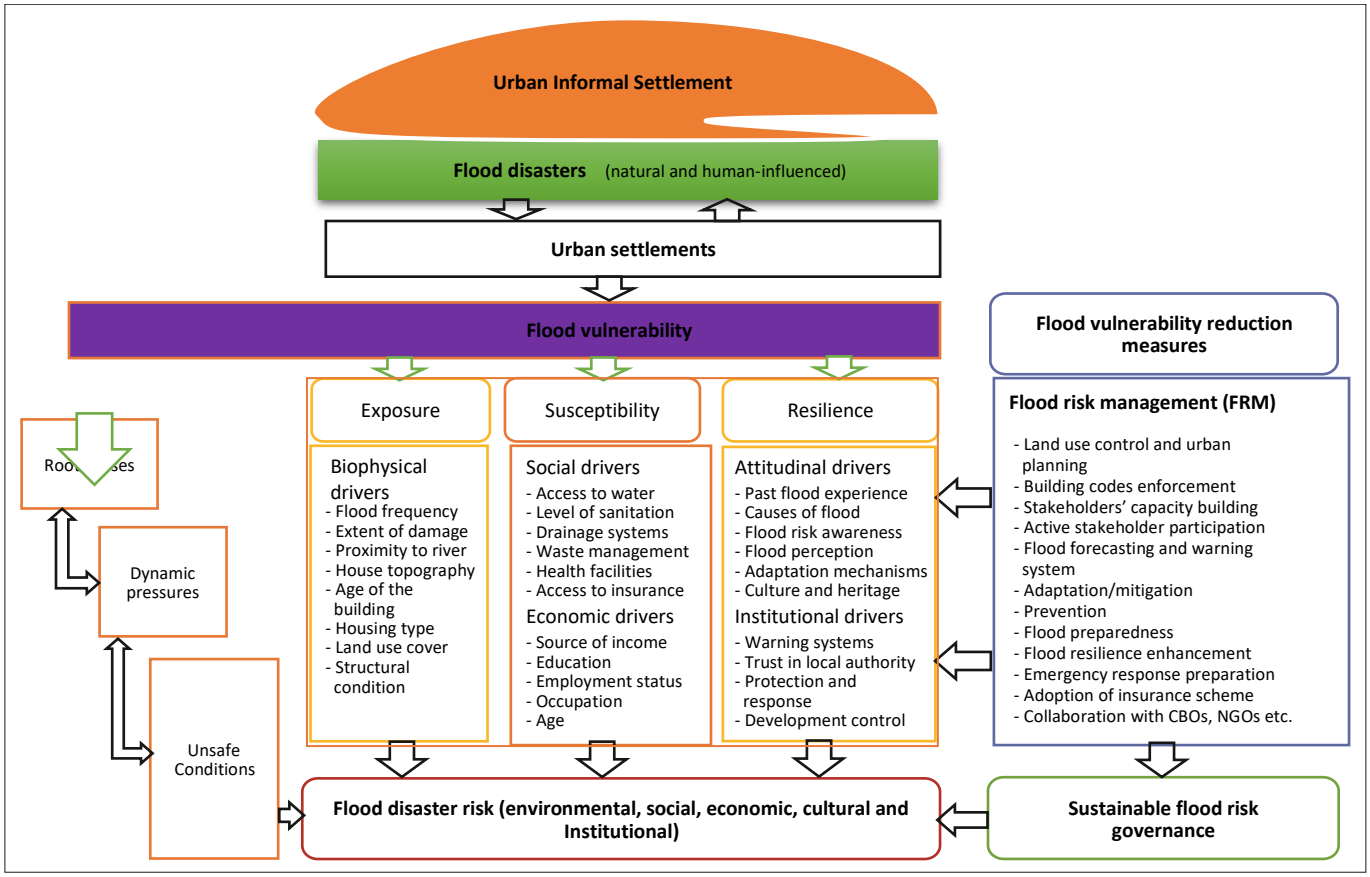

Figure 2.1: The flood vulnerability assessment: conceptual framework for African cities. *(Source*: Adopted from Salami et al., (2017**)**

Sensitivity refers to the degree to which a system is influenced, unfavorably or beneficially, by a particular exposure,' according to the Intergovernmental Panel on Climate Change (IPCC 2007). The sensitivity of socioeconomic and environmental systems differs.

According to the Intergovernmental Panel on Climate Change, sensitivity refers to the degree to which a system is changed, either negatively or positively, by a certain exposure (IPCC 2007). Socioeconomic and environmental systems have varying degrees of sensitivity. The effects of floods are at the forefront of flood-related sensitivity. Direct (physical) impacts (e.g., a change in rainfall affecting a city's water supply) and indirect (socio-economic) impacts (e.g., the age structure of a population influencing the degree to which mortality increases during a heat wave) can both change a system's sensitivity (Judy et al. 2011).

Adaptation is the modification of natural or human systems in response to present or anticipated climatic stimuli or their consequences, with the goal of minimising impact and maximising benefits. Individual or communities determine flood vulnerability in terms of their

ability to predict and cope with flood impacts (Munyai et al., 2019; Arosio et al., 2020). Vulnerability measures the hazards associated with flooding in the context of environmental and socioeconomic capacity to adapt. Varying social groupings or classes within a society are at different risk levels, both in terms of the likelihood of a major flood event occurring and in terms of assisting different classes in recovering (Munyai et al., 2019; Arosio et al., 2020). Ngie (2012) suggested that that in order for vulnerability to exist, the population's ability to absorb, respond to and recover from the impacts must be considered (French 2017).

2.5.1 Understanding the diversity of community context: Community's factors and strengths

- **Starting with a broad perspective**

It is a good idea to start by assessing the current situation in a community, using various methods of acquiring and interpreting data. This usually entails residents expressing a wide range of problems, issues and ideas. A greater knowledge of the different situations of the people and the area can be established from this broad perspective (Hicks & Ison, 2018). The study can then begin to focus on specific topics to investigate more thoroughly.

- **Recognising community differences**

It is critical to recognise that different people in a community have varied circumstances and strengths (Cretney, 2018; O'Brien et al., 2018). It is frequently necessary to break down information in order to comprehend how it represents the situations of men, women, the elderly, youth and others, and to understand how these conditions differ – and thus how support could differ. It is also crucial to include people who, since they are not forceful or do not have a clear way of expressing themselves, are easily disregarded or discounted while gathering information and creating strategies for assessing or reducing flood impacts. These are groups that are marginalised and excluded from society.

- **Building on strengths**

As mentioned previously, a livelihood strategy focuses on people's strengths. From this perspective, a community already has talents, skills, activities, opportunities and features on which to grow. This necessitates identifying and recognising potential and opportunities, as well as determining how to assist them.

- **Identifying external help**

Facilitating economic activity and revenue generation in the informal settlements during flood disasters is one aspect of livelihood support. It is critical to assist the appropriate economic

activity to develop and grow in a setting of high unemployment, limited access to formal jobs and entrenched poverty (Olorunfemi, 2011). Building on a situation's strengths necessitates careful consideration by government and other community partners of what they can do, what value they can add, and what additional help and resources they can provide. It is critical for towns to understand their roles and obligations, as well as to discover strategies to assist livelihoods. Municipalities must assess their contribution possibilities as well as their own capacity constraints (Shackleton et al., 2011; Olajide, 2015). They will have to be strategic about what they prioritise, what they do in-house, and what they achieve through collaborations with other government agencies, the private sector or non-governmental organisations.

- **Taking a participatory approach:**

The first step is to understand how individuals see their situation and what their livelihood goals are. There are no preconceived notions about what things are; instead, they must be discovered through interactive activities. As a result, it is critical to take a participatory approach. There is no single methodology, however, and the sustainable livelihoods approach stands out for its methodological versatility. The approach to sustainable livelihoods does not necessitate the development of novel participatory methods (Khedrigharibvand et al., 2019; Röder et al., 2020), but it does necessitate the use of existing methods to acquire a broad picture of assets, possibilities, and restrictions to the poor's advancement. There are methods for identifying existing traits, trends, issues and circumstances in a certain settlement. Community surveys and action planning are two effective strategies for identifying and agreeing on how to improve things, what to prioritise, and how to acquire help with these.

2.5.2 What kind of data is needed to assess the vulnerability situation?

Livelihoods analysis does not have to be exhaustive to be effective. Rather than attempting to comprehend all parts of the Vulnerability Context, the goal is to pinpoint the trends, shocks, and features of seasonality that are most important to livelihoods.

The focus can then shift to determining the impact of these factors and how to mitigate their negative effects. This necessitates a prior understanding of the nature of local livelihoods, namely what types of livelihood strategies local people adopt and what factors prevent them from reaching their goals during flood hazards. Such knowledge cannot be gathered without social analysis, which identifies specific social groupings and their relationships with components in the Vulnerability Context. While it is critical to limit the scope of the investigation, it is equally critical to think extensively about elements within the Vulnerability Context that may affect local people in order to prevent flood hazards.

2.6 Legislative acts and frameworks related to flood management

Flood events are rising around the world as a result of climate change and socioeconomic growth, necessitating a transition away from traditional flood protection and post-event action and toward a more holistic, risk-aware resilience approach. Countries' national legal systems can play a significant role in fostering and facilitating such a change (Mehryar & Surminski, 2021). This section explores the potential and shortcomings of national and international legislative frameworks, acts and laws in managing flood risk and increasing flood resilience in the context of climate change and socio-economic development in developing countries in general and South Africa in particular.

2.6.1 International legislative frameworks for flood disaster risk reduction

Formal international legislative systems play an important role in setting out rules and frameworks for flood risk governance in countries around the world (Kreibich et al., 2015; Mashi et al., 2019). These legislative frameworks and laws are aimed at regulating flood management decisions, strategies and responsibilities for effective flood risk reduction (Priest et al., 2016). International frameworks and laws are implemented by the international community to support the integration, coordination and implementation of local and national disaster risk reduction measures and the coordination of stakeholders and distribution of resources among different stakeholders, sectors and institutions to ensure adequate preparedness, mitigation and response to flood risk at different scales (Williams et al., 2018).

According to Mehryar and Surminski (2021), this ensures that disaster management experts and all relevant stakeholders are aware of their roles and responsibilities in preparing and responding to flood events at local and national levels. Therefore, international flood legislative frameworks and laws compliment national legislative frameworks and laws and play an important role in determining flood risks management for effective flood risk reduction (Suykens et al., 2016; McDonald & McCormack, 2021).

- **The Sendai Framework for Disaster Risk Reduction**

Countries all over the world have made tremendous progress in building legislative frameworks for disaster risk reduction, as well as reinforcing existing frameworks to ensure their effectiveness in the face of rising dangers (Clarke et al., 2018). Although most countries have a high level of risk awareness, the recurring state of catastrophes internationally highlights the need to further decrease and avoid vulnerabilities, as well as increase disaster management cooperation (Ziervogel et al., 2016). The 2015 United Nations World Conference

on Disaster Risk Reduction (UN World Conference on Disaster Risk Reduction) and the Sendai Framework for Disaster Risk Reduction 2015–2030 (SFDRR;) make a bold call for global cooperation to achieve significant outcomes (Raikes et al., 2019). The Sendai Framework for Disaster Risk Reduction 2015–2030 was agreed upon and accepted by developed and developing countries from all around the world (Khoza et al., 2021). By 2030, governments must significantly reduce disaster risk and losses, according to the SFDRR. By making all policies risk-informed, it provides a chance to enhance disaster risk reduction across the globe through many internal and external policy sectors (Faivre et al., 2018). As a result, it signals a critical change from disaster management to risk management, and it defines resilience as a shared denominator with the 2030 Agenda for Sustainable Development (Bang et al., 2019).

Six years after almost all African states signed the Sendai Framework for Disaster Risk Reduction 2015–2030 (SFDRR), disasters continue to have a significant impact on African populations, livelihoods, and infrastructure (van Niekerk et al., 2020). Unlike the Hyogo Framework for Action, which lasted from 2005 to 2015, African nations not only adopted the SFDRR, but also integrated the multiple priorities by adopting five additional African-specific targets (Van Niekerk, 2021). In 2016, the African Union adopted a Program of Action (PoA) for the Implementation of the Sendai Framework for Disaster Risk Reduction in Africa (2015–2030) (Van Niekerk et al., 2020). The PoA, in accordance with the Sendai Framework, provides advice and direction for activities in Africa to avoid and reduce catastrophe risk, as well as to improve resilience for all at the continental, regional, national, and subnational/local levels (Aitsi-Selmi et al., 2016).

In accordance with the Sendai Framework, the PoA provides guidance and direction for efforts to prevent and decrease disaster risk, as well as to enhance resilience for all at the continental, regional, national and subnational/local levels in Africa (Aitsi-Selmi et al., 2016). The South African Action Plan on the Sendai Framework for Disaster Risk Reduction makes a significant contribution to a number of South African policies aimed at building a risk-informed approach (Khoza et al., 2021). The plan lays out a comprehensive strategy for reducing risk, strengthening society's resilience and leveraging investments through a variety of policies, including development, humanitarian aid and flood risk management, water and biodiversity protection (Aitsi-Selmi et al., 2016).

After the Hyogo Framework expired and the Sendai Framework for Disaster Risk Reduction was adopted in 2015, countries all over the world, including developed and developing countries, agreed to and adopted two major international agreements: the Sustainable Development Goals (SDGs) and the Paris Agreement on Climate Change (van Niekerk et al.,

2020). Efforts were made to ensure that these agreements are mutually reinforcing and that disaster risk reduction, biodiversity and conservation, climate change adaptation, sustainable development, and humanitarian goals may be integrated more easily (Clarke et al., 2018).

- **Sustainable Development Goals (SDGs)**

The United Nations Sustainable Development Goals were established in 2015 to replace the Millennium Development Goals (2000-2015) (Raikes et al., 2019). It is the road map for attaining Sustainable Development and better livelihood and welfare for all by attempting to handle the world's challenges collaboratively (?). It requires that all countries across the globe both developed and developing countries to work collectively in a global partnership to achieve the aim of environmental sustainability and livelihood through transformation by solving several challenges confronting humanity in order to *ensure economic prosperity, well-being, and environmental protection for both developed and developing countries by 2030* (Echendu, 2020). Social, economic and environmental goals are interrelated and inseparable, balancing the three fundamental components of sustainable development. SDGs offer a diverse and holistic approach to development as opposed to traditional development goals, which are focused on a prescribed set of indicators (Mehryar & Surminski, 2021). Floods, for example, have a disproportionate influence on communities around the world because of the sheer number of people affected. Since the world's nations are at varying stages of development and do not confront identical difficulties, there are disparities in influence. In fact, flooding disturbs a variety of facets of life, and the SDGs affected could be comparable to those in other developing nations and in Africa as a whole (Mashi et al., 2019).

Floods exacerbate the already precarious living conditions of the impoverished in African countries, jeopardising the continent's ability to meet the UN's Sustainable Development Goals (Echendu, 2020).

Floods have the potential to damage people's physical, social and economic capitals, and the livelihoods of already impoverished households (Faivre et al., 2019). When such floods occur frequently, the consequences are amplified. As a result, flooding is a key contributor to the existing poverty thus preventing countries from achieving SGD1. Flooding also makes fulfilling SDG 2 a challenge in African countries. Goal 2 of the Sustainable Development Goals is to eliminate hunger in all of its manifestations by 2030.

The agricultural sector is very significant and plays a critical role to ending hunger, although it is the most affected by flooding in most parts of the world, particularly in Africa, where capacity to prevent or mitigate the effects is limited (van Niekerk et al., 2020). Food security is the most

reliable method of preventing hunger, and it entails making food affordable and accessible, particularly staple foods, yet Africa is still far from achieving it (Van Niekerk, 2021).

The third Sustainable Development Goal (SDG 3) strives to guarantee that everyone leads a healthy and happy life. Flooding, which affects health in a variety of ways and has long-term consequences, has derailed this ambition. Flooding's effects on health are linked to other SDGs, such as no poverty and zero hunger, in the same way that the SDGs are interlinked and linked. If people are sick, their ability to work is harmed, resulting in poverty and hunger. Flooding has a direct influence on poverty and increases sensitivity to hunger, whereas hunger, among other things, is a prelude to disease outbreaks due to decreased immunity. Flooding affects people's health in both direct and indirect ways.

2.6.2 Local and national legislative frameworks for flood management in South Africa.

Although South Africa is not prone to huge, destructive floods, it appears that smaller floods, particularly in urban areas and among vulnerable groups, are becoming increasingly common (Wentink & Van Niekerk, 2017). In South Africa, flooding has resulted in the disruption of communication systems and potable water supplies, as well as damage to road infrastructure, water service failure, property damage and loss of life (Solik & Penning-Rowsell, 2017). South African flood risk management shifted dramatically after apartheid ended in 1994, with the Disaster Management Act of 2002 recommending a modern proactive method (Ziervogel et al., 2016). The current framework for disaster management in South Africa was established by the Disaster Management Act (DMA) of 2002, which included recommendations for floods, droughts, and fires (Solik & Penning-Rowsell, 2017; Bruwer et al., 2017).

The disaster management is defined in the Disaster Management Act (DMA) of 2002 as *an integrated and coordinated process for preventing, reducing and mitigating the risk and severity of disasters, ensuring emergency preparedness, rapid and effective response to disasters and post-disaster recovery* (Republic of South Africa, 2003:6). When the DMA was passed, it gave new authority to each of the national, provincial and municipal levels, but the *most crucial sphere for efficient disaster management implementation is local government, where most operational actions connected to disaster management would occur* (Bruweret al., 2017).

- **The South African Disaster Management Act 57 of 2002 As amended Act 16 of 2015**

The Disaster Management Act No. 57 of 2002 is the guiding framework for effective disaster risk management at all spheres of government in South Africa (Zuma et al., 2012).

Immediate action was taken in June 1994 when the Western Cape Province was devastated by severe flooding and eventually the Disaster management Act (DMA) and the National Disaster Management Framework (NDMF) were adopted in 2002 and 2005 respectively as a result increasing disaster events as guiding framework for disaster management (Van Niekerk, 2014; Ziervogel et al., 2016). Over time, South Africa's position as a global leader in integrating disaster risk reduction into all domains of government through a decentralised approach was confirmed in 2005 when the National Disaster Management Framework was established (Van Niekerk, 2014). By providing four key performance indicators (KPIs) and three supporting enablers, the NDMF laid a solid foundation for a framework for effective DRR in South Africa (Kunguma, 2020).

- **National Disaster Management Framework of 2005 (NDMF)**

South Africa's position as a global leader in integrating disaster risk reduction into all domains of government through a decentralised approach was confirmed in 2005 when the National Disaster Management Framework was established (Van Niekerk, 2014). Key Performance Area 3: Disaster risk reduction and Key Performance Area 4: Response and recovery are very important legislative guidelines for preparing and responding to the effects of flooding especially in informal settlements.

2.7 Conclusion

This chapter examined the theoretical and conceptual framework relevant to achieve the objectives of this study. Concepts such as the sustainable livelihood framework and community capital framework were reviewed. Important as these frameworks are, they are insufficient in achieving the objectives of this study. The flood vulnerability assessment: conceptual framework for African cities was developed and explained as a suitable framework for achieving the objectives of this study. Furthermore, the second part of the chapter explained in detail, various international and national legislative frameworks relating to disaster risk management particularly flood risk reduction. The chapters first of all examined international legislative frameworks for disaster risk reduction. Frameworks such as the Hyogo Framework for Action, the Sendai Framework for Disaster Risk Reduction and the sustainable development goals were discussed.

Furthermore, the discussion concluded by examining the South African legislative frameworks for disaster risk reduction, such as the Disaster Management Act and National Disaster Management Framework, were also discussed.

CHAPTER 3

LITERATURE REVIEW

3.1 Introduction

Rapid population growth, climate change, change in rainfall patterns in combination make poor urban neighbourhoods vulnerable to flood events, thus reducing urban resilience (Williams et al., 2018; Williams et al., 2019). According to Khan et al. (2014) human activities such as unplanned rapid settlement development, uncontrolled building construction in general, and significant land-use changes can all have an impact on the spatial and temporal pattern of flood hazards. It is consequently vital to identify and understand important determinants as well as complex interactions between them that contribute to rural and urban poor communities' vulnerability to flood events (Afriyie et al., 2018; Mavhura, 2019; Jamshed et al., 2020). Identifying elements that impede or encourage these communities' ability to respond to risks is also useful in urban resilience policymaking (Coaffee et al., 2018; Hecht et al., 2019). Flooding problems have become much more prevalent, necessitating a comprehensive flood impact study to better comprehend the situation in order to prevent its fatal consequences (Terti et al., 2019; Norizan et al., 2021).

Flooding is caused by a variety of factors, including topography, drainage, infrastructures and the climate of the region. The most important contributing elements for flood threats are the intensity and length of the rain (Couasnon et al., 2020). Floods are among the most common and expensive natural disasters confronting the world today, with enormous human and economic loss (Jamshed et al., 2019). Floods account for an estimated 90% of the damage caused by natural disasters globally (Hambati & Gaston, 2015). Annual global flood damage is estimated to be in the billions of dollars (Chernov & Sornette, 2020). Flooding has wreaked havoc on highways, settlements, crops and people's livelihoods (Shah et al., 2020). Floods are produced by a combination of natural and human forces in South Africa. Due to lack of infrastructure, drainage systems, and people's dwellings being built with inadequate materials, informal settlements are particularly vulnerable to environmental hazards, such as flood catastrophes.Several case studies look into flood-prone informal settlements, with the majority of them focused on floods, household vulnerabilities, and coping strategies (Carrasco & Dangol, 2019; Ngarava et al., 2021). While this is vital, it is also recognised that improved coordination efforts are required to transition from coping to adaptation, both within communities and between communities and local government. We need to look at issues of

governance, political dynamics, and leadership in order to better comprehend communities' capacities to participate in collaborative endeavors

3.2 Floods

Floods are one of the most common risks, resulting in deaths, injuries, property damage, contaminated drinking water and power outages. The surrounding and regional communities are impacted, sometimes for days at a time. Climate change, poor river management and infrastructure expansion in places that are always inundated, according to Swain et al. (2020), are likely to increase the scale and frequency of floods in the future. New developments in flood plains increases the vulnerability of residents to the floods, thus adding to the pressures on the urban system. When there is a flood, this means there is a less possible water storage area (Kekez et al., 2020).

3.2.1 Types of Floods

Flooding is an exceptional build-up of water above ground produced by high tides, severe rain, or quick runoff from paved surfaces (Khayyam & Noureen, 2020). Floods can also happen when a stream bursts its banks and submerges the surrounding area (Akukwe et al., 2018). Flooding is a common natural and human-caused hazard that happens when the pace of rainfall or precipitation exceeds the rate of absorption, causing rivers or oceans to overflow their normal limits (Díez-Herrero & Garrote, 2020). Flood is primarily a meteorological hazard to the environment, although it is frequently caused by humans' poor use or misuse of the physical environment (Ajiboye & Orebiyi, 2021). There are various forms of floods that turn into disasters when they cause damage to human communities including informal settlements. Seasonal precipitation across large catchment areas, melting snow or a combination of these factors generate river floods or seasonal floods (Stein et al., 2020; Das & Scaringi, 2021).

Flash floods, also known as tropical storm floods, occur when strong rains become too much for streams and rivers to handle, causing them to overflow and cause flooding. Finally, coastal floods occur when ocean water overflows due to storms, gusts and other phenomena, resulting in onshore flooding (Callaghan, 2021). Floods, according to Smith (1999) and Church and Jakob (2020), are the most prevalent type of disasters worldwide, with three major varieties being classified as river floods, flash floods, and coastal floods. Flooding is the most common disaster scenario for the majority of people who live along the shore:

- Flash floods, which are connected with severe, convectional storms that last only a few minutes and are measured in minutes rather than hours. Floods of this nature

occur all around the planet. Flash floods are one of the world's most dangerous natural hazards, posing a severe risk of death and wreaking havoc on buildings and infrastructure. Despite the fact that this type of flood frequently affects ungauged watersheds, it is still a little documented phenomenon.

- Single-event floods, which last much longer than flash floods, are caused by a variety of rainfall conditions in which broad rains last for several hours or days and travel across a drainage basin. These are frequently linked to cyclonic storms.
- Multiple event floods occur when successive flood peaks occur in close proximity to one another as a result of complicated weather conditions. This form of flooding can linger for weeks or months and is the most dangerous of all floods.
- Seasonal floods - flooding can occur on a large scale on an annual basis during a wet season and last for several months, bringing either immense profit or disaster. Flooding along the Nile River ensures appropriate crop production, whereas flooding in India causes enormous suffering and loss of life.
- River floods - occurs when the water level in a river, lake or stream rises and overflows onto the surrounding banks, shores and neighboring land. The water level rise could be due to excessive rain or snowmelt. The damage from a river flood can be widespread as the overflow affects smaller rivers downstream, which can cause dams and dikes to break and swamp nearby areas.
- Coastal floods - occurs when dry and low-lying land is submerged by seawater. The range of a coastal flooding is a result of the elevation of floodwater that penetrates the inland which is controlled by the topography of the coastal land exposed to flooding.
- Human made flooding – occurs where there is involvement of humans either intentionally or unintentional. These include pipe burst from the household and dam burst overflowing in residential or commercial areas.

3.3 Global view of floods

Flooding is projected to become more common around the world as global temperatures rise and precipitation rises (climate change) (Tabari, 2020). A projected rise in river flood hazard is one of the most commonly mentioned effects of future climate change. Flooding is a global hazard that poses a significant threat to the health and livelihood of many people around the world (Loo et al., 2015). Floods are the most common and damaging of all-natural disasters, accounting for 54 percent of all-natural disasters from 2000 to 2019 and 43.41 percent of the overall global death rate in 2019 (Arnell & Gosling, 2016). It should be noted that natural floods cannot be prevented but their effects can be minimised with good evacuation preparations,

land-use planning, environmental management and building rules or standards (Norizan et al., 2021).

It is estimated that global floods account for damages costing 400 billion USD (Choi, 2016; Dellink et al., 2019) and have equally affected approximately 1 billion people with almost 60,000 casualties (Guha-Sapir et al., 2017; Deryugina et al. 2018). Informal settlements are more exposed to flood disasters because they are poor and most vulnerable due to lack of capacity (Okaka & Odhiambo, 2019; Louw et al., 2019; Pelling & Garschagen, 2019).

This has been the case in some poor communities around the world (Nicholls et al., 2021). According to Van Coppenolle and Temmerman (2020), more than 400,000 people are exposed to 1 in 100-year storm and flood events. The extensive river flood events in Bangkok in 2011 and the storm surge flood in New York caused by Hurricane Sandy in 2012 and many other flood events around the world have proved this. There have equally been other flood events across Europe, Asia, and America over the past decade (Ritchie & Roser, 2014; Jongman et al., 2012). The economy of Africa is greatly thwarted by the occurrence of natural disasters and greatly undermines the survival of poor communities (Coulibaly et al., 2020; Ötker & Srinivasan, 2018). According to Lukamba (2010), hydrometeorological disasters that occurred in Africa from 1974 to 2003 were in Eastern Africa, Western Africa, Northern Africa, Southern, and Central Africa with 41%, 25%, 13%, 11%, and 10% respectively.

Flood occurrences across Africa were estimated from 1974 to 2003 to be 162 (Eastern Africa), 98 (Western Africa), 74 (North Africa), and 47 (Central Africa). Floods have had many negative impacts across the continent. For example, the 2021 floods in Somalia affected 400,000 people and displaced 101,300 in 14 districts with over 40,000 hectares of farmland, 12 schools, and 27 villages destroyed (UN OCHA, 2021). According to UN reports (2020), the flood that lasted 4 months (October 2019 to January 2020) in Congo left more the 170,000 homeless in the most affected areas alone. From August to September 2020, floods occurred in over 8 different countries across Africa (Niger, Burkina Faso, Senegal, Ghana, Nigeria, Cameroon, Tunisia, and Mali) with over 760,000 people affected and hundreds killed (Ajonina et al. 2021). Floods have equally resulted in the loss of over 200 lives and affected 46,370 people with 9,255 displaced (International Federation of Red Cross (IFRC), 2015). Ethiopia in 2006 witnessed serious flooding claiming the lives of 256 persons with 250 reported missing and about 10,000 others displaced (Ranke, 2016).

Floods are frequent and often very severe in most parts of the Asia making the region a hotspot for flood events, with Asia and the Pacific particularly vulnerable to these flood events. To put things into perspective, flood events that occurred in China in 1998 affected 223 million people, recorded 3004 deaths, 15 million people displaced, and an economic loss of approximately

US$ 23 billion (Shah et al., 2020; Kirezci et al., 2020). Furthermore, the year 2000 experienced torrential floods in Cambodia and Vietnam which killed 428 people and caused an estimated economic loss of about US $250 million (Alhasanat, 2017; Chernov & Sornette, 2020). A total of 140,000 deaths were recorded globally in 1991 due to flood events, and 25 million people were impacted by flood events in 1998 (Needham et al., 2015; Kiro et al., 2020). Floods are responsible for as much as 90% of the damage caused by natural catastrophes in Malaysia. Annual flood damage is estimated to be in the billions of dollars (Khan et al., 2014).

Flooding has wreaked havoc on highways, settlements, crops and people's livelihoods. Countries like Japan, India, South Korea, Vietnam, Pakistan, China, and Bangladesh have experienced severe flooding in the last decade, impacting hundreds of thousands of lives and destroying the livelihoods, homes and health (Eckstein et al., 2019; Eckstein et al., 2017). Less developed countries due to lack of capacity and preparedness, are the most vulnerable to flood events. Lack of institutional capacity has affected the ability of less developed countries to design effective disaster response and early warning preparation to deal with flood events (Shah et al., 2020). Proper coordination, communication and the use of innovative technologies can assist stakeholders in receiving early flood warnings and determining the impact that floods are expected to have (Shrestha et al., 2021).

Countries in Europe are equally feeling the effects of flooding despite the level of technological development implemented to mitigate the effects of floods. The European Union (EU) has recorded an estimated 400 severe floods which wreaked havoc to the economies of Europe, impacting the lives and properties of approximately 8.7 million people, recorded more than 2000 deaths, and recorded an estimated 72 billion Euro in economic losses (World Health Organisation (WHO), 2017; Ionita & Nagavciuc, 2021). Some regions in Europe are feeling the effects of flood events more than other regions. In the last 10 years, Europe has experienced a change in rain fall patterns with more rains and frequent flooding. The German winter floods (1993, 1995 and 2021), the flood events in the Netherlands and France; the severe 2002 and 2013 floods in the Elbe River catchment area; the Eastern European floods (2005, 2008, and 2010); the central European floods (2010); and the United Kingdom floods (2000, 2007, 2014, 2020) are some of the floods with the most devastating effects in Europe in the last three decades (Ionita et al., 2014; Ionita, 2015; Muchan et al., 2015; Stevens et al., 2016; Ionita & Nagavciuc, 2021).

3.4 Floods in South Africa

South Africa like other parts of the world has been impacted by natural hazards including floods. For instance, recent disastrous flooding in portions of South Africa, as well as the second large cyclone to hit neighbouring Mozambique and Zimbabwe, have prompted concerns about climate change's impact on the region (Ntanganedzeni & Nobert, 2020). Furthermore, extreme weather events and natural disasters are likely to become increasingly common in Southern Africa in the next years. Climate change has been related to an increase in the likelihood of extreme weather events. Increasing air and water temperatures result in increasing sea levels, supercharged storms, and greater wind speeds.

Floods that are more extreme and last longer, as well as higher precipitation and flooding, are projected as a result. Every winter, many informal villages in the Cape Flats flood due to the high water table and heavy rainfall in Cape Town (Desportes, 2016; Drivdal, 2016). Because their homes (shacks) are built with poor materials and they frequently have a low income, people of informal settlements are particularly exposed to the projected repercussions of climate change (Moser & Satterthwaite, 2010). A corpus of work connected to this examines vulnerabilities with a tendency to utilise the household as the key unit of analysis, laying out individual coping mechanisms. Flooding impacts not only families, but also internal communal places, therefore such coping is definitely vital, but it is frequently insufficient. Flooding vulnerabilities in informal settlements are linked to macro-policies (Alemaw, 2018; Aroca-Jiménez et al., 2018), and adaptation is a multi-scale effort involving individuals, households, communities, local governments, regional (provincial) governments, national, and even international levels, as well as businesses and non-governmental organizations (NGOs). If a community or group cannot secure adaptation on its own but requires collaboration with (local) government, the conditions for collaboration must be improved (Satterthwaite, 2011).

Collaborations with key stakeholders could promote flood adaption in South Africa's informal settlements. In addition to recognising the importance of macro-policies, community leaders were given special attention when floods adaptation initiatives or help is disbursed because they serve as key intermediates between local government and communities (Drivdal, 2016). Furthermore, because urban informal settlements are internally heterogeneous and organisational life is defined by fluidity and fragmentation (Oldfield, 2000), these communities appear to be surrounded by micro-politics. Micro-politics have recently been proposed, demands more attention in flood risk management since it might affect the implementation of flood mitigation initiatives (Challies et al., 2016).

3.4.1 Impact of flood in South Africa

Individuals, communities and households are impacted at different scales by floods (Ntanganedzeni & Nobert, 2020). As a result, coping mechanisms adopted by these different groups are different depending on the magnitude of the flood. The effect of floods are often minimal on communities, households and individuals that have the capacity and resources to handle the floods because they often emerge faster, compared to communities, households and individuals that lack the capacity and resources to manage the effects of the floods.

There is evidence from previous research to show that households who are socially vulnerable or underprivileged (rural households and households in informal settlements) have lower levels of disaster preparedness (Dalu & Shackleton, 2018; Okaka et al., 2019; Sarmiento et al., 2020). As a result of both climate change and continuous socio-economic growth, flood risk is predicted to rise significantly in the next years (Perez et al., 2015; Grasham et al., 2019). Floods are becoming a more common occurrence, resulting in increased property damage, corporate economic losses, environmental degradation and fatalities in several countries around the world including South Africa. Several devastating and destructive impacts of floods have been reported in the literature, such as destructions of roads, Information Communication Technologies (ICT), accommodation, bridges, electricity lines and sub-stations and camping facilities, especially those located close to the riverine environment in South Africa (Rowe & Smithers, 2018; Ngarava & van der Merwe, 2018; Dube & Nhamo, 2020). The long-term effects of flooding on communities include increases rate of infections and water-borne diseases such as cholera, dysentery and diarrhea, which increased the demand for safe drinking water and the distribution of water purification tablets (Mellor et al., 2016; Cairncross & Feachem, 2018).

Floods also slow down economic progress in the economy because damages to critical infrastructure can halt businesses, schools, factories, hospital from operating thus adding social, environmental and economic pressures on the economy (Thomas, 2017; Hallegatte et al., 2019). The effects of flooding can also slow the progress of the country from achieving sustainable development goals and fostering economic prosperity (Firoiu et al., 2019; Echendu, 2020).Flooding has the potential to destroy or damage roads, bridges, buildings and sewage disposal systems. Flood catastrophes have a negative impact on agricultural production, resulting in community food insecurity (FAO–SAFR 2002). According to Akukwe et al. (2018), the direct consequences of floods are enormous but their effects are normally felt in poor communities that depend on agriculture for their livelihood and are also seen as contributing to a decline in productivity and a loss of income for agricultural farmers.

A decline in agricultural productivity reflects directly in decline in agricultural production and income for the farmers (Kokera & Ndoma 2016), and this combined with the effects in other sectors shows how severe the consequences of floods can be especially in poor communities. Primarily, losses can be high in low-income communities, where crops, livestock and agricultural infrastructure, suffer the most damage, which often have severe consequences on their incomes and livelihoods (Hess et al., 2016; Hossain et al., 2020). Furthermore, these primary losses are primarily related to the disruption of economic and social activities, particularly in high income areas that have high social and economic investments (Stenberg et al., 2014; Khan et al., 2021).

- **Economic impacts**

It is critical to conduct an economic assessment of flood occurrences because it is required both to advise on continuing efforts to mitigate the effects of current floods and to assist in the development of policies that will make these areas more informed and resilient to future flood disasters (Khayyam & Noureen, 2020). Flooding appears to have a financial impact on macroeconomic trends such as economic growth rates, investment, the current balance of payments, inflation and wages (Fuller, 2018). The financial losses of the floods include losses on agricultural production, soil erosion, vegetables, electricity for industrial and household use, unemployment, infrastructure loss and burdens on financial institutions (Hambati & Gaston, 2015; Jamshed et al., 2019). Floods, in general, cause economic and financial hardship for all impacted towns, particularly disadvantaged communities, and this is especially true when they last for several years. Floods can have massive economic consequences, generating debilitating agro-economic problems as well as severe economic hardships for community growth and livelihoods (Ajiboye & Orebiyi, 2021).

Floods are known to generate both direct and indirect financial problems around the world. In South Africa, flooding has been documented to present significant damaging effects to many sectors of the economy thereby causing a decline in the general economic performance of the nation. According to Lamb et al. (2016), floods can negatively affect the nation's hydraulic infrastructure such as dams, bridges and culverts. This, in turn, has resulted in a decrease in the water supply to affected communities. Other consequences of flooding result in the displacement of a large number of people and cause significant loss of life and property, resulting in a rise in poverty, agricultural deficit, unemployment, and even death from starvation in South Africa recently (Tandi & Mawere, 2018). The economy is also impacted by crop damage, which has a direct or indirect impact on the agriculture industry. For instance,

in the study of Ngarava et al. (2021) who examined the impacts of flooding on the production of livestock in Port St Johns, South Africa. The study found that economic impacts associated with flooding in South Africa range from damage to grazing land which resulted in a decrease in the production of cattle, sheep, poultry, pig and goat. Consequently, the impact caused a decrease in the availability of beef, mutton and chicken as well as a rise in product prices.

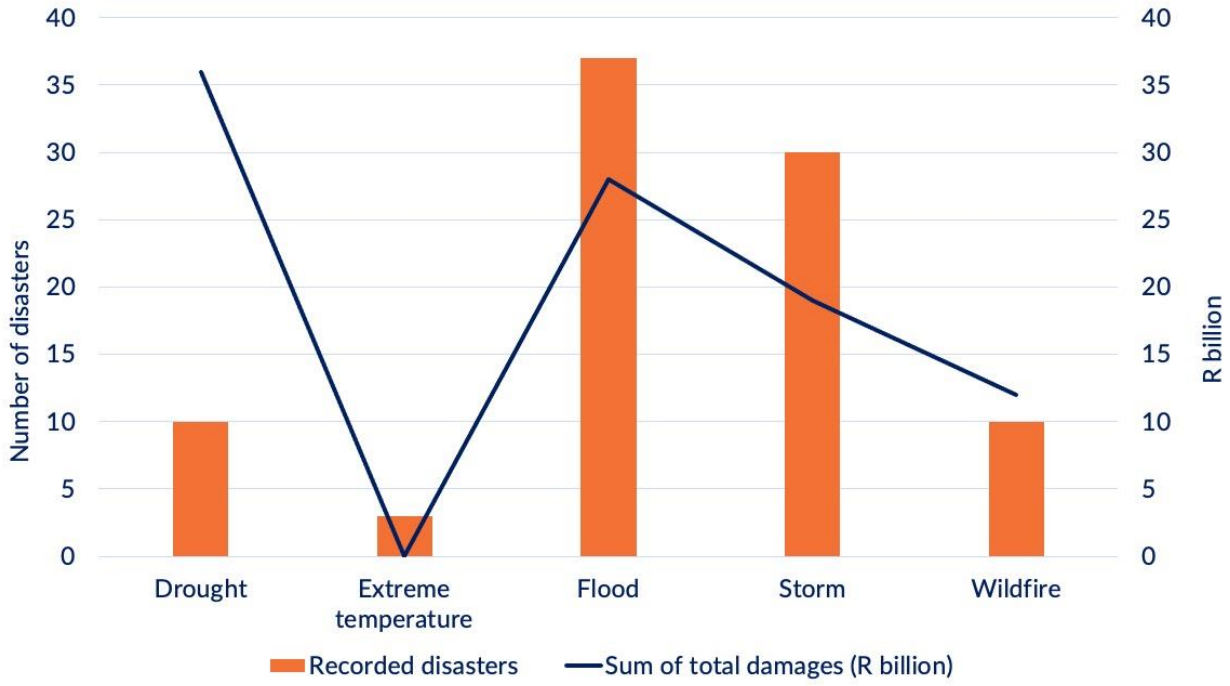

Figure 3.1. Weather related risk disasters in South Africa from 1980 to 2020 and the economic cost.

(*Source*: Institute for security studies, 2020)

Figure 3.1 shows various disasters events in South Africa as well as the economic impacts of recorded disasters. Flooding remains the most re-occurring disaster in South Africa, followed by storms. The impact of flooding resulted in loss over 35 billion Rand between 1980 to 2020 indicating that floods caused more damages than other natural disasters in South Africa (Couasnon et al., 2020). The damages range from sinking of houses to washing away of agriculture produce as well as deaths of livestock (Institute for security studies, 2020).

The city of Tshwane Metropolitan Municipality including the study area, for instance, is vulnerable to hazards such as diseases, fires, drought, thunderstorms and flooding. This is associated with high levels of poverty, landlessness and poor infrastructure (Loots & Smithers, 2020). The physiography of the area and the location of settlements render the City of Tshwane Metropolitan Municipality prone to flooding. Before and after the 1999–2000 floods,

disaster management for floods was found to be lacking and ineffective. This was the first major flood disaster, caused by tropical cyclone Eline, but the municipality was completely unprepared according to Loots and Smithers (2020). Years later, flooding became a major disaster once again, which occurred between 2010 and 2019 at Eerste Fabriek, in the Gauteng Province. Figure 3.2 below indicates the location of the Eerste Fabriek and areas that are vulnerable to floods.

Figure 3.2. Shacks at an informal settlement in Eerste Fabriek, Mamelodi which were swept away by floods in December 2019.
(Picture: Bongani Shilubane)

Different sectors in South Africa were affected by these floods. For instance, insurers are bracing themselves for an unprecedented number of claims emanating from the flood damage, which tore off roofs, flooded roads, uprooted trees and left several people injured and dead (Akhter et al., 2020; Siwedza & Shava, 2020). The increased frequency of extreme weather events including floods over the past couple of years was observed which left consumers and insurers counting the toll of weather-related hazards (Siwedza & Shava, 2020). The general consensus from studies is that climate change has a massive impact on property losses and South Africa should brace itself for a new normal of heavy rains and hailstorms, powerful winds and drought conditions in many regions (Munyai, 2017; van Niekerk et al., 2018; Ohiomah et al., 2021). Weather-related hazards such as windstorms and floods have increased by 600 percent since the 1950s, according to studies, a coalition of global insurers, brokers and industry service providers (Rowe, 2019; Chikoore et al., 2021). Floods can inflict significant

damage, but they can also have positive consequences, such as the depositing of agricultural land and the replenishment of soil moisture (Bubeck et al., 2017).

Furthermore, the study considers these as concrete and intangible losses. Fear, anxiety, aggravation, distress, insecurity, bad health and finally death are among the difficulties that can arise when intangibles are quantified. According to Chan (2015), the loss of human life and homes during floods is terrible and has a quick impact.

The tangible harms can further be broken down into direct and indirect categories. Direct damages, he adds, arise from direct physical contact of damageable property with floodwater and are presumed to equal the cost of restoring that property to its pre-flood state. Physical damage to buildings and their contents, bridges, roads, trains, agricultural land, and crop loss are all examples of direct damages. According to Chan (2015), the most immediate and visible effects of floods are damage to public infrastructures such as roads, power, the energy supply system, buildings, industrial facilities, and private property.

Losses stemming from the breakdown of some physical or economic linkages, such as loss of output, loss of income and business, and delays in the shipping of products, are instances of indirect damages. Floods, according to Vlachos (1995) are a sociological phenomenon that extends beyond hydrological conditions and has ramifications for human societies' well-being. Because of urbanisation, sprawl, increased densities, or industry, the social environment is always changing, which may affect the population’s vulnerability to floods. Humans are drawn to river valleys and low-lying beaches because of their geographic location. Floods get larger, more frequent, and more intense as a result of urbanisation and deforestation. A decision to evacuate to a safer location, as Surian (2009) and Le et al. (2021) point out, is an economic decision because it costs money. People that do business in the region are also losing money. Most community members experience direct financial loss, which leads to monetary issues such as inflation in the prices of available homes and company premises, rises in land values and the cost of rebuilding. Compensation or special fiscal support to address private property losses is always under strain. According to Kuźmiński (2020), natural disasters create a number of problems for insurance as they typically result in large, unpredictable losses. These have the potential to create economic hardship and the loss of countless lives.

Natural catastrophes entail geographically associated losses from a single incident. They are subjected to extended periods of continuous floods and catastrophic flooding, posing a serious danger to Bangladesh's economy. Agricultural employees, who account for over 40% of the total rural population, are affected by unusual floods that reduce their pay. These employees are poor and landless, and their earnings are their primary source of income. What happens is that severe and sustained flooding in the early monsoon months destroys crops and disrupts

routine production processes in submerged farms (Sharma et al., 2013; Middleton et al., 2017). When this happens, the demand for agricultural employees for land preparation, crop planting, harvesting, and post-harvest processing falls, lowering yields (Kasso & Bekele, 2018; Firth et al., 2020).

In most cases, the drop in demand for agricultural labour during flood months persists long after the floods have passed in the areas that have been affected most severely. Flood directly affects major sectors of the economy, and agriculture is one of the sectors that bears the brunt of floods because floods have a direct effect on agricultural productivity, which automatically reduces agricultural output and farm incomes, as well as create a ripple effect on the taxes that farmers would infuse into the system, both locally and internationally (Nguyen et al., 2016; Damania et al., 2017). Farmers export across the African continent and abroad, fresh vegetables, herbs, beef and poultry meats, as well as pork and moths (Nguyen et al., 2016; Baiano, 2020). Floods effects are felt throughout the economy, with South Africa having suffered heavily and incurred economic losses from floods in the last two decades, including direct agricultural losses of US$ 360 million (Mulungu & Ng'ombe, 2019; Kassegn & Endris, 2021).

- **Environmental impacts**

Some areas in KwaZulu-Natal were affected by floods and landslides in 2019 where many properties and lives (see Figures 3.2 and 3.3) were impacted (Department of Cooperative Governance and Traditional Affairs, 2019). Heavy rains claimed 32 lives and many children in and around Durban alone sustained various injuries. Floods and landslides caused a lot of damage in the area, for instance, road destruction, collapsed buildings and other property losses (see Figures 3.3 and 3.4).

Figure 3.3. Storms and rain caused flooding, landslides and major damage in Durban in 2019.
(*Source*: KwaZulu-Natal Cogta)

Figure 3.4. Damages caused by flooding, landslides in Durban in 2019
(Source: KwaZulu-Natal Cogta)

Some of the examples of vulnerable groups in the KwaZulu-Natal area affected by the disaster are schools, students, the elderly and farmers. Schools and roads were closed after widespread flooding in Durban in particular. Due to schools closing, minors and females became victims of rape. Various farm products or yields were affected, due to flooding, as well as a decline in output and loss of farmlands (Bamford, 2020; Bopape et al., 2021). Businesses were disrupted due to roads collapsing, and the economy in the area was affected because people could not move as a result of road damages, especially those that link different towns. The overflowing of Umgeni River prompted evacuations of vulnerable members of the community including people with low income that were unable to cope. Hundreds of residents, mostly women and children were evacuated from heavily flooded areas (Department of Cooperative Governance and Traditional Affairs, 2019). Studies on floods have been conducted at national, provincial and city levels, with a focus on causes and consequences of flooding (Mothapo, 2019).

Few studies have been conducted in South Africa's rural areas, especially the study area. Despite their high level of risk, there is little to no research on socio-economic effects of floods on informal settlements in different parts of South Africa.

- **Social impacts**

Because floods specifically affect individuals, the social consequences are more likely to be severe. In less developed countries, most people do not have the experience and capacity to deal with the effects of floods, thus making it a common nightmare in poor communities. Floods have many socioeconomic implications for both communities and individuals. As most people are aware, flooding has direct consequences such as loss of life, property damage, crop devastation, livestock loss and deterioration of health due to waterborne infections (Ngarava et al., 2021; Louis & Mathew, 2020). Many regions in South Africa, particularly in the Gauteng Region, have been declared disaster areas as a result of flooding and other climate-related events (Louis & Mathew, 2020). Although relief and emergency measures might be implemented in some sections of the province, it always appears that these efforts may not be adequately coordinated, as disaster management teams and the public face difficulties (Khandlhela & May 2006).

According to the Prevention Consortium Secretariat (2007), the social impact of flood events alters the way individuals live, work, play, relate to one another, organise to meet their needs, and overall cope as members of society. Floods generate a social disturbance, which can significantly reduce the quality of life for individuals and communities affected (Dong et al.,

2020; Shah et al., 2020). Social components of flood vulnerability can be used to establish policies that reduce risk and improve communities' ability to predict and respond to flood hazards. During floods, people relocate to other places with better chances in pursuit of a better living environment. The migration of young people leaves the world vulnerable, leaving the elderly and children in the hands of people who are unable to boost growth in the region. Subsistence farming communities are the hardest hit when other members migrate. This creates a strain for farming families in rural areas around the world (Arnell & Gosling, 2016). It is estimated that the number of environmental refugees will increase if sustainable actions are not taken to reduce the effects of flooding on livelihoods of poor communities in South Africa (Díez-Herrero & Garrote, 2020).

Investigations on the effects of previous flood events focuses on social aspects of individual and community risk. The same incident may have different consequences on people affected, it is difficult to generalise on the relationship between the scale of the event and the actual or effects on those suffering as a result of floods.

When communities are forced to adapt to flood hazards, there is a long-term increase in coping capacity that might result from a combination of changes in individual behaviour, resources, infrastructure and functions of persons and communities (Dong et al., 2020; Shah et al., 2020). In terms of the effect of flooding, there are three types of health effects: those that occur during or soon after the flood, those that emerge in the days or early weeks following the flood, and those that appear months or years later. According to the International Organization for Migration (McLeman, 2011), frequent rains once afflicted Zimbabwe, Zambia, and Mozambique, resulting in an increase in diseases such as malaria, diarrhoea and skin ailments as a result of poor sanitation and stagnant water.

People were unable to seek medical help because bridges had been washed away and clinics were too far away. Many communities were not accessible and people lost their properties. Survival of a hazard depends on an individual, family or community in that they have a choice to heed the warning of a hazard, if not, they bear the brunt of losing property, suffer injury, loss of friends or relatives or death. There are evacuation advisories issued before the incident, people continue to live in those areas although unsafe because there is a sense of belonging that overrides common sense about the threat of hazard. This is due to the fact that one is more familiar with individuals at home on a personal level. It is also tough to let go of one's historic ties to the location, past or one’s roots. No threat will compel them to leave, they will always rationalise the threat in order to reduce the likelihood of it occurring. It is also true that if a location is appealing in its own right, it is likely to grow on people regardless of the disaster (Shao et al., 2017). Flood events can increase the level of stress and anxiety in the

community, more especially because the effects of floods last for a long time, and this can destroy communal networks and social contact is threatened, resulting in low morale and social alienation (Akhter et al., 2020).

A study found that communities exhibit a high degree of solidarity during the emergency phase of a disaster because there is an intense desire to help each other without expecting reward or compensation (Rabalao, 2010). This study opined that this community spirit is a result of sharing common problems and participation as a collective attempt to tackle them; conscious efforts should therefore be made to enhance and nurture community morale (Rabalao, 2010; Mugambiwa & Makhubele, 2021). The deplorable living conditions of people in these communities add to the disaster's scope. A calamity frequently results in increased levels of social exclusion. Poverty generates disasters and disasters exacerbate poverty, leading to feelings of helplessness and fatalism (Tahira & Kawasaki, 2017; Paz-Alberto et al., 2017).

People who live in flood plain areas are frequently destitute because they are unable to purchase land and are forced to inhabit unoccupied land along the river's edge. Many towns in lowland areas are also discovered to be built on landfills (Tahira & Kawasaki, 2017).

3.5 Adaptation strategies to floods

Flood risk refers to a community's vulnerability to flooding as well as the possibility of an event occurring, and the consequences if it does. The practice of flood risk management is a system based on establishing and implementing policies, strategies and activities to reduce flood risk (Van Herk et al., 2011). Flooding is a worldwide problem caused by a variety of factors, both natural and man-made, such as poorly planned infrastructure. For example, melting snow and ice, tsunamis, torrential rains, storm surges, river overflow, damaged dams, urban drainage basins and a lack of vegetation are all consequences of global warming, which might result in severe flooding now or in the future. As a result, minimising the negative effects of climate change such as floods is becoming more important for protecting livelihoods and assuring long-term planning. Different coping/adaptation strategies have been developed and proposed in literature to deal with the effects of flooding. According to Jamshed et al. (2020), some of these adaptation strategies include actions such as migration from flood-affected areas, flood forecasting, flood insurance for animals and crops, food stockpiling, emergency health services, and the construction of flood shelters. They however stated that these measures have not been strategically integrated into flood DRR measures in South Africa. Nature and human-based solutions (Fensholt & Simon, 2012; Costa et al., 2020), knowledge and problem-based solutions (Réjichi et al., 2015) are all-inclusive systems that serve as a broad range of climate change mitigation co-benefits (Nath & Behera, 2011; McCabe, 2013).

Creating elevated areas with blocks, stones and furniture; blocking water inlets with available materials; digging trenches around dwellings before and during floods; and boiling drinking water to reduce the danger of water-borne sickness are just a few of the adaptation strategies that can be implemented to mitigate the effects of floods (Reed et al., 2013). Ecosystem-based adaptation (EBA) such as growing of mangroves in the coastal areas is commonly proposed as a model for transformative change in adaptation methods, such as South Africa's climate change adaptation plan, which supports an equitable and long-term transition to a climate-resilient community and economy (Roberts et al., 2012; Ziervogel et al., 2017; Aronson et al., 2019). EBA employs a managed ecological mechanism to promote resilience and climate change adaption. Additional benefits of EBA include greenhouse gas reduction and biodiversity improvement, as well as improved water and air quality, implying that these additional benefits were the primary driver of adoption to achieve important policy goals (Odiyo et al., 2014; Volenzo & Odiyo, 2019).

EBA is also linked to many types of habitats or land use, such as forestry, agriculture, marine, urban, or freshwater habitats (Shin et al., 2020). Several studies have found that implementing EBA is problematic all over the world (Doswald et al., 2014; Nalau, 2018). The ecosystem-based adaptation (EBA) framework under the impact of climate change has been necessitated to inform adaptation situations for the disaster risk reduction and management (DRRM) sector of South Africa. The assessment of risks related to extreme events based on provisional modelling of drought, flood and sea-level rise impacts and a description of adaptation responses has necessitated the ecosystem-based adaptation (EBA) framework under the impact of climate change to inform adaptation situations for disaster risk reduction and management (DRRM (Brink et al., 2016; Sauka, 2019). Simonovi (2012) utilised a combination of various climate models to provide a first-hand indication of prospective danger connected to drought, flood and sea-level rise in the past decade. South Africa has produced a Strategic Framework that includes the EBA implementation plan which aims to encourage the management of adaptation action at all levels, from local to national, and to improve collaboration across sectors.

All levels of government, stakeholders, organisations and individuals with the ability to respond, mitigate and manage risk have recorded potential benefits of effective adaptation. The National Climate Change Response (NCCR) supports South Africa's response to these numerous challenges facilitated by climate change including flood hazards. The NCCR also emphasises the importance of assessing well-functioning ecosystems' biodiversity in enabling communities to adapt to climate change and support broader developmental goals (Pramova et al., 2012; Parnell, 2015; Mazeka et al., 2019). The three aspects of a flood risk assessment

are hazard assessment, vulnerability and adaptive capability evaluation including damage assessment. These are emphasised and organised into themes. Early warning systems have proven to be effective tools for disaster risk reduction. It allows for effective disaster planning and encourages coordination between relevant stakeholders in disaster management. According to Jubach and Tokar (2016), early warning information can enable disaster managers to take actions that can significantly reduce loss of life and property damage.

3.6 Impact of floods on informal settlers

Natural floods cannot be prevented, but their devastating effects on the community can be mitigated with effective early warning systems (Khalid & Shafiai, 2015). Most informal settlers are located in floodplains because this is the only undeveloped land accessible near cities which promises the opportunity of a better life for dwellers (Beard et al., 2016).

This exposes those living in informal settlements to the risk of floods, not only because of their physical placement in the flood plain, but because they lack the capacity and resources to effectively deal with effects of flooding (Abubakari & Twum, 2019). Flooding is one of the effects of climate change and precipitation which causes a lot of problems to local authorities especially in informal settlements. The problem of flood in informal settlements is made worse by rapid population growth and urbanisation as well as the lack of resources by local authorities to deal with high influx of people and recurring flood events (Sakijege et al., 2012).

The majority of informal settlements lack water drainage channels that are built to the required standards thus making them susceptible to flood events (Amoako, 2018). The lack of water drainage channels in most informal settlements is a major cause of flooding. The problem is exacerbated by poor solid waste management in informal settlements (Sletto et al., 2019). Flooding has a variety of consequences, including the loss of informal housing, inundation, soil erosion, poor water quality, injury, death, as well as disruptions to livelihoods and city economies, damage to houses, assets, public infrastructure, population displacement, and disease transmission (Williams et al., 2019). The increased exposure of poor people to natural dangers both emphasises and alters the interaction between communities and their biophysical environment.

Furthermore, during flood occurrences, both groundwater and surface water become highly polluted, particularly in informal settlements with poor waste management, hygiene and sanitation (K'oreje et al., 2020). Floating pit latrines and the improper disposal of liquid waste from toilets can quickly contaminate shallow wells (Corburn et al., 2020). Ground and surface water pollution is also caused by improper solid waste management and dumping. A flood vulnerability study in the Limpopo Province revealed that while flood disasters affects

everyone in the community and significantly influences vulnerability of individuals and households, poor individuals and households are more vulnerable from a series of socio-economic conditions making them prone to flood disasters (Khandlhela & May 2006). The study concluded that socioeconomic and political drivers have a significant role in determining the level of vulnerability of individuals, households and the community's vulnerability of the effects of flooding. It is evident that the effects of flooding on a community and factors influencing the vulnerability and coping capacity of the community to floods are complex and therefore require a holistic understanding of flooding especially on poor communities that often lack the capacity to deal with them (Imran et al., 2019; Williams et al., 2019; Xu et al., 2020)

Building urban resilience in the face of climate change requires an awareness of the uncertainties surrounding the evolution of co-dependent environmental, political and economic processes (Carrasco & Dangol, 2019). This is an area where further information is needed. This study aims to contribute to this knowledge by exploring the relationship between socioeconomic and governance processes at a local level where these challenges are most intense, using an informal settlement in South Africa as an example. In this study, extensive empirical research in the Eerste Fabriek community is used to build knowledge of environmental risk and urban vulnerability. In order to be useful in developing resilience at the city, regional, national or global scale, this understanding and information must be scaled up (Sakijege et al., 2012; Amoako & Inkoom, 2018).

Several national and international organizations have emphasized the importance of analyzing informal settlements' flood susceptibility, emphasizing the need for greater resilience to ensure sustainable development. Natural hazards are defined as atural processes or occurrences that may result in death, injury, or other health consequences, property damage, social and economic disruption, or environmental degradation (Klein et al., 2003; Paton, 2006). Vulnerability, which is characterised by susceptibility and ability to cope, determines the likelihood and magnitude of harmful impacts. Exposure, sensitivity and adaptive capacity are all factors that influence the likelihood and magnitude of these effects (Naylor et al., 2020; Mekonen & Berlie, 2021). In an urban setting, determining vulnerability to natural disasters considers how climate change may affect the exposure and sensitivity of informal settlement populations, with a focus on social, economic, political and environmental factors that climate change interacts with to create risk. The ability of a system to rebound or bounce back after a time of stress is considered an antonym of susceptibility.

3.7 Conclusion

There is enough evidence to show that climate change, rapid population growth, urbanisation, poor waste disposal methods and pressure from economic growth have increased flood threats, necessitating the incorporation of disaster resilient features into planning and development strategies through holistic flood risk reduction and preparedness approaches. Ensuring resilience to flood and flood capacity building in development planning thus serves to not only reduce flood risk, but also to tackle strategic vulnerability drivers and increase the preparedness levels in order to increase coping capacities and respond more effectively to disasters. In South Africa, disaster resilience has recently emerged as a development priority in response to disaster risks, particularly floods, given the country's significant vulnerability to flood events in strategic areas of the country.

This Chapter has revealed the value of knowledge gathering on flood events and literature mapping to understand the complexity of socioecological and environmental impacts of floods in relation to a natural hazard in informal settlements. It gives a better understanding of the relationship between urbanisation, environmental quality and poverty, as well as the socio-political mechanisms that enable successful climate change adaptation in South Africa especially the study area. The study shows an innovative model for informal settlements planners and environmental managers to identify key issues and their relationships in addressing the multifaceted and complex risks associated with flood-induced hazards.

CHAPTER 4

RESEARCH METHODOLOGY

4.1 Introduction

This chapter highlights the research methodology followed to achieve the objective of this study. Focus areas will include the philosophical view, research design, population and sampling techniques, limitations, delimitations, data collection and analysis, data validity and reliability and ethical considerations of the study (Kothari, 2017).

4.2 Philosophical view

Scientific research is based on four main philosophical views. These include pragmatism, positivism, realism and interpretivist (Kaushik & Walsh, 2019). By definition, the research philosophy is the process to develop research assumptions, the nature and knowledge about the research area. These allows the researcher to generate ideas into knowledge for the research focus area (Žukauskas et al., 2018).

- **Positivist research philosophy**

Involves the assumption that the world can be observed and understood objectively. It involves the process whereby the researcher remains objective, impartial and removes personal opinions and feelings from research work by remaining independent. Surveys and experiments are used to collect data (Park et al., 2020).

- **Interpretivist research philosophy**

Deploys a more subjective approach when interpreting the world. It stresses that the social world is not easy to understand and therefore, paid more attention. It is more about what the interests of the researcher are more than what the research presents. Knowledge is based on abstract description of meaning formed from human experiences. It involves case studies and interviews for data collection (Ryan, 2018).

- **Pragmatism research philosophy**

Follows the facts. The choice of the research philosophy is informed and based on the research problem. Practical results are more important. It does not belong to any philosophical system and reality (Kaushik & Walsh, 2019). It provides researchers with a freedom to choose research methods, techniques, experiences and procedure best suited for the research aims. It deploys interviews, case studies and surveys for data collection. Knowledge is derived from previous experiences (Mitchell & Education, 2018).

- **Realistic research philosophy**

Follows positivist and interpretivist principles. It is also based on the assumptions and perceptions of subjective nature of human. Of all research philosophies mentioned above, the pragmatism research philosophy is best suited for this study, in that it follows the facts and practical results which are more important for this philosophy (Mitchell & Education, 2018). It does not belong to any philosophical system and reality, therefore giving this study the opportunity to explore without limitation. It provides researchers with a freedom to choose research methods, techniques, experiences and procedure best suited for the research aims (Borges and Revez, 2019). Freedom of expression is what every researcher wants in order to add to the literature. It deploys interviews, case studies and surveys for data collection (Gaus, 2017), this is how this study is designed. Knowledge is derived from previous experiences with this philosophy (Mitchell & Education, 2018). Furthermore, a similar study was conducted in Ghana on *Cities and floods: Some pragmatic insights into the determinants of households' coping strategies to floods in informal Accra, Ghana* deployed a pragmatic research philosophy. Indeed, research encourages the use of similar studies when choosing research methodologies, as it is not always easy to reinvent the wheel.

4.3 Research design

The research design is a method for combining the many components of a study in a cohesive and logical manner in order to successfully handle the research problem and answer the research questions (Leedy & Ormrod, 2015). Data collection, analysis, and interpretation are all part of the research design. The research problem informs the study design (Creswell, 2014). Quantitative, qualitative, and mixed methodologies research methods are the three categories of research methods (Taguchi, 2018). A systematic analysis of phenomena using

measurable data and statistical, mathematical, or computer approaches is known as quantitative research (Rutberg & Bouikidis, 2018). In this case, quantitative data analysis entails descriptive or inferential data between variables (Creswell, 2014).

The qualitative research method is a humanistic approach to understanding a research question by observing people's attitude, beliefs, experiences, interactions and behaviour (Rutberg & Bouikidis, 2018). When analysing the data, it puts less focus on empirical methods and uses a thorough reading of secondary data to extract principles, patterns and models. It begins with the selection of the research area and progresses to the development of the theory (Belotto, 2018). The mixed research methodology brings together both qualitative and quantitative methods for a more holistic approach (Leedy & Ormrod, 2015).

However, in order to achieve objectives of this study, a quantitative research method was employed to analyse socio-economic effects of floods in Eerste Fabriek community. This study used a questionnaire as a data collection tool, this data collection tool has been proven to work well with a quantitative research method in social science research (Weston, et al., 2017; Shamsalinia et al., 2019). The survey questions included a rating scale which resulted in numerical data that required statistical techniques of analysis (Bowen et al., 2017).

4.4 Population and sampling techniques

The target population is the entire group of cases that meet the specified criteria (Singh, 2013). Social scientists have always been interested in the characteristics of a large number of people, things or cases (Watts, 2017). However, it is not possible for them to accurately test all these variables; as a result, sampling is used in situation analysis studies. Sampling is a process used in statistical analysis in which a predetermined number of observations are taken from a larger population (Mouton, 2012). Furthermore, Mouton (2012) reported that a population is a group of people or units a study will be based. The sample size is the number of analytical units that makes up a sample, and a sample size has to be representative of the units or people and be enough to give a meaningful statistical result (Leedy and Ormrod, 2015). Based on the above literature, this analysis will adopt simple random sampling technique. Simple random sampling is a technique that ensures that each unit in the population has an equal chance of being selected in the sample (Singh, 2013).

This technique is also suitable for this study because it give everyone a chance to be sampled. The technique is also relevant for this study area to avoid bias. The Mamelodi community is

known to be volatile and should any techniques other than the one that gives everyone a fair chance to participate in the study be adopted, it might create a problem within the community.

4.5 Sample size

Any empirical study whose purpose is to make inferences about a population from a sample must consider the sample size (Taherdoost, 2017). A random sample must be of sufficient size in order to generalize from it while avoiding sampling errors or biases (Blaikie, 2018). In addition, Blaikie (2018) add that, when the population is large, it is difficult to gather information from each unit in the population. As a result, collecting data from all of the units in a population is rarely feasible; instead, the researcher will gather data from a smaller group or subset that represents the entire population. The amount of precision, the level of confidence or risk, and the degree of variability in the parameters being measured were used to calculate the sample size (Bordens & Abbott, 2018).

The level of precision is critical for estimating the population value of a variable, how much these estimates are likely to vary between samples, and the level of confidence that may be placed in the results (Trafimow & Myüz, 2019). It is sometimes referred to as sampling error, this represent a range in which the true value of the population is estimated to be. The range is expressed in percentage form usually set as 5% margin of error or expressed in decimal form as 0,05 at 95% confidence level which is mostly used. The confidence or risk level emanates from the Central Limit Theorem's concepts (Taherdoost, 2017). The Central Limit Theorem is based on the premise that when a population is sampled repeatedly, the average value of the attribute obtained by those samples equals the true population value. In a normal distribution, the confidence or risk level indicates that approximately 95% of the sample results are within two standard deviations of the true population value (e.g., mean). To put it another way, if a 95% confidence level is chosen, 95 out of 100 samples will have the true population value within the precision range provided. There's always a danger that the sample you got isn't representative of the entire population. This risk is lowered for confidence levels of 99 percent and raised for confidence levels of 90 percent (or lower). As a result, the 95 percent confidence interval is frequently utilized.

The degree of variability in the attributes being measured refers to the distribution of attributes in the population. The more varied the population, the higher the sample size required to achieve a certain degree of precision. The population becomes less variable (homogeneous) as the sample size decreases. As a result, the proportion of 50% suggests a higher level of unpredictability than the percentages of 20% or 80%. The rationale for this is that 20% and

80% show that a substantial majority do not or do have the attribute of interest, respectively (Bordens & Abbott, 2018).

4.5 Determining sample size

There are four methods for calculating sample size: using a census for small populations, emulating a sample size from similar research, using public data, and using formulas. (Taherdoost, 2017). These strategies complemented the simple random sampling technique selected for this study (Blaikie, 2018). Published tables were used to determine the sample size for this study (See Table 4.1.). Even though the population of the study area is known, the study did calculate the sample size using formulas because the last formal census in South Africa was done in 2021, and formulas usually need accurate recent data. . Censuses are mostly used to count small groups of people (e.g., 200 or less). It reduces sampling error and provides information on the entire population. Furthermore, some costs, such as questionnaire design and constructing the sampling frame, are fixed, meaning that they were the same whether the sample size was 50 or 200. In order to obtain a desired level of precision, the entire population would have to be sampled in small groups (Anderson et al., 2017). This strategy is not viable for this study as the population of the study is way more than 200, therefore a census will not be practical.

Similar studies were explored to adopt the sample size from there, but literature scan did not show studies that have the same dynamics as the TMM, as it is the 3rd biggest municipality in the world, there are a lot of dynamics that need to be considered. Therefore, this study resorted to using Published tables (See Table 4.1) to determine the sample size for the study. Even though the known population of Mamelodi is not recent, published tables unlike formulas are not sensitive to that as they give estimates. Published tables were used to determine the sample size for the study. Literature encourages the use of published data in research (Blaikie, 2018). The following table, reflected in figure 4.1 below was used to determine the sample size for the study.

Table 1. Sample size for ±3%, ±5%, ±7% and ±10% Precision Levels Where Confidence Level is 95% and P=.5.

Size of Population	Sample Size (n) for Precision (e) of:			
	±3%	±5%	±7%	±10%
500	a	222	145	83
600	a	240	152	86
700	a	255	158	88
800	a	267	163	89
900	a	277	166	90
1,000	a	286	169	91
2,000	714	333	185	95
3,000	811	353	191	97
4,000	870	364	194	98
5,000	909	370	196	98
6,000	938	375	197	98
7,000	959	378	198	99
8,000	976	381	199	99
9,000	989	383	200	99
10,000	1,000	385	200	99
15,000	1,034	390	201	99
20,000	1,053	392	204	100
25,000	1,064	394	204	100
50,000	1,087	397	204	100
100,000	1,099	398	204	100
>100,000	1,111	400	204	100

a = Assumption of normal population is poor (Yamane, 1967). The entire population should be sampled.

Figure 4.1: Published table adopted to determine the sample size of this study: (*Source*: Adam, 2020).

4.6 Data collection

Data collection is the process to systematically collect and measure information on variables of interest, to enable one to answer stated research questions, test hypotheses and evaluate results (Leedy & Ormrod, 2015). When it comes to research, the data collection aspects do

not vary, they are common in the different fields ranging from physics, anthropology and social sciences (Groenland & Dana 2019). The important task is to ensure the integrity and accuracy of the information. Primary data was used in this study. A survey questionnaire was designed for collection of primary data to accommodate both structured and semi-structured questions. The questionnaire was carefully formulated during development to avoid ambiguity, sensitive and provocative questions (Leedy & Ormrod, 2015). A survey questionnaire is good for a study that involves humans (Kumar, 2019). A questionnaire is the most important tool for data collection especially for social science research, the current study falls within the social science ambit (Gascon et al., 2017).

The design of a questionnaire is critical to ensure that correct research questions are addressed and that accurate and appropriate data for statistical analysis is collected. The questionnaire provides an opportunity to structure the questions to be asked, which can be both closed and open-ended (Ebert et al., 2018). The questionnaire included three sections namely: administrative section, demographic (or classification) section and information sought which include impact questions section. The administrative section will recorded the identity of the respondent and the interviewer by name, date and address and where the interview was conducted (de Jong et al., 2018). It will also contained an interview/ questionnaire number. The demographic (or classification) section will described the respondent by a number of demographic characteristics including age, gender, residential location, marital status, language, qualifications et cetera (de Jong et al., 2018). These are background variables.

The information sought/ Impact questions section included all questions that were asked to extract data from respondents to address the study objectives and makes up the majority of the questionnaire (Leedy & Ormrod, 2015). This part was also broken into sub-sections to organize questions into categories that deal with distinct aspects of the research. To ensure reliability and validity, a small number of questionnaires were piloted using a small number of possible participants in the study area as a pre-test. The purpose of the questionnaire pre-testing is to discover and eliminate ambiguities, as well as make any necessary modifications. The questionnaire was administered to respondents through face-to-face meetings while adhering to all the Government regulations and protocols for COVID-19.

4.7 Data Analysis

The process of analysing data entails categorising it into themes, patterns, trends and relationships that can be controlled (Mouton, 2012). The motive behind data analysis is to extrapolate, examine and synthesis data by examining the relationship between concepts, constructs or variables and to see if there are any patterns or trends that can be detected or isolated to create themes in interpretation (Kumar, 2019). The design of the study, type of data collected and the characteristics of the research problem coupled with sub-problems and research question give rise to a specific data analysis procedures (Muthiah et al., 2020). The current study used a quantitative research design incorporating both descriptive and empirical statistical analysis. Data cleaning and coding was employed to ensure data quality for this study before analysing it (Tran et al., 2017). The practice of correcting or deleting incorrect, corrupted, improperly formatted, duplicate, or incomplete data from a dataset is known as data cleaning.

There are numerous ways for data to be duplicated or mislabeled when merging multiple data sources (Wang et al., 2019). The act of converting acquired data or observations into a collection of relevant, cohesive categories is known as data coding (Williams & Moser, 2019). Data coding was accomplished by classifying and labeling empirical objects under investigation in order to organise and analyse them in the context of the current study (Baarda & van Dijkum, 2019). Data for this study was analysed through Statistical Package for the Social Sciences (SPSS) and STATA software's (Baarda & van Dijkum, 2019).

4.8 Empirical analysis of the factors affecting the socio-economic status of households to floods

Factors that influence the socio-economic status of households towards floods were determined using the A Generalised Linear Model (GLM) with gamma family model. A GLM statistical model is used when there are several possible categories into which the dependent variable can fall. The advantage of using a GLM model is the computational ease with which the influential factors can be calculated and expressed in analytical form (Deressa et al., 2009). As predictions are based on a raw scale, GLM provides a flexible option to relax the normality assumption without the need for retransformation. GLM estimators, on the other hand, may be less precise, especially for data with heavier tails in log scale. Due to the nature of the data used in this study, estimators were precise (Deressa et al. 2009; Hassan & Nhemachena 2008).

A generalized linear model (GLM) with gamma family.

The GLM model with gamma family allows household characteristics to have different effects on the relative probabilities different choices. The GLM model for the effects of floods on the income level of community members include choosing a dependent variable (income of community members) Ai and the set of explanatory variables x, as (Greene 2003):

$$\Pr(A_i = j) = \frac{\exp^{B_j x_j}}{1 + \sum_{k=1}^{j} \exp^{B_k x_i}} \quad (1)$$

where βj represents the set of regression coefficients associated with the outcome of the independent variable X. Equation (1) can be normalised to remove indeterminacy in the model by assuming that βj = 0, and the probabilities can be estimated as:

$$\Pr(A_i = j / x_i) = \frac{\exp^{\beta_j x_i}}{1 + \sum_{k=1}^{j} \exp^{\beta_k x_i}}, j = 0,1...j, \beta_0 = 0 \quad (2)$$

Estimating equation (2) yields J log-odds ratio.

$$\ln\left(\frac{P_{ij}}{P_{ik}}\right) = x_j^i \left(\beta_j - \beta_k\right) = x_j^i \beta_k, \text{ if } K = 0 \quad (3)$$

Factors affecting the income of community members are therefore the log-odds in relation to the flood-related mitigation strategies that sought to income the livelihood of the community members. Greene (2003) explains that the coefficients of the GLM model are difficult to interpret, and often associating βj with the j_{th} outcome is tempting and misleading.

The empirical model was specified as:

$$Iiy = \beta_0 + \beta_1 age + \beta_2 income + \beta_3 Educ + \beta_4 marital_{status} + \beta_5 gend + \beta_6 employment + \beta_7 \text{exp}erienceflo + \beta_8 economic_{value} + \beta_9 access\_health + \beta_{10} compl1 \quad (4)$$

4.9 Data validity and reliability

Data validity is the extent to which the data acquired answers the research questions (Leedy & Ormrod, 2015). It involves establishing the logical link between the questions and objectives of the study. According to Kumar (2019), validation of data for tangible concepts such as demographics, age and gender, which follows quantitative data methods, are easier to validate whereas the less tangible concepts such as attitude, perception, and feelings, which mainly

follows the qualitative data collection method and are more flexible and spontaneous, therefore tend to be difficult to establish. Reliability is the degree of accuracy, consistency and stability of data produced through a research instrument (Leedy & Ormrod, 2015). It involves the process of testing the information several times using the same instrument under the same conditions and getting the same results. Data is deemed unreliable when the same process is repeated and provide different results. Thus, data validation and reliability is the process to assess the trustworthiness, reliability and consistency in terms of the credibility, transferability, dependability and confirmability of the instrumentation and results of the study (Kumar, 2019). Statistical tools such as principal component analysis (PCA), Multicollinearity and heteroscedasticity and VIF tests were performed to measure the validity and reliability of the data.

4.10 Limitations and delimitations of the study

4.10.1 Limitations

Limitations include challenges that may be encountered in caring out the study (Kumar, 2019). For the current study, envisaged limitations may include:

- **Unwillingness to participate in study.**

Eerste Fabriek, like any other informal settlement especially in capital cities, is volatile and plagued by service delivery protests. Therefore, when doing a study about socio-economic impacts of a hazard that is believed to be caused by service delivery such as flash floods, reported to be caused by blocked sewer pipes which is the responsibility of a municipality as well as land and housing backlogs, this might create problems in the community. The researcher had to inform participants that this study is for educational purposes and has nothing to do with the TMM.

- **COVID-19**

The COVID -19 virus has brought a new normal to people's daily lives. Townships and informal settlements are overpopulated, as a result the risk of spreading COVID-19 is higher. Therefore, when collecting data, there was a risk of the researcher being exposed to COVID-19. In addition, there was a risk that respondents might not allow the researcher to enter their houses as a precautionary measure to avoid contracting COVID-19. To avoid contracting

virus, the researcher took precautions and used non-pharmaceutical interventions that include social distancing by maintaining a 1.5-meter distance from respondents, wore a mask at all times and sanitised frequently. In the process of data collection, the researcher ensured that interviews were conducted outside the house due to nature of the shacks, which are typically small without proper ventilation in the form of windows. The researcher brought along a set of surgical masks and sanitizers for respondents during interviews. The researcher also provided respondents with one extra mask for use later. To avoid using one pen to respond to the questionnaire, the researcher read out questions for respondents and completed the questionnaire on behalf of respondents.

- **Crime**

The Eerste Fabriek informal settlement is overpopulated, with many people without jobs and others doing drugs such as nyaope and plagued by alcohol abuse. When collecting data, there was a possibility of encountering nyaope boys and others who could harm or rob the researcher and research assistants of their belongings such as smartphones, cameras, laptops, recorders and even clothes. To avoid such incidents, the researcher used pen and paper and carried old phones with recording and picture features. The researcher ensured that only old clothes we worn to avoid attracting attention. Furthermore, the researcher approached community leaders to assist in the process of introducing the researchers to the community members to avoid suspicions about the researcher.

- **Vandalism**

Informal settlements are by nature volatile, fights may ensue at any time, the vehicle or transport of the researcher could be vandalised in the process of data collection. Given that the researcher had to park the car at one point and walk by foot to conduct interviews and distribute questionnaires, there was a possibility of drug addicts vandalising the vehicle of the researcher while looking for something valuable to steal. To prevent this, the researcher used a taxi to get to Eerste Fabriek informal settlement.

4.10.2 Delimitations

Delimitations are study specific factors and characteristics that may limit and affect the scope and boundaries of the study (Leedy and Ormrod, 2015). They include factors such as geographic location, sample size and setting in which the study is taking place. The delimitations for this study included the following:

- **Scope limited to Eerste Fabriek informal settlement**

According to the TMM, many parts of Mamelodi Township and its informal settlements are prone to floods, however due to time and financial constraints, the study focused Eerste Fabriek informal settlement. The December 2019 flooding mostly affected the Eerste Fabriek informal settlement with about 700 shacks washed away and therefore, this study will share some light on some of the challenges faced by this community.

- **Scope limited to social and economic effects of floods**

Flooding can cause devastation especially in an informal settlement where there is no service delivery such as roads, housing, sanitation, water, electricity, storm water drainage and many others. There are many issues to look in to, however; this study was limited to assessing social and economic effects of floods in Eerste Fabriek due to limited time.

4.11 Ethical considerations

In legal terms, it is a pre-requisite to obtain informed consent before conducting any research work (Kumar, 2019). Permission to carry out this study was sought from the University of Free State in order to obtain ethical clearance to conduct the research. Consent was also sought from respondents and the ward councilor in the area using a written consent form that respondents were asked to sign as reported by Leedy and Ormrod (2015). Care was exercised when seeking sensitive information so as not to embarrass or harm people participating in the study. For an example, in some instances, there was a possibility of the questions bringing back traumatic memories from the floods. Complete confidentiality was maintained and assured (Kumar, 2019). There was no mentioning of names of participants in the final report. The researcher did not coerce or force respondents to answer questions or complete the questionnaire if they did not feel like it. Potential respondents were advised to give information voluntarily. Unbiased and incorrect reporting of the findings was avoided. Humans were at the center of this study and plagiarism was avoided by referencing all the literature used for this study in a reference list.

4.12 Conclusion

This chapter presented and discussed the methodological approach necessary for achieving the objectives of this study. The discussion focused on the philosophical view, research design, population and sampling techniques, empirical analysis, limitations, delimitations, data collection and analysis, data validity and reliability and ethical considerations. The next chapter will present the results and discussions from the study.

CHAPTER 5

PRESENTATION OF RESULTS AND DISCUSSION

5.1 Introduction

This chapter presents the analysis and discussion of the study. The aim of this study was to assess socio-economic effects of floods in the informal settlement of Eerste Fabriek in the Township of Mamelodi. The chapter is divided into four sections. The first section discusses socio-economic characteristics of the community members and their perceptions of floods. The second section presents a discussion on the social effects of flooding in the information settlement. The third section presents economic effects of floods in the informal settlement while the fourth section presents a discussion on adaptation and mitigation strategies used by community members to reduce the effects of flooding on the environment. The last summarises the chapter and provide concluding remarks.

5.2 Socio-economic characteristics of respondents

Socio-economic information of respondents, such as gender, educational level, age, household size and farming experience, will be discussed in this section. Socio-economic factors that were likely to affect effects of floods on informal settlements or income-generating capacity of respondents include gender, age, marital status, family size, availability of income-generating activity (occupation) and wealth status (Week & Wizor, 2020). The information in Figure 5.1 reveals the information on the gender of respondents. Findings show that 48% of males and 52% females participated in the study. Gender disparities were observed in literature in the context of flooding and its impacts on informal settlements (McDowell et al., 2020; Spaccatini et al., 2021) and as a result may represent a specific target audience for risk reduction strategies. For example, multiple studies have revealed that female respondents perceive flood risk more acutely than their male counterparts. Gender differences in flood risk perception were discovered in a research of flood risk perception in the Republic of Ireland (O'Neill et al., 2016). Females were more inclined to worry about natural disasters than males. Although the study found that increased risk perception did not translate into higher levels of protective behavior (Pagneux et al., 2021; O'Neill et al., 2016), possibly indicating that despite increased perception among women, traditional 'gender roles' (men as 'protectors') still prevail, and risk reduction measures are more frequently influenced by male perceptions.

Similarly, female respondents' likelihood of acquiring flood insurance was observed to be comparable (with male respondents) or lower (Shapira et al., 2018; Khan et al., 2020). In contrast, studies have found no link between gender and the intention to take adaptive measures to reduce flood damage (Zaalberg et al., 2009; Zaalberg & Midden, 2010), underscoring the issue's intrinsic complexity. Notably, the research described above concentrated on pre-flood views and behaviors; few studies have looked at gender differences in post-flood risk perceptions and behaviors, particularly as they pertain to human health.

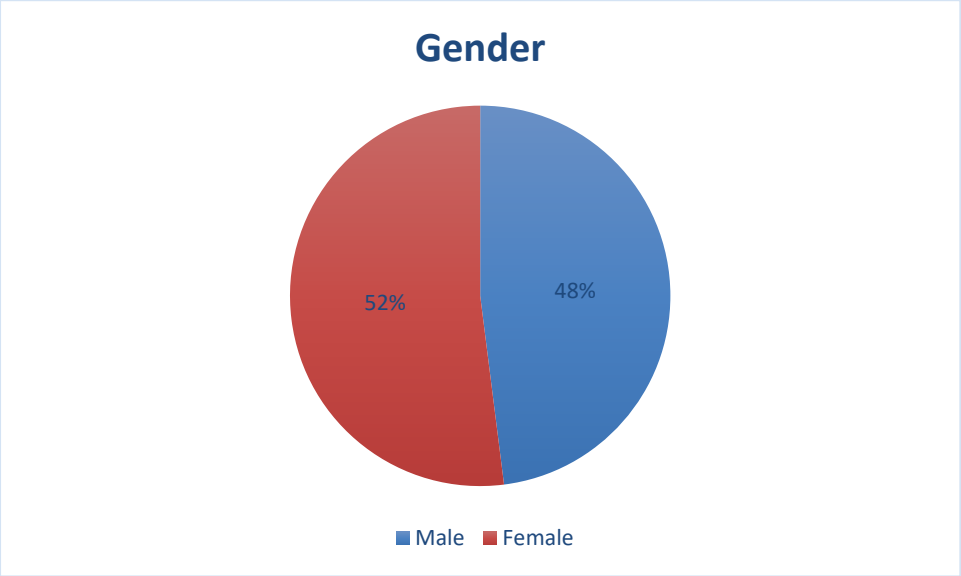

Figure 5.1 Gender

Figure 5.2 presents marital information of respondents. It shows that married people have the highest percentage with 46% of total respondents, followed by singles with 44%. Divorced and widowed people make up roughly 6% and 4%respectively.

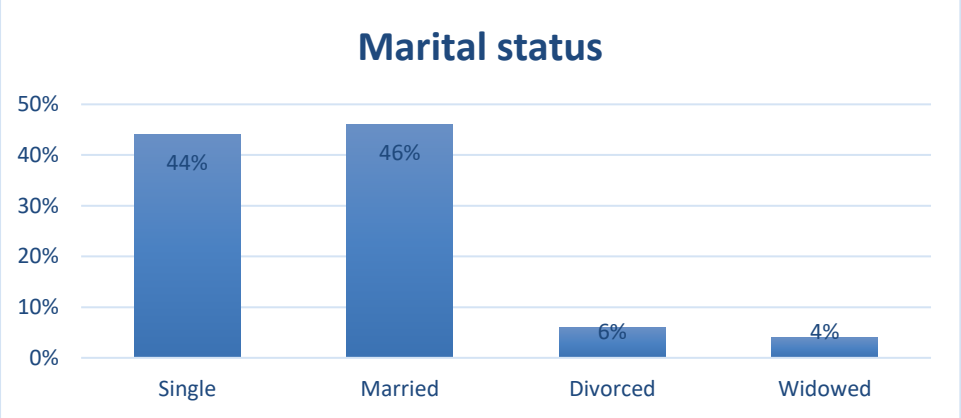

Figure 5.2 Marital status of respondents

It is suggested that a higher percentage of married people is more likely to give money to help flood victims, long-lasting rains make them think about preparedness for floods, they know what floods are and they are familiar with viruses and infections that accompany the period during and after floods (Cvetković, 2016; Ambagahawita et al., 2021), they know where elders, the disabled and infants live, they know safety procedures for responding during floods and they would evacuate to a friend's place. On the other hand, studies show that a lower percentage of divorced citizens take preventive measures to reduce tangible consequences of floods (Cvetković & Grbić, 2021); they are not yet prepared, they know what a flood is, they would evacuate to the upper floors of the house, they know what to do after an official warning that a flood is approaching, they learned about floods at faculty, through informal education, and the media.

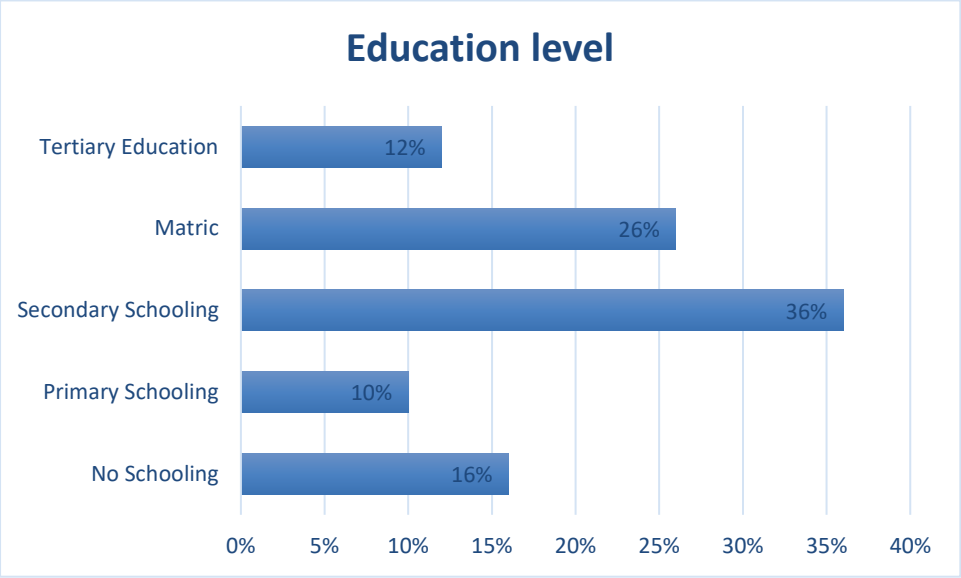

Figure 5.3 The educational level of respondents

The educational level of respondents was categorised into no schooling, primary, secondary, matric and tertiary education as presented in Figure 5.3 above. Primary education indicates that a respondent has seven years of formal schooling, secondary school is an additional five years or more, college certificate or diploma is 12 years, and a university degree is 15 years in total. The education level of respondents is presented in Figure 5.3 above. Findings show that about 36% attended secondary school, 26% have matric, 16% no schooling,10% primary education and 12% tertiary education. Findings found an overall reduction in educational attainment, lower academic performance and higher rates of absenteeism among respondents who have experienced climate shocks such as floods (Hoffmann and Blecha, 2020; How et al., 2020).

Education enhances household heads' decisions to adopt and use technologies to reduce flood impact efficiently, which will enhance their productivity (Otieno, 2011). As expected, information in Figure 5.4 below shows that employment increases with the population of the study area and consistent with economic theory, employment is larger in those areas with larger earnings per worker (Sarmiento, 2007). The larger concentration of employment occurs in areas where the main employment is a full-time job, in this case it is 36% of respondents. Studies show that services and total employment is always larger in areas with a larger concentration of human capital (more population with college degrees) (Sarmiento, 2007; Chatterjee et al., 2018; Zemtsov et al., 2019). Interestingly, employment per capita (after filtering out population) is larger in urbanised counties.

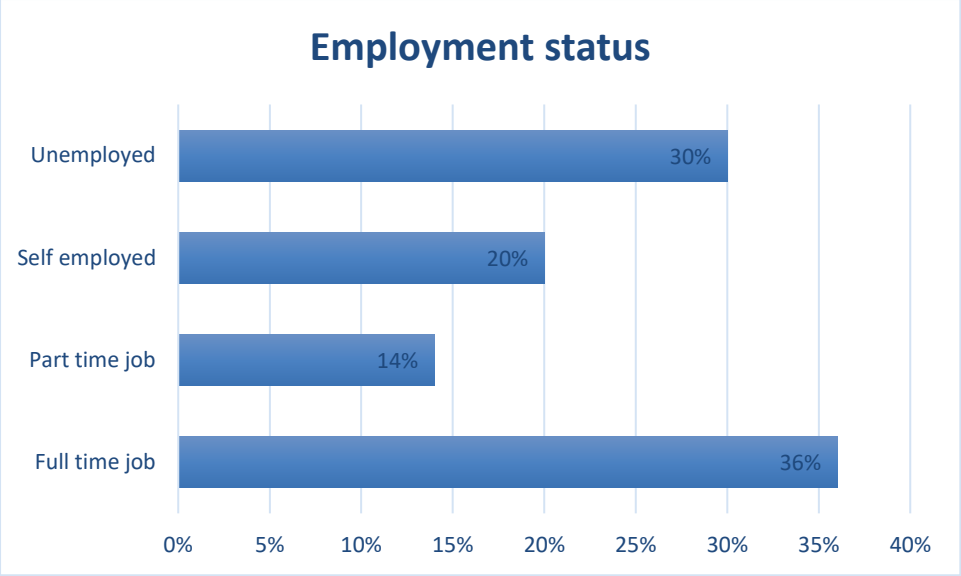

Figure 5.4 Employment information

The income-generating activities of the respondents are presented in Figure 5.5 bellow. Income-generating activities are those economic activities that allow individuals and groups to employ input labour, land and capital for positive returns (Agbontale, 2009; Ajayi and Solomon, 2017). In this study, communities, as well as individual perceptions were assessed. Perceptions of individual respondents were analysed quantitatively looking at income through salary, allowances, wages and social grants. Findings indicate that 40% of the income comes from salaries while allowances, wages and social grants were 6%, 18% and 36% respectively. Socio-demographic profile of respondents was also assessed as this could influence their willingness to engage in income-generating activities. Age, gender, marital status and educational level among other things were all measured.

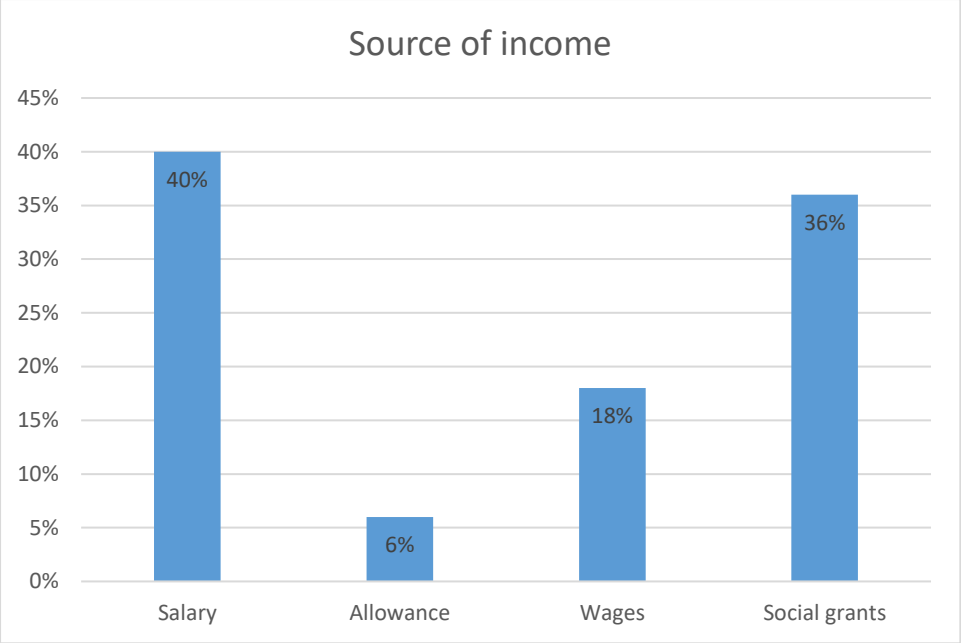

Figure 5.5 Source of income

Figure 5.6 below presents information on house structures in the study area. Based on the findings, 76% of house structures are corrugated iron structures and 24% are brick houses. Studies show that the rising water on the exterior of the building acts inward against the building's walls as the floodwaters rise (Immaculata and Emmanuel, 2018; Brisibe et al., 2021). A quick drawdown of outer floodwaters can also result in outward stresses on a building's walls as the interior floodwater attempts to escape which makes residents vulnerable to flood risk if buildings cannot withstand flood impact (Brisibe et al., 2021; Chung & Adeyeye, 2018). It is important to have policy interlinks with insurability by excluding from the flood risk scheme, residential property built-in high flood risk areas. There is evidence that people still continue to build in this area and other rural areas in spite of the risk, to a greater extent area that are vulnerable to flood risk in South Africa seem to experience a high demand for housing (Jordhus-Lier et al., 2019).

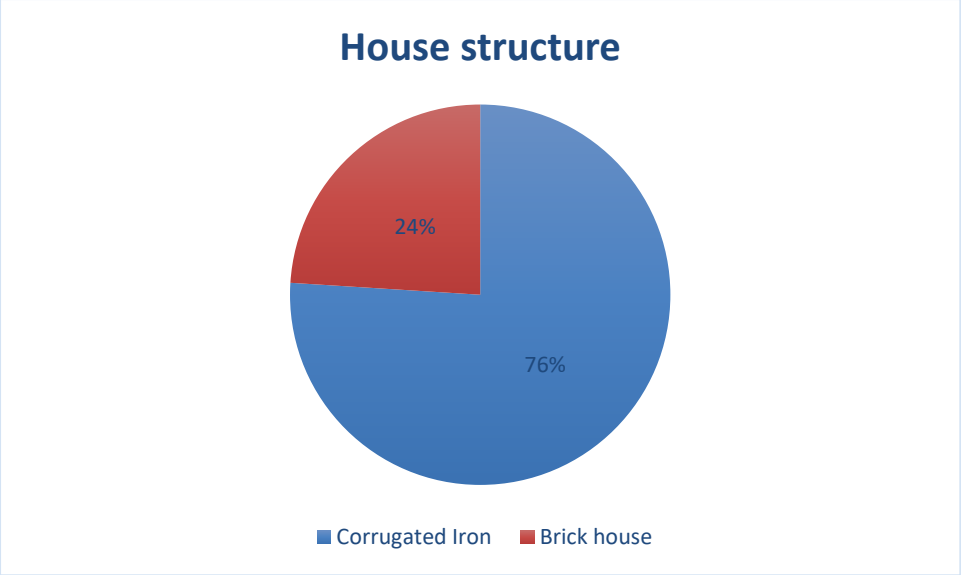

Figure 5.6 House structures

Information on age, education, household size and monthly income of respondents is presented in table 5.1 below. Results show that the minimum and maximum age of the participants is 22 and 60 respectively. While years of education vary between 0 and 15 with household size between 1 and 6. The analysis further shows that minimum household income per month is about R350 and maximum R10000. This is a demonstration that this phenomenon is a social problem, and that age and education level of residents have a bearing (Morote & Hernández, 2020). If floods become a reality, there will be an urgent need for public awareness which will require an educated community, as education is a key element in helping to reduce risk and adapting to these phenomena (Morote & Hernández, 2020; Morote & Hernández, 2021). Different studies have expressed the importance of education in reducing risk and adapting to climate change (Lutz, 2011; Morote & Hernández, 2020; Morote & Hernández, 2021).

Table 5.1 Descriptive statistics for age, education, household size and monthly income

Variables	Minimum	Maximum	Mean	Std. Deviation
Age	22	60	43.82	8.67
Years of education	0	15	8.3	4.511
Household size	1	6	3	2
Monthly Household Income	R350	R10000	R3038.78	1928.278
Years Lived in Eerste Fabriek	2	20	9.42	4.041

5.3 Flood risk perception and awareness

Flood risk perceptions play a critical role in how individuals choose to mitigate the risk. For example, if an individual estimates the risk from a hazard to be low, they are less likely to act to reduce their exposure to this hazard (Martin, 2009). 98% of respondents confirmed that they have experienced flood events and only 2% indicated that they have not, refer Figure 5.7 below;

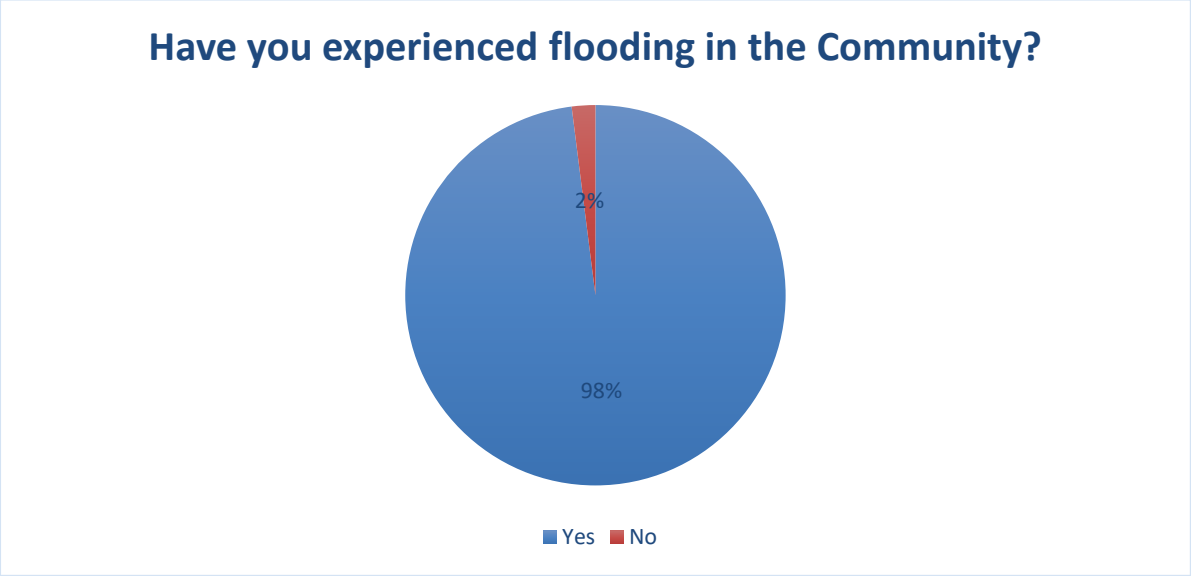

Figure 5.7 Flood perception and awareness

The information on flood events in the study area is presented in Table 5.2 below. The analysis reveals that 70% of respondents confirmed that the community always experienced flooding whenever it rained in the area while 20% stated that floods occur in the community once in a while. 20% of respondents stated that the community experienced floods once a year as contrary to other people's opinions.

Table 5.2 Flood occurrence in the study area

How often do you experience flooding in the Community?	Percent	Frequency
Every time it rains	70	35
Only once a year	10	5
Several times a year	20	10
Total	100	50

Figure 5.8 below presents people's perspectives on what is likely to be the causes of floods in the community.

74% of respondents feel strongly that flooding is a major problem in the community while 22 agree and 4% had no view on the issue. Studies have shown that flood occurs when the water level in a certain location rises to the point where it can no longer absorb the water (Liu et al., 2019; Shao et al., 2019). Too much rain, clogged rivers and streams, weakening dam walls and storm surges can all contribute to flooding (waves driven ashore by strong winds) (Ramachandra et al., 2017).

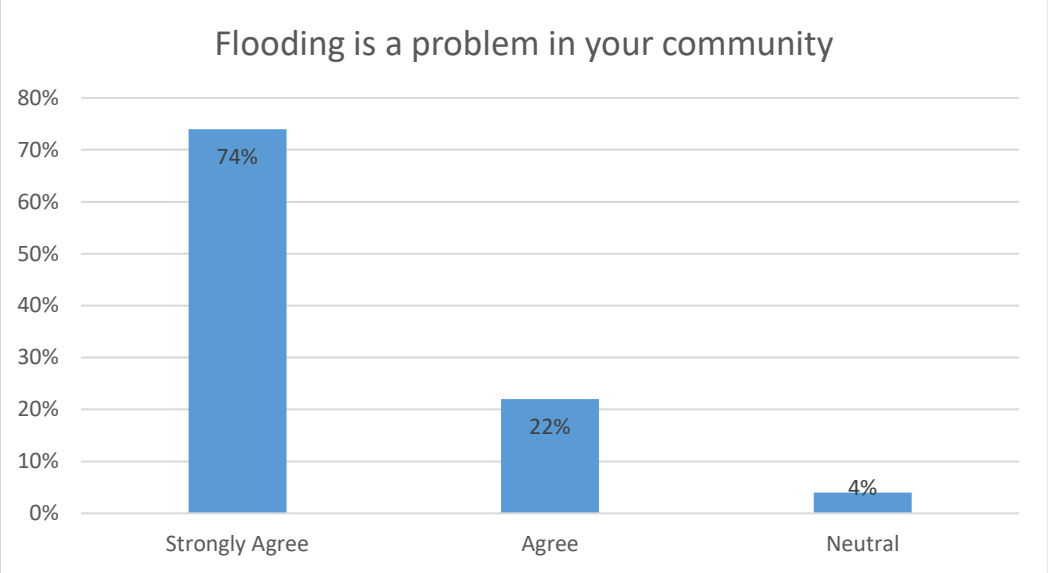

Figure 5.8 Flooding is a problem in your community

The extent of flooding problems in the study area is presented in Figure 5.9 below. 84% of respondents indicate that flooding is major problem in the community while 16% do not view it as major problem. This is an indication that there are other major factors in the community such as poor infrastructure, road networks, poor education access to basic facilities (Dong et al., 2020). Floods have far-reaching socioeconomic ramifications for both communities and individuals especially in South Africa (Dube et al., 2021; Vambe et al., 2021). As most people are aware, flooding has immediate consequences such as loss of life, property damage, crop destruction, livestock loss, and deterioration of health due to waterborne diseases (Bubeck et al., 2017; Nhundu et al., 2021).

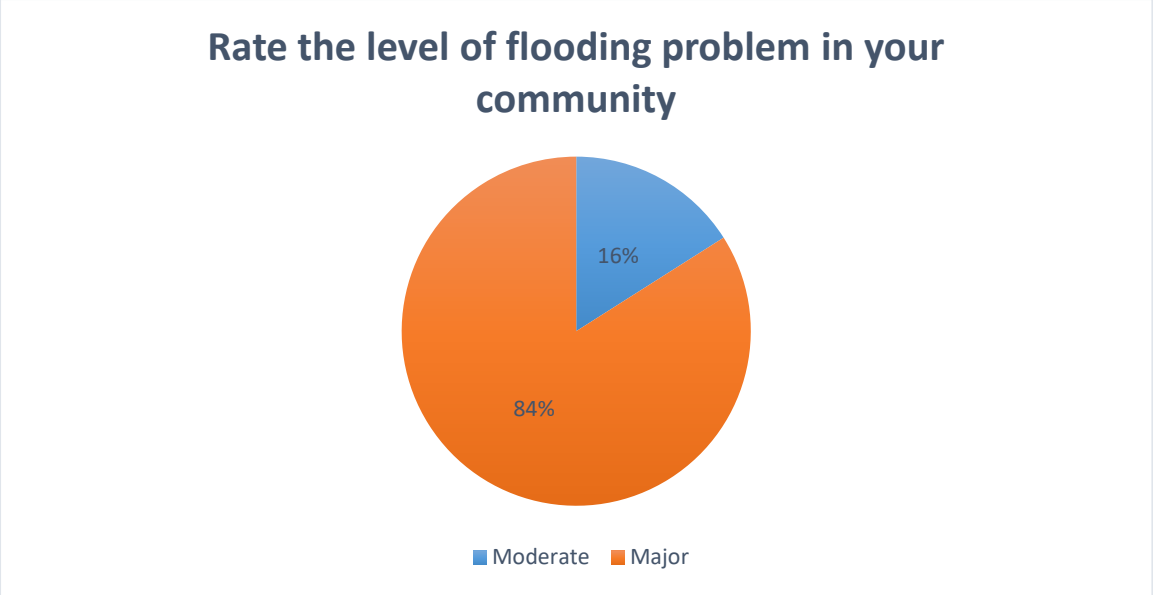

Figure 5.9 Rate the level of flooding problem in your community

According to research, exposure to flood risk can cause home values to drop by roughly 4%, although the impact varies depending on where you live (Rebecca, 2020). Houses that are at risk in the study area are presented in Figure 5.10 below. 72% of respondents strongly agreed that houses are at a risk of flooding and 22% somewhat agree with 2% neutral on this issue. This finding indicates that the majority of the houses in the community are at risk, and that a more proactive approach needs to be adopted. Hydrabarrier for example, is a viable alternative to sandbags when it comes to spill containment and other water containment and prevention applications. These water barriers are long-lasting, available in a range of sizes, reusable and may be filled and emptied as needed. This simplifies the work of storing them (Devlin et al., 2012; Myrick et al., 2020).

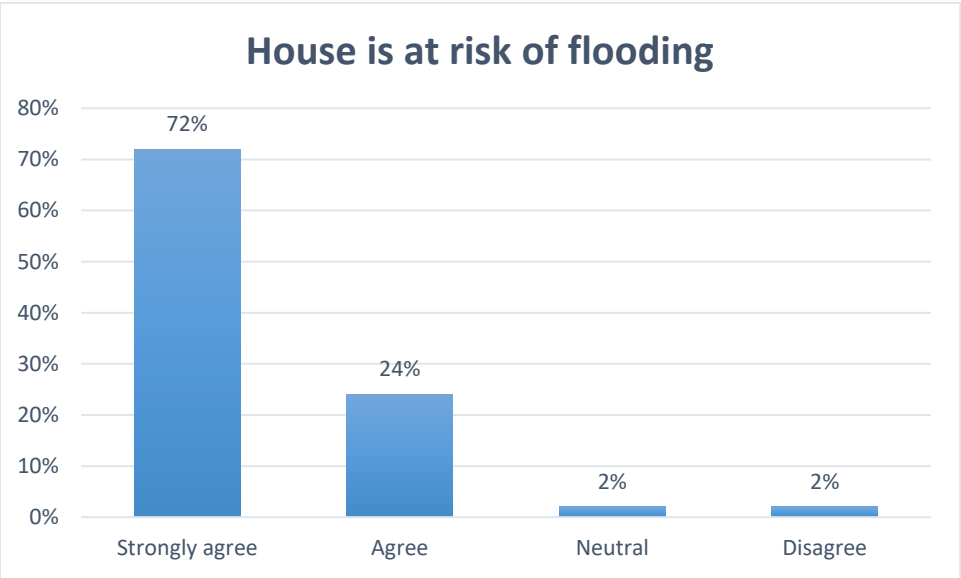

Figure 5.10 Flood risk

Causes of flooding in informal settlements is presented in Table 5.3 below. Respondents believe that flooding is caused by heavy rains (98%), unavailability of drainage systems and rivers (78%), Flood plain area and environmental degradation (62%), Wetland (52%), Step slope (42%) and Broken dams (24%). It is evident that heavy rains are viewed as the biggest cause of flooding by far while broken dams are viewed as less likely to cause flooding. Research shows that every year significant precipitation events produce catastrophic flooding around the world, resulting in tragic deaths and costly infrastructure and property damage (Kron et al., 2019; Hochrainer-Stigler et al., 2019). Given that these catastrophic occurrences can be caused by a variety of factors, a thorough understanding of atmospheric processes that contribute to their creation is essential.

Table 5.3 Causes of Floods in the informal settlement

Causes of flood	Yes		No	
	%	Freq	%	Freq
Heavy rains	98	49	2	1
Unavailability of drainage systems	78	39	22	11
Broken dams	24	12	76	38
Step slope	42	21	58	29
Wetland	52	26	48	24
Rivers	78	39	22	11
Floodplain area	62	31	38	19
Environmental degradation	62	31	38	19

Respondents were also asked about their perceptions on the frequency of floods. Their responses are presented in table 5.4 below. 62% think floods are becoming more frequent while 4% think they are less frequent, 20% do not see a difference and 14% have no idea whether floods are less frequent or not. It is evident that the majority of respondents think floods are becoming more frequent in the community.

Table 5.4 Flood frequency

Do you think floods are becoming more less frequent	Percent	Frequency
More frequent	62	31
Less frequent	4	2
No difference	20	10
Do not know	14	7
Total	100	50

5.3 Social effects of flooding in the informal settlement

Social effects of flooding in the informal settlement are presented in Table 5.5 below. Results reveal that respondents rated the impact of flooding on their lives, housing, schools and hospitals very high (80%, 76%, 72 % and 70% respectively). The impact on health, income and food security were rated moderately at (62%, 56% and 52% respectively). Lower ratings were observed on impact on suicides and conflicts (6% and 24%). From the findings it is noted that the biggest impact is on lives and livelihoods. Previous studies have shown that flooding results in the loss of life as well as labor that could have been employed to increase agricultural productivity. Physical floods can harm farm crops and cattle, reducing community food availability (Adeloye, 2010; Boori, 2017; Ajaero, 2017; Week and Wizor, 2020). Studies have also shown that flooding can make certain people in the community poor by damaging property, houses, infrastructure, livelihoods and productive capital (Oriji, 2015; Mtapuri et al., 2018).

Table 5.5 Flood impacts

Rate impact of flooding	Very high		High		Neutral		Less		Very less	
	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq
Flood threaten house structure	76	38	18	9	6	3	-	-	-	-
Flood threaten household income	56	28	26	13	10	5	4	2	4	2
Flood threaten our lives	80	40	12	6	8	4	-	-	-	-
Flood cause food scarcity	52	26	22	11	20	10	4	2	2	1
Flood cause homelessness	70	35	14	7	14	7	2	1	-	-
Flood cause diseases	46	23	10	5	24	12	12	6	8	4
Flood has affected my health	62	31	24	12	14	7	-	-	-	-
Flood cause unemployment	48	24	28	14	12	6	8	4	4	2
Flood cause migration	54	27	18	9	24	12	-	-	4	2
Flood has affected schools and hospitals	72	36	16	8	8	4	-	-	4	2
Flood cause conflict of place	24	12	26	13	40	20	4	2	6	3
Flood has increase suicide	6	3	6	3	36	18	10	5	42	21

Damages caused by floods in the community are presented in Table 5.6 below. Flood damage is the damage to a home or individual as a direct result of flooding (Molinari and Scorzini, 2017; Ogie et al., 2018). To put it another way, it must rain heavily enough to cause flooding or a flash flood (Ogie et al., 2018; Islam et al., 2019). This can happen as a result of a natural

disaster or a cyclone that produces a lot of rain in a short amount of time. 96% of respondents confirmed that the biggest damage by far is on houses (96%), followed by household furniture (86%), electrical appliances and important documents (80%). Respondents indicated that livestock and crops are the least affected by floods (26%).

Table 5.6 Damages caused by flood

Damages caused by flood	Yes		No	
	%	Freq	%	Freq
Flood cause damage to houses	96	48	4	2
Flood damage fresh water supply	32	16	68	34
Flood damage house garden	56	28	44	22
Flood damage livestock and crops	26	13	74	34
Flood damage household furniture	86	43	14	7
Flood damage important documents	80	40	20	10
Flood damage household vehicle	30	15	70	35
Flood damage electrical appliances	80	40	20	10

The social impacts of flood events in the community are presented in Table 5.7 below. Anxiety, fear, wrath, frustration, sadness, and loss are some of the emotions that flood victims may experience. It's typical for people who have been through traumatic events like flooding to have trouble sleeping, lose their appetite, have gloomy or angry moods, and have heightened sensations of fear (Chomsri & Sherer, 2013; Działek et al., 2013). Respondents confirmed that educational (94%), religious (96%) and recreational facilities (98%) were not affected by floods.

In contrast, studies indicate that floods can affect educational, recreational and religious facilities, for instance, flooding history shows that educational establishments have been disproportionately hard-hit by flooding events (Mudavanhu, 2014; Shah et al., 2018; Shah et al., 2021)

Table 5.7 Social impacts of Floods

Social effect of flooding	Yes		No	
	%	Freq	%	Freq
Access to health facilities during flood	6	3	94	47
Access to educational facilities	6	3	94	47
Access to religious facilities	4	2	96	48
Access to recreational facilities	1	2	98	49

5.4 Economic impact of flooding in the informal settlements

Economic impacts of the flood are presented in Table 5.8 below. Communities on floodplains may be economically susceptible due to the loss of livelihoods, reduced purchasing power,

and decreased land value. Floods can also cause long-term trauma to victims and their families. The loss of a loved one has profound consequences, particularly for children (Behera et al., 2020; Henderson et al., 2020). About 86% confirmed that they experienced economic loss from floods while 80% damages were repaired as stated by the respondents. More so, some of the repairs were done using the money for school fees.

Table 5.8 Economic impacts of Floods

Economic effect of flooding	Yes		No	
	%	Freq	%	Freq
Have you experienced economic loss from flood	86	43	7	14
Repaired damages caused by flood	80	40	20	10
Used money for food to repair damages	82	41	18	9
Used money for school fees to repair damages	52	26	48	24
Lost money fixing electrical appliances due flooding	68	34	32	16
Lost money fixing damages to household furniture	74	37	26	13

Respondents were also asked to indicate the approximate amount spent in managing the effects of flooding in the community. Results show that respondents spend a minimum of R1500 and a maximum of R7000. The implication of this result mean that while community members are struggling to survive on very low incomes, they still have to divert funds from their households to deal with the effects of floods. This can significantly disrupt lifestyles and increase the levels of poverty. See Table 5.9 below.

Table 5.9 Descriptive statistics for the estimated economic value spent on floods

Descriptive Statistics				
	Minimum	Maximum	Mean	Std. Deviation
Estimated economic value	R1500	R7000	R2500	100.56

5.5 Adaptation and coping mechanisms

Adaptation and coping mechanisms towards flood events are presented in Table 5.10 below. Flood protections are being strengthened, peak flows are being reduced by water retention, vulnerability is being reduced, and people are being relocated to safer regions (Verburg et al., 2012; Klijn et al., 2012). Early warning systems, dry and wet floodproofing and floating buildings are all examples of ways to reduce susceptibility. 94% of respondents confirmed that no social grants were received in adapting to flood events in the community. 78% stated that there is no financial contingency plan towards flood adaptation in the study area. Installation of rock beams, rock rip-raps, sandbags, maintenance of normal slopes with vegetation or application of soil cement on steeper slopes, and construction or expansion of drainage are

some of the common flood control strategies (Farid et al., 2017; Zhang et al., 2018). Dykes, dams, retention basins and detention are some of the other options.

Table 5.10 Adaptation and coping mechanisms

Adaptation and coping mechanism	Yes		No	
	%	Freq	%	Freq
Receive social grant	6	3	94	47
Financial contingency plan	24	12	62	31
Community flood action plan	22	11	78	39
Community flood management committee	8	4	92	46
Community flood awareness and preparedness	42	21	58	29
Community flooding evacuation plan	48	24	52	26
Municipality provide support during flood	68	34	32	16

In environmental studies, rather than attempting to prevent floods entirely, flood mitigation involves the management and control of floodwater movement, such as channeling flood run-off through the use of floodwalls and flood gates (Alves et al., 2020). Flood mitigation strategies information in the study area are presented in Table 5.11 below. Various strategies were employed in the community as stated by the respondents, for instance, 66% confirmed that in an effort to mitigate flood impact, building houses with raised foundations was employed. From the results, it is noted that strategies are not in place to combat flood impacts, this means that, more proactive efforts are needed in the area.

Table 5.11 Flood mitigation strategies

Flood mitigation strategies	Yes		No	
	%	Freq	%	Freq
Municipality provide early warning messages	30	15	70	35
Municipality response subsystems	12	6	88	44
Municipality provide storm water drainage	6	3	94	47
Municipality provide sandbags	58	29	42	21
Municipality provide tree logs	50	25	50	25
Build houses with raised foundations	66	33	34	17
Construct protective walls	30	15	70	35

5.6 Empirical results

This section provides a discussion of the empirical results of this study. Prior to conducting the regression analysis, several statistical tests were performed to test the validity of the data. These tests include the principal component analysis (PCA), Multicollinearity and heteroscedasticity tests and Variance inflation factor (VIF). Results of the tests performed are discussed below.

5.6.1 Variance inflation factor

According to Chennamaneni et al. (2016), the variance inflation factor (VIF) in statistics is the ratio of the variance of estimating a parameter in a model with multiple other terms divided by the variance of a model with only one term. In an ordinary least squares regression analysis, it quantifies the severity of multi-collinearity. VIF starts from 1 upwards. The value for VIF indicates the percentage the variance is inflated for each coefficient. For example, a VIF of 1.9 tells you that the variance of a particular coefficient is 90% bigger than what you would expect if there was no multicollinearity. The general rule is that 1 = not correlated, between 1 and 5 = moderately correlated and value greater than 5 = highly correlated (Kolawole et al., 2020).

Table 5.12 Variance inflation factor

Variables	VIF	1/VIF
Year of education	9.232	.108
Years Lived in Eer~k	7.405	.135
Age	7.293	.137
Education level	6.285	.159
Flooding isa probl~m	6.273	.159
Your house isat ri~g	5.169	.193
Estimated economic~e	4.153	.241
Access religious f~y	3.984	.251
Have you experienc~n	3.407	.293
Employment status	2.555	.391
House structure	2.237	.447
Marital status	2.215	.452
comp1	1.95	.513
Gender	1.563	.64
Mean VIF	**4.552**	.

Results presented in Table 5.12 shows a mean VIF value of 4.55 less than 5. This means that the dependent and independent variables are moderately correlated showing that the data is good. The VIF of 4.5 is still within the acceptable range, which is below, 10 indicating that multi-collinearity is not a problem.

Breuschâ Pagan/Cookâ Weisberg test for heteroskedasticity
Assumption: Normal error terms
Variable: Fitted values of Monthly_Household_Income
H0: Constant variance
chi2(1) = 0.38
Prob > chi2 = 0.5401

The test of heteroscedasticity shows no multicollinearity. The results show that the chi square is not significant. The Non-significant of heteroscedasticity test shows that there is no problem of multicollinearity in the data. This means that the data used in this study is credible and void of correlation between the dependent and independent variables. Determining the heteroscedasticity of your data is essential for determining if you can run typical regression models on your data.

5.6.2 The principal component analysis

The goal of principal component analysis (PCA) is to reduce the dimensionality of a data set with a lot of interrelated variables while keeping as much variation as possible. This is accomplished by converting to a new set of uncorrelated variables known as principal components (PCs), which are ordered so that the first few retain the majority of the variation present in all of the original variables (Zimmermann et al., 2015). The flood variable was generated using PCA and the test for suitability based on KMO and Barllet test of sphericity was also performed, and everything was perfect

Table 5.13 Principal component analysis test

Determinant of the correlation matrix Det = 0.000	
Bartlett test of sphericity	Values
Chi-square	397.021
Degrees of freedom	91
p-value	0.000
H0	variables are not intercorrelated
Kaiser-Meyer-Olkin Measure of Sampling Adequacy	
KMO	0.734

5.6.3 The effect of flooding on the livelihood of residents of Eerste Fabriek in Mamelodi Township

A generalised linear model (GLM) with gamma family was used to examine the effect of flooding on the livelihood of residents of Eerste Fabriek in Mamelodi Township. Flooding has several socio-economic and environmental effects. These effects have different

consequences on the livelihood of the community members. This section looks at the effect of flooding on the income level of community members by examining different socio-economic variables. Table 5.14 presents model estimates of the effect of flooding on the income level of the community members.

Table 5.14 Effect of Generalised linear models

Monthly_Household_~e	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Estimated_economic~e	0.000	0.000	0.86	0.388	0.000	0.000	
comp1	-0.013	0.021	-0.61	0.539	-0.054	0.028	
Marital_status	0.204	0.116	1.76	0.078	-0.023	0.431	*
House_structure	-0.551	0.246	-2.24	0.025	-1.033	-0.068	**
Education_level	0.343	0.144	2.38	0.017	0.060	0.626	**
Year_of_education	-0.048	0.048	-1.00	0.317	-0.141	0.046	
Employment_status	-0.305	0.089	-3.42	0.001	-0.480	-0.130	***
Gender	-0.232	0.164	-1.42	0.156	-0.553	0.088	
Access_religious_f~y	0.115	0.621	0.18	0.853	-1.102	1.333	
Years_Lived_in_Eer~k	0.057	0.048	1.19	0.236	-0.038	0.152	
Have_you_experienc~n	0.855	0.818	1.05	0.296	-0.748	2.457	
Flooding_isa_probl~m	-0.698	0.453	-1.54	0.123	-1.585	0.189	
Age	-0.076	0.041	-1.86	0.063	-0.157	0.004	*
Social_grants	0.682	0.390	1.75	0.080	-0.082	1.447	*
Constant	6.951	1.886	3.69	0.000	3.256	10.647	***

Mean dependent var	3190.000	SD dependent var	1659.367
Number of obs	35.000	Chi-square	53.295
Prob > chi2	0.000	Akaike crit. (AIC)	655.833

*** p<0.01, ** p<0.05, * p<0.1

Understanding the effects of flooding on the income level of community is important for evaluating the relative importance of different policy decisions. The empirical results are presented in Table 5.14 above. From among household characteristics, marital status, house structure, formal education level, employment status, age and social grants are the significant variables. Age of the household head is a crucial factor in determining the household economic status and needs. The results show that age of a household head significantly influences the ability of the household head to develop adaptive capacity and deal with the effects of flooding on their household. The result is negative and significant at 10% level of significance. The

implication of this result is that the older the head of the household, the lower the odds of the household's ability to deal with flooding which might have a negative effect on the household income and their livelihood. This means that if the age of the head of the household increases by 1 then their chances of developing flood adaptive capacity reduces by 7.6%. This results is consistent with the findings of (Dou et al., 2017; Abdullah et al., 2019) who found a negative influence between age, food security and natural disasters.

House structure is another factor that was found to significantly impact a households' ability to deal with the effects of flooding on their income. The results show that house structure is negative and significant at 5% level of significance. The structure of the house plays a major role during flooding as well constructed houses have the ability to absorb the shocks caused by flooding. The implication of this result is that house structures made of light and cheap materials are less likely to handle the shock caused by flooding which will negatively affect the household. Eerste Fabriek in Mamelodi Township is an informal settlement where houses are made of light and cheap materials, thus exposing them to the risk of flooding. The house structures in these informal settlements are not strong enough to handle the shock and as a result, negatively affects their livelihood whenever there is flooding. This result is consistent with Drysdale et al. (2021).

Educational level is measured by the number of years the head of the household attended formal education. The results show a positive and significant influence of educational level and flood management capacity and is significant at 5%, which shows that household heads with higher educational levels are more likely to develop adaptive capacity to deal with the effects of flooding. This can significantly improve the income and livelihood of household members.

This means that with an increase in educational level by 1 year, there is a 34.4% chance of developing effective flood management capacity. The result of this study is consistent to the findings of Sulaiman et al. (2016), Dou et al. (2017) and Hajdu et al. (2020).

The employment status of the household head is an important factor that influences the ability of the household head to effective develop flood management strategies and build resilience. This means that a head of households that is employed is more likely to develop effective flood management capacity than an unemployed household head. The results show that employment status is negative and significant at 10% level of significance. The implication of this result is that the adaptive capacity of a household head reduces when he is unemployed compared to an employed household head. The level of employment in informal settlements is very low and hence their inability to develop flood management capacity. This result was expected given the socio-economic characteristics of respondents.

The results show that social grants have a positive effect with household flood management capacity. This means that a household head that receives a social grant is more likely to increase their adaptive capacity compared to a household head who is unemployed and does not receive social grants. Given low levels of income and unemployment in the Eerste Fabriek informal settlement, social grants play a huge role in enhancing the livelihood of households especially during floods. Most of these social grants come as unconditional cash transfers which have proven to be effective tools for fighting poverty and food insecurity in rural communities (Aker et al., 2016). Cash transfer recipients are often households in rural communities who are vulnerable to poverty, inequality and food insecurity. Therefore, this result was expected as most household in the Eerste Fabriek informal settlement depend on social grants for their livelihoods.

5.7 Conclusion

This chapter presented the results of the study. The chapter examined socio-economic characteristics of the respondents and their perceptions on floods. The social and economic effects of flooding in the informal settlement were explored as well as coping and adaption strategies used to mitigate the effects of flooding. Empirical results were presented and discussed. Empirical results examined the effects of flooding on the income and livelihoods of community members. Household characteristic variables such marital status, house structure, formal education level, employment status, age and social grants have significant influence on the households' ability to deal with the effects of flood on their livelihood.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Summary of study

The world at large is experiencing a plethora of extreme weather events caused by climate change. These events are exacerbated by factors such as lack of resources, growing population and industrialisation. In addition, these human activity factors result in changes in weather patterns that manifest into climate change, causing extreme weather events like heavy precipitation that result in flooding and negatively affect the lives of people and degrade the environment. South Africa, like the rest of the world is susceptible to catastrophes, largely triggered by climate change and associated extreme weather conditions caused by above-mentioned human activities. Therefore, South Africa's progresses in attaining Sustainable Development Goals (SDGs) is threatened by the growing challenges and impacts of climate change which manifest in, amongst others frequent tropical storms and heavy precipitation that occurs sporadically and causes floods. The SDGs targets make provision for the protection of the rights of the people, building resilience against disasters and environmental protection. South Africa's 2019 SDG country report indicates that the country's 2012 National Development plan is 74% aligned to the SDGs, while there are challenges, this makes it easy for South Africa to respond and implement the targets set by the Agenda 2030 of Sustainable Development. Recently however, floods have been occurring frequently, and this might derail the implementation because of social and economic impacts of these floods.

The problem of flooding which arises when the natural flow of water or the catchment area is disrupted due to factors that include human settlement on the flood line and rapid urbanisation and industrialisation is worldwide and warrants investigation, in order to make literature available. Recent studies show that informal settlements increase chances of flooding, firstly by the location along the riverbanks and catchment areas and secondly, by types of structures which in most cases are shacks and mud-houses that can be easily flooded. According to the Department of Environmental Affairs (DEA, 2016), South Africa is facing a plethora of environmental related challenges ranging from droughts, floods, land degradation and soil erosion. Climate change affects the ability of the country to cope with the extreme conditions. Floods affects almost all regions of the Tshwane Metropolitan Municipality, however the most vulnerable are people living along flood lines which in most cases are informal settlements. This study was conducted in the Township of Mamelodi which is part of the City of Tshwane (CoT), located in the Gauteng Province of South Africa. Eerste Fabriek informal settlement

was chosen as the focus area in this study. A simple random sampling technique was used to select 50 participants for this study and a quantitative research method was used to analyse and present the results of this study. The purpose of the study was to assess socio-economic effects of floods in the informal settlement of Eerste Fabriek in the Township of Mamelodi.

6.2 Conclusion

A number of findings emerged from this study, such as causes of floods, economic and social impacts of flooding as well as the role of gender and household structures among others. Socio-economic factors that were likely to affect the effects of floods in this area or income-generating capacities of respondents include gender, age, marital status, family size, availability of income-generating activity (occupation) and wealth status. Findings show that 52% of females and 48% males participated in the study. The importance of gender disparities in the context of flooding and its impacts on informal settlements was observed. Although the study found that female respondents' likelihood of acquiring flood insurance is comparable (with male respondents) or lower, previous studies found no link between gender and the intention to take adaptive measures to reduce flood damage. Findings also showed that 36% of respondents attended secondary school, followed by matric (26%), no schooling (16%), primary school (10%) and (12%) tertiary education.

The results show overall reduction in educational attainment, lower academic performance and higher rates of absenteeism among respondents who have experienced climate shocks such as floods. The larger concentration of employment occurs in areas where the main employment is a fulltime job, which covers 36% of respondents. Studies found that services and total employment are always higher in areas with a large concentration of human capital (more people with college degrees). Interestingly, employment per capita (after filtering out population) tends to be higher in more urbanised counties. The socio-demographic profile of respondents was also assessed as this could influence their willingness to engage in income-generating activities. Age, gender, marital status and educational level among other things were all measured.

The study revealed flooding as a big problem in the community. This study showed that 74% of respondents strongly agreed that flooding is a major problem in the community, with 22% slightly agreeing and 4% expressing no view on the issue. The first objective of this study was to determine the causes of floods in the Eerste Fabriek informal settlement. The study found that flood events that occurred in the community were caused in the main by heavy rains

(98%), Unavailability of drainage systems (78%), Rivers (78%), Floodplain area (62%) among others. This shows the extent of the risk in the community.

The second objective was to determine social effects of floods in the informal settlement. The results of this study revealed that access to health facilities was impacted during flood events where about 6% confirmed and a further 94%, 96% and 98% confirmed that educational, religious and recreational facilities were not affected by flood events in the community. Furthermore, 96% confirmed that flood cause damage to houses, 86% confirmed that flood damage household furniture, 80% confirmed that flood damage important documents whereas, 80% confirmed that flood damage electrical appliances. The third objective examined the economic effects of flood in the informal settlement. The results confirm that 86% of the respondents confirmed that they experienced economic loss from flood, 80% confirmed that they spent money to repair damages caused by flood, 68% lost money fixing electrical appliances due flooding while 74% lost money fixing damages to household furniture.

The empirical results examined the effects of flooding on the income and livelihood of the community members. The household characteristics variables such marital status, house structure, formal education level, employment status, age and social grants have significant influence on the households' ability to deal with the effects of flood on their livelihood. The findings suggest that homes in flood-prone informal settlements, such as those in the research area, have potential that might be used to strengthen local adaptation efforts. Strong social networks among homes, which are vital for support methods, are among the potentials. The existence of social networks through neighbors, relatives, friends, as well as livelihood and gender groups, has shown to be crucial and capable of offering immediate relief and support in this study.

6.3 Recommendations

Based on these findings, some policy recommendation can be proposed to help improve the resilience of the community members to flooding;

- Results of this study indicate that important adaptation strategies such as building shacks on high-lying areas, parameter walls and sand beds are not adopted by community members due to lack of capacity. Policymakers should liaise with community members to identify those important adaptation and mitigation strategies and assist community members build capacity through education and training. This

can be done through capacity building on issues such as sandbags, elevated walls and other measures deemed effective.

- Empirical results showed that social grants through cash transfer programs have the potential to increase the capacity of community members to mitigate for flooding. Given the high level of unemployment within the community, policymakers can increase the number and frequency of cash transfer programs to the most vulnerable in the community while providing employment opportunities to those who can work. This can greatly increase the capacity of community members to deal with flooding. Policymakers can develop flood-relief benefit programs targeting vulnerable communities.

- Findings also suggest that homes in flood-prone informal settlements, such as those in the research area, have potential that might be used to strengthen local adaptation efforts such as strong social networks among others, these are vital for support. The existence of social networks through neighbors, relatives, friends, as well as livelihood and gender groups, has shown to be crucial and capable of offering immediate relief.

6.4. Suggestions for further studies

This study examined the socio-economic effects of flooding in the Eerste Fabriek informal settlement. The limitation of this study is that it empirically examined the effects of flood on the community from a linear point of view. A similar study can be conducted where the socio-economic effects can be examined using non-linear tools like systems thinking which examine the causal relationships and feedback loops that exist in the system. This can assist policymakers develop sustainable solutions to solve the problem of flood in the community. This will enable community members to be included in the policy development and decision making process.

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APPENDIX A

Ethical clearance certificate

UNIVERSITY OF THE FREE STATE
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UFS UV

GENERAL/HUMAN RESEARCH ETHICS COMMITTEE (GHREC)

28-Sep-2021 Dear Mr Nkoni Modiba **Application Approved**

Research Project Title:

ASSESSING THE SOCIO-ECONOMIC EFFECTS OF FLOODS ON INFORMAL SETTLEMENTS: CASE STUDY OF EERSTE FABRIEK IN MAMELODI TOWNSHIP

Ethical Clearance number:

UFS-HSD2021/1139/21

We are pleased to inform you that your application for ethical clearance has been approved. Your ethical clearance is valid for twelve (12) months from the date of issue. We request that any changes that may take place during the course of your study/research project be submitted to the ethics office to ensure ethical transparency. furthermore, you are requested to submit the final report of your study/research project to the ethics office. Should you require more time to complete this research, please apply for an extension. Thank you for submitting your proposal for ethical clearance; we wish you the best of luck and success with your research.

Yours sincerely

Dr Adri Du Plessis Chairperson: General/Human Research Ethics Committee

205 Nelson Mandela Drive Park West Bloemfontein 9301 South Africa

P.O. Box 339 Bloemfontein 9300 Tel: +27 (0)51 401 9337 duplessisA@ufs.ac.za **www.ufs.ac.za**

APPENDIX B

POPIA compliant consent

UNIVERSITY OF THE FREE STATE
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DATE

RESEARCH STUDY INFORMATION LEAFLET AND CONSENT FORM

TITLE OF THE RESEARCH PROJECT

ASSESSING THE SOCIO-ECONOMIC EFFECTS OF FLOODS ON INFORMAL SETTLEMENTS: CASE STUDY OF EERSTE FABRIEK IN MAMELODI TOWNSHIP

PRINCIPLE INVESTIGATOR / RESEARCHER(S) NAME(S) AND CONTACT NUMBER(S):

NTS Modiba 2019446083 0823065114

FACULTY AND DEPARTMENT:

FACULTY OF NATURAL AND AGRICULTURAL SCIENCES DISASTER MANAGEMENT TRAINING AND EDUCATION CENTRE FOR AFRICA

STUDY LEADER(S) NAME AND CONTACT NUMBER:

Dr Tlou Raphela 0721084987

WHAT IS THE AIM / PURPOSE OF THE STUDY?

The aim of the study is to assess the effects of floods problems in Eerste Fabriek informal settlement of Mamelodi Township; and it will focus on different variables of the community including social and economic aspects. The study seeks to understand how floods events affect the social and economic activities of the inhabitants of the Eerste Fabriek informal settlements. There is also a need for a more detailed analysis to develop appropriate policy and strategies to deal with the mushrooming of informal settlements in areas prone to floods disaster to reduce the flood impact on the environment, social and economic activities of communities (Sajor et al., 2017). This study will provide policy makers with information to deal with socio-economic issues brought about by floods.

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WHO IS DOING THE RESEARCH?

205 Nelson Mandela Drive/Rylaan, Park West/Parkwes, Bloemfontein 9301, South Africa/Suid-Afrika P.O. Box/Posbus 339, Bloemfontein 9300, South Africa/Suid-Afrika, T: +27(0)51 401 9111, www.ufs.ac.za

My names are Nkoni Thabiso Selby Modiba. I am a student at the University of Free State pursuing Master Degree in Disaster Management. Firstly, I am conducting the study as part of the fulfulment of my mini dissertation for the my Masters Degree. Secondly, I am conducting the study to find out how the community of Eerste Fabriek can be assisted to better prepare and respond to future flood disasters. Lastly, I am conducting the study with the aim to come-up with possible policy interventions that can assist the Tshwane Municipality to better put intervention measures to deal with root causes of the flood disasters.

HAS THE STUDY RECEIVED ETHICAL APPROVAL?

This study has received approval from the Research Ethics Committee of UFS. A copy of the approval letter can be obtained from the researcher.

Approval number: Insert approval number

WHY ARE YOU INVITED TO TAKE PART IN THIS RESEARCH PROJECT?

You are chosen to participate in this study because you have experienced the 2019 flooding of the Eerste Fabriek informal settlement, and also because you are an adult and can share your experinces. The data collection process will include interviewing adults who are willing to participate in the study and has experienced flooding in this area. The community leaders will also be consulted to assist in the spreading of information about the study. According to the calculations in the Research Proposal, about 212 participants will be approached to take part in the study. Also, the number of participation will depend on the willingness of the community members to participate in the study.

WHAT IS THE NATURE OF PARTICIPATION IN THIS STUDY?

The participant's role in the study will be to share their experience of flooding in Eerste Fabriek Informal settlement including how the floods affected the economically and socially.

A questionnaire will be used to collect data for the study in an interview format. The researcher will interview the participants. This will be done following the COVID-19 non-Pharmaceutical protocols including social distancing by sitting 1 and half meters apart, sanitizing, wearing of masks and the researcher will complete all questionnaire himself to avoid exchanges of the pen and paper. The questions to be asked are attached in the questionnaire attached to this application. It is estimated that the interview will take approximately 30 minutes. The researcher will also be cognizant of the fact that the interview may cause pain and trauma for the participants especially to relive the flood incident especially if they were physically hurt, experienced material loss and the loss of life of family members and relatives. The researcher will assure the participants that they should tell him if they feel uncomfortable to answer questions or if they do no longer want to continue with the interview .Being sensitive of the feelings of the participants will be prioritized over the completion of the questionnaire.

CAN THE PARTICIPANT WITHDRAW FROM THE STUDY?

Being in this study is voluntary, and you are under no obligation to consent to participation. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a written consent form. You are free to withdraw at any time and without giving a reason, however when the results are published, it will not be possible to do so.

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WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THIS STUDY?

Participation of a large number of participants will provide the researcher with a clear picture of the flood situation in the area as compared to a small number of participants. Participation of a large number will ensure that the results of the study tell a better analysis of their situation and therefore may result in better recommendations that can be shared with the policy makers. Participation will remain confidential and no names will be used in the study. The participants will be identified by numbers. There is no sponsor involved in this study.

WHAT IS THE ANTICIPATED INCONVENIENCE OF TAKING PART IN THIS STUDY?

The participants will be inconvenienced in terms of the time they will use to attend the interviews to respond to the questionnaire with the researcher. An estimated 30 minutes will be taken to complete the questionnaire.

The participants may also feel some discomfort in sharing personal information such as the family income and by sharing traumatic experience from flooding. The time taken to complete the interview may also affect participants who are self-employed and that might eat into their income. For participants whose livelihoods might get affected, alternative times like after hours or on days when they are not working will be arranged.

WILL WHAT I SAY BE KEPT CONFIDENTIAL?

The names of the participants will not be recorded, anywhere and no one will be able to connect them to the answers given. Their answers will be given a fictitious code number or a pseudonym, and will be referred to in this way in the data, any publications, or other research reporting methods such as conference proceedings. The data collected will be accessible to only the researcher, the research assistant if hired and the supervisor of the research study. The research assistant will sign a consent form to not use the information beyond this research study. The answers provided by the participants will also be reviewed by people responsible for making sure that research is done properly, including the transcriber, external coder, and members of the Research Ethics Committee. Otherwise, records that identify participants will be available only to people working on the study, unless you give permission for other people to see the records. Create a sentence to inform participants that their anonymous data may be used for other purposes, e.g. research report, journal articles, conference presentation, etc. A report of the study may be submitted for publication, but individual participants will not be identifiable in such a report). The study will not use a focused group data collection option. You may decide to no longer participate in the study at any time during the data collection process, however you will not be able to withdraw from the study when the report is published.

HOW WILL THE INFORMATION BE STORED AND ULTIMATELY DESTROYED?

The researcher will store hard copies of your answers for a period of five years in a locked cupboard/filing cabinet in my office at work for future research or academic purposes; electronic information will be stored on a password-protected computer. Future use of the stored data will be subject to further Research Ethics Review and approval if applicable. Should the information deemed old and no longer relevant, all hard copies will be shredded and all electronic copies will be deleted from computer. With all security systems, there can be a break-in into my office and the record of the data may be accessed, however our office park is access controlled and the likelihood of a break in is very low. Similarly with the password protected file on my computer, cyber security is guaranteed and therefore hackers may access information from my laptop. I have installed virus protection software on my computer and continually update it. Also, I do not use public WIFI which might be unsafe for personal information. Since there will be no use of names in the questionnaire, the personal information will never be linked to the participants.

WILL I RECEIVE PAYMENT OR ANY INCENTIVES FOR PARTICPATING IN THIS STUDY?

There will be financial reward offered to the participants as the study is meant for academic purposes. Due to Covid-19, the researcher will buy face-masks and sanitizers to give to the participants to be able to be protected during the interview process.

The participants may also be inconvenienced as they researcher will be going into their personal space, so therefore the interviews will be conducted outside where there is increased ventilation to reduce possible COVID-19 transmissions. Also, should it no be a good time to conduct the reviews, the researcher will be flexible and come at a time which will suit the participants.

HOW WILL THE PARTICIPANT BE INFORMED OF THE FINDINGS / RESULTS OF THE STUDY?

If you would like to be informed of the final research findings, please contact Mr Thabiso Modiba on Selby.modiba@gmail.com, 0823065114. The findings will be accessible at the University of Free State, Faculty of Natural and Agricultural Science under then Disaster management Training and Education Centre for Africa (DIMTEC) Should you require any further information or want to contact the researcher about any aspect of this study, please contact Mr Thabiso Modiba, 0823065114, Selby.Modiba@gmail.com.Should you have concerns about the way in which the research has been conducted, you may contact Dr Tlou Raphela, RaphelaTD@ufs.ac.za, 0514012036, 0721084987.

Thank you for taking the time to read this information sheet and for participating in this study.

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CONSENT TO PARTICIPATE IN THIS STUDY

I, the undersigned, _____ (participant's full names to be

included), (the "**Participant**") confirm that I voluntarily agree to participate in the research study referred to as the _____ (the **"Study**") in relation to

_____

_____

and which Study is being conducted by

_____ (insert the name of

the researcher), (the "**Researcher**").

I, the undersigned Participant, further confirm that–

1. the Researcher has explained the nature, procedure, potential benefits and anticipated inconvenience of my participation in the Study;

2. I have read (or had explained to me) and understood the Study as explained in the attached information sheet;

3. I have had sufficient opportunity to ask questions and am prepared to participate in the Study;

4. I understand that my participation in the Study is entirely voluntary and that I am free to withdraw at any time without penalty (if applicable);

5. I voluntarily provide the UFS and the Researcher with my personal information and consent to the UFS and the Researcher collecting, disclosing and processing my personal information in order to conduct the Study and any related activities in relation thereto;

6. I hereby acknowledge and confirm that I understand the purpose for which the UFS and the Researcher may collect, store, use, delete, destroy, outsource, transfer or otherwise process, as the context and circumstances may require and as contemplated in terms of POPIA, my personal information as set out herein;

7. I am aware that the findings of the Study will be anonymously processed into a research report, journal publications and/or conference proceedings and that my personal information will be aggregated and deidentified at such stage;

8. I also give the UFS permission to share, without notification, the collected data with other researchers at the UFS or other Higher Education Institutions. This permission is dependent on the same principles of ethical research practices, anonymity/confidentiality, safekeeping of information, and other issues listed above applying.

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I, the Participant, agree to the recording of the insert specific data collection method.

Full Name of Participant: _____

Signature of Participant: _____ Date: _____

Full Name(s) of Researcher(s): _____

Signature of Researcher: _____Date: _____

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APPENDIX C

Final questionnaire

INTERVIEW WITH COMMUNITY OF EERSTE FABRIEK INFORMAL SETTLEMENT

SECTION A: ADMINISTRATION SECTION

Questionnaire Number_____

Interviewers Name and Surname: _____

Date of completing this questionnaire _____

This questionnaire Survey is aimed at collecting data to be used for a master's degree in Disaster Management at the University of the Free State. As a resident of the Eerste Fabriek informal settlement, you are kindly requested to complete the following questions for study purses only.

My research topic is as follows:

Assessing the socio-economic effects of floods on informal settlements: A case study of Eerste Fabriek in Mamelodi Township, South Africa.

Your participation in the survey will assist to come up with possible causes of floods, social and economic implications; coping strategies and recommendations for policy makers that might be generalizable to the region.

This questionnaire has received written approval from the Human Research Ethics Review Committee from the University of the Free State under protocol number UFS-HSD2021/1139/21.

Should you require any further information or want to contact the researcher about any aspect of this study, please contact Mr, Selby Thabiso Modiba on 0823065114; Email: Selby.modiba@gmail.com.

Should you have concerns about the way in which the research has been conducted, you may contact my Supervisor Dr Sebastian Nyam on 0813493312; Email: yongsebastian04@gmail.com.

SECTION B: DEMOGRAPHIC DETAILS OF RESPONDENTS

Please indicate your answer with an [X]

1 Gender: _____ (1= Male; 2= Female; 3= other)

2 Age: _____ years

3. Marital status : Single….. Married……. Divorced …… Separated…….others……

4 House structure

Corrugated Iron	
Brick house	
Mad house	
Timber house	

5. Education level:

No Schooling	
Primary Schooling	
Secondary Schooling	
Matric	
Tertiary Education	

6. Number of years spent in school ……..Years

7. Employment status

Full time job	
Part time job	
Self employed	
Unemployed	
Student	

8. What is your source of income?

Salary	
Allowance	
Wages	
Maintenance	
Social grants	
Remittance	

9. How much is your monthly household income R…. ….?

10.. Number of dependents ……..

11. Were you born in Eerste Fabriek informal settlement?

Yes	
No	

12.How long have you lived in Eerste Fabriek informal settlement ……..Years?

SECTION C: FLOOD RISK

Please indicate your answer with an [X]

13. Do you experience flooding in your community/household?

Yes	
No	

14. If yes, how often do you experience flooding in your community/household?

Every time it rains	
Only once a year	
Several times a year	
Once every 2-4 years	

15. Do you believe that flooding is a problem in your community/household?

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

16. If you agree, how would you rate the flooding problem?

Minor	
Moderate	
Major	

17. Do you think that your home is at risk of flooding?

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

18. What are the main causes of floods in your area?

Heavy rain	
Unavailability of drainage system	
Broken dam	
Step slope	
Wetland	
River	
Floodplain area	
Environmental degradation	
All of the above	

19. Do you think floods are becoming less or more frequent in last 10-12 years?

More	
Less	
No difference	
Do not know	

20. Please Rate the following flood impacts

		Very High	High	Medium	Less	Very Less
1	Flooding threatened house structure					
2	Flooding threatened household income					
3	Flooding threatened my /our lives					
2	Flooding has caused food scarcity					
3	Flooding caused homelessness					

4	Flooding caused communicable diseases like cholera					
5	Flooding affected health					
6	Flooding caused unemployment					
7	Flooding caused reduction in household income					
8	Flooding caused reduction in spending on festivals					
9	Flooding caused population migration					
10	Flooding affected school of children					
11	Flooding caused hopelessness and sense of loss					
12	Flooding caused conflict of space to build house structures in the community					
13	Flooding caused increase of rates in Informal settlement dwellers' suicide					

21 In what way does floods affect your household?

Water enters inside the house	
Water comes around the house	
Water enters the garage	
Driveway gets flooded	
Backyard get flooded	
Front yard get flooded	
Escape routes gets flooded	
Other, specify……	

22. In your experience, what are some of the damages caused by flood in your household?

Damage to household house	
Damage to household water supply	
Damage to household food gardens	
Damage to household livestock	
Damage to household furniture	
Damage to household important documents	

Damage to vehicle(s)	
Damage to household electronic appliances	

23. In addition to floods, what are other disaster risks your household and community are susceptible to?

Fire	
Cholera	
Malaria	
Diarrhea	
Typhoid	
Severe weather storms	

24. Are you considering to leave this area because of floods disasters?

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

SECTION 4: SOCIAL IMPACT OF FLOODS

Please indicate your answer with an [X]

25. Was there an incident where households have to be relocated to new area due to flooding?

Yes	
No	

26. In what way does flooding affect you?

Home flooded/destroyed	
Flood related illness	
Flood related death	
Drop out of school	
Lost employment	
Loss of important document	
Other, specify……	

27. Are you able to access health facility in your area during flooding?

Yes	
No	

28. Are you able to access educational facility in your area during flooding?

Yes	
No	

29. Are you able to access religious facilities in your area during flooding?

Yes	
No	

30. Are you able to access recreational facilities in your area during flooding?

Yes	
No	

31. Do you live with the elderly, physically disabled person and children?

Yes	
No	

32. Have you ever had to evacuate them during flooding?

Yes	
No	

SECTION 5: ECONOMIC IMPACT OF FLOODS

Please indicate your answer with an [X]

33. Have you ever experienced an economic loss because of flooding?

Yes	
No	

34 Have you ever repaired the damage caused by flooding in your household at any time?

Yes	
No	

35. If you answered yes in 34 above, what is the estimated economic value of your loss to flooding R……?

36. Does your work get affected during flooding in your area?

Yes	
No	

37 If yes how:

Absenteeism from work dealing with floods in the area/household	
Unable to travel to work due to flooded roads	
Area of work flooded	
Flooded house/shack	
Other, Specify……	

38. Financially, how has the flooding in your community affected your household?

Money lost for food to fix the damage	
Money lost for children school fees to fixing the flooding damage	
Money lost to fixing damaged electrical appliances	
Damaged furniture	

39. Are you able to go collect your social grant during flooding in your area?

Yes	
No	

40. If no, is there contingency financial plan when the grant is not collected?

Yes	
No	

SECTION 6: FLOOD MANAGEMENT AND STRATEGIES

Please indicate your answer with an [X]

41. What does your community prepare for flooding?

Availability of flood action plan	
Availability of flood management committees	
Community awareness and preparedness programs	
Train community members in warning and evacuation plans	
Other, specify……	

42. Does the municipality provide assistance during floods disasters?

Yes	
No	

43. What types of flood disaster mitigation services does the municipality provide in your area?

Warning messages	
Community Flood plans	
Community based response subsystem for flood disaster	
Storm water drainage system	

44. Does your community have flood an evacuation plan?

Yes	
No	

45. Were you ever evacuated during the floods in your area?

Yes	
No	

46. If yes, please select the possible reasons why you were evacuated.

My house was flooded	
My yard was flooded and I could not leave	
Other, specify	

Sandbags	
Tree logs	
Raised pit latrines	

Elevation of house/shack foundation	
Construction of protective wall	
Other, specify	

47.

What strategies and measures have you put in place to reduce flood impact?

48. What mode of communication do you use to receive flood and other server weather warnings?

Television	
Newspaper	
Community members/leader	
Family or friends	
Cellphones	
social media	
Other, specify	

49. What institutional mechanisms are in place to deal with flood disasters in your area?

Disaster Management Centres	
Disaster management champions in your community	
Evacuation and response plans	
Early warning systems	
Other, specify……	

50. Do you know where the disaster management Centre is located closer to your area?

Yes	
No	

51. Have you or your community ever received external assistance in preparing for floods?

Yes	
No	

52. If yes, who gave external assistance?

National government	
Non-government organization or voluntary organization	
United Nations agency	
Voluntary groups	
Local politician or a party	
Disaster management officials	
Other, specify	

53. Has anyone from the following assisted you or your community during floods?

Disaster Management team	
Ward councilor	
Minister/s	
NGO's	
Voluntary group	
Local politician or a party	
I do not know	
Other, specify	

54. What changes in relation to floods disasters risk would you want to see implemented by the municipality?

Relocation of the residents to a safe area	
Provision of housing structures	
Enforcement of laws to prohibit people from residing in flood plain areas	
Education and awareness about flood disasters	
Other, specify……	

55. Does the municipality provide assistance during floods disasters?

Yes	
No	

56. Do you understand the impact of staying in a floodplain area?

Yes	
No	

57. What changes in relation to floods hazards would you want to see implemented by the municipality?

Relocation of the residents to a safe area	
Provision of housing structures	
Enforcement of laws to prohibit people from residing in flood plain areas	
Education and awareness about flood disasters	
Other, specify……	

58. What are the overall changes and improvements in relation to flood disasters would you want to see implemented for your area?

_____

_____

_____

_____

Thank you for taking time to complete the survey

APPENDIX D

Editing certificate

26 NOVEMBER 2021

CHIZINDA
ENTERPRISES

I hereby confirm that I have proof-read, formatted and
edited the style, layout, references and language of the

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to be submitted to the

University of Free State

by

Nkoni Thabiso Selby Modiba

2019446083

Entitled

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Note: The edited work described here may not be identical to that submitted. The author, at its sole discretion has the prerogative to accept, delete or change amendments made by the editor before submission.

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