DURBAN UNIVERSITY OF TECHNOLOGY

FLOOD RISK MANAGEMENT IN URBAN SETTLEMENTS IN THE ETHEKWINI AREA

CAROLINE CHIOMA OLANREWAJU

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FLOOD RISK MANAGEMENT IN URBAN SETTLEMENTS IN THE ETHEKWINI AREA

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CAROLINE CHIOMA OLANREWAJU

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ABSTRACT

Floods have accounted for two-thirds of all natural hazards affecting millions of people and resulting in damage amounting to billions of US dollars. Over the years, flood disasters in the KwaZulu-Natal province of South Africa have increased in severity, with eThekwini municipality enduring the worst of most of the disasters. Floods in eThekwini (study area) are very destructive, resulting in devastating and fatal consequences. Flood risk in the study area was examined to identify the causes of vulnerability and the current flood risk reduction practices employed by all stakeholders of disaster management, with a view to developing an Integrated Flood Risk Management (IFRM) Framework that may be employed to improve and enhance flood risk management effectiveness and disaster management practices. To achieve this, the research adopted a mixed research approach, in a case study of four strategically located cities, representing the entire eThekwini Municipal Area. Questionnaires and semi-structured interviews were used to collect information from purposively sampled community members and key role-players of disaster management, respectively, in addition to a historical literature review of secondary data within the period under review, to develop an IFRM framework. Development of the framework is based on the principle of integrating flood risk and stormwater management, building disaster resilience through Community-Based Disaster Risk Management (CBDRM), aimed at reducing vulnerability and increasing coping strategies, along with good practices and policies in disaster management.

A major problem the municipality faces regarding flood risk was identified and verified as the habitation of people on “at-risk” land. Relocation policies have proved very expensive, extremely slow and mostly unachievable. The research further identified a yearly pattern of flood disasters resulting in the loss of property and life, attributed to weak flood disaster response plans. It was also uncovered that vulnerability of community members was due to the lack of adequate capacity to manage the flood disasters, as well as the absence of clear strategies in place to reduce vulnerability, and weak implementation strategies to integrate all stakeholders of disaster risk management. In such cases, the most appropriate

strategy to reduce vulnerability would be through flood disaster preparedness and efficient emergency flood response.

The IFRM model, therefore, instigates risk reduction through appropriate flood disaster response plans, supported by reliable and accurate flood forecasts, advocating for the application of a risk management approach. This provides measures for preventing a hazard from becoming a disaster, where the major focus is to reduce vulnerability. Effective implementation of the IFRM components requires an enabling environment in terms of policy and practice, including clear roles, functions and effective regulation and enforcement. The nature of flood disaster in the eThekwini municipality creates a situation that needs immediate action to fulfil the aspirations of people in the municipality. Thus, political commitment to principles and practice is critical.

The framework for integrated risk management in flood disasters offers a guideline for the holistic management of floods through inclusion of all stakeholders viz-a-vis the government, the actors of disaster management and the general public. It also emphasises the interconnectedness between the three components: flood disaster management, disaster resilience and disaster management good practices and policies.

DECLARATION

I, Caroline Chioma Olanrewaju declare that this work in its entirety is my own work and contains no material that has been used by myself or any other person in the award of any other degree from any university and all sources quoted have been fully acknowledged by means of references.

20/06/2024

……………………………… ………………………

SIGN DATE

DEDICATION

This thesis is dedicated to the Lord God Almighty who gave me the vision and enabled me through the attainment of this great height.

To my dad, Brigadier-General Chidi F Nwogu of blessed memory, whose utmost desire was to see me succeed in every area of my life. I love you so much daddy and thank you for shaping my life and instilling in me the resilient spirit I have today.

To my Mum, Rose Nwogu, my biggest cheerleader, for her support and encouragement in the pursuit of my life's achievements.

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To my beautiful and adorable twin boys, Asher and Matthias, for bringing so much happiness into my life at the time I needed it the most. Giving me the courage to push on. My darlings, you are indeed laughter to my soul and God's gifts to me. You made me realize Psalm 126 that reads: "*when the Lord turned again my captivity, I was like them that dreamed. My mouth was filled with laughter and my tongue with singing*".

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TABLE OF CONTENTS

ABSTRACT iii
DECLARATION v
ACKNOWLEDGMENTS vii
TABLE OF CONTENTS viii
LIST OF FIGURES xvi
LIST OF TABLES xix
LIST OF ACRONYMS AND ABBREVIATIONS xxi
RESEARCH OUTPUT xxiii
CHAPTER ONE 1
INTRODUCTION AND BACKGROUND 1
1.1 INTRODUCTION 1
1.2 BACKGROUND OF STUDY AREA 1
1.3 CONCEPTUALISING AND UNDERSTANDING KEY TERMINOLOGY 3
1.3.1 Hazard 3
1.3.2 Disaster 4
1.3.3 Risk 4
1.3.4 Disaster Risk 5
1.3.5 Disaster Risk Reduction (DRR) 5
1.3.6 Disaster Management 5
1.3.7 Disaster Risk Management (DRM) 6
1.3.8 Vulnerability 6
1.3.9 Capacity 7
1.3.10 Resilience 8
1.3.11 Precipitation 8
1.3.12 Framework 8
1.3.13 Disaster Management Good Practices 9
1.4 GLOBAL OVERVIEW OF FLOODS 9

1.4.1 Overview of floods in Africa 11
1.5 STUDY AREA DESCRIPTION 14
1.5.1 Causes of floods in eThekwini 15
1.5.1.1 Precipitation 15
1.5.1.2 Temperature 16
1.5.1.3 Urbanisation 16
1.5.1.4 Climate change 17
1.6 PROBLEM STATEMENT 17
1.7 PURPOSE OF STUDY 18
1.8 RESEARCH AIM AND OBJECTIVES 18
1.8.1 Research questions 19
1.9 CONCEPTUAL FRAMEWORK 19
1.10 RESEARCH METHODOLOGY 21
1.10.1 Sampling 22
1.10.2 Data collection and analysis 22
1.11 JUSTIFICATION OF STUDY 23
1.12 DELIMITATIONS 24
1.13 LIMITATIONS 24
1.14 SCOPE OF STUDY 24
1.15 STRUCTURE OF DISSERTATION 24
1.16 CONCLUSION 26
CHAPTER TWO 27
CONCEPTUAL FRAMEWORK 27
2.1 INTRODUCTION 27
2.2 THE FRAMEWORK 27
2.3 DIMENSIONS OF THE CONCEPTUAL FRAMEWORK 29
2.3.1 FDRM 29
2.3.1.1 Flood Risk Assessment 31
2.3.1.2 Flood and Stormwater Management 36

2.3.2 Disaster Resilience.....43
2.3.2.1 Participatory process.....44
2.3.2.2 Resource maximisation.....45
2.3.2.3 Motivation.....45
2.3.2.4 Institutional linkages.....45
2.3.3 Policies and Practices.....46
2.4 CONCLUSION.....48
CHAPTER THREE.....49
LITERATURE REVIEW.....49
3.1 INTRODUCTION.....49
3.2 URBAN FLOODS AND IMPACTS.....50
3.3 CLIMATE CHANGE AND FLOOD RISK.....51
3.4 FLOOD VULNERABILITY.....53
3.5 DISASTER RESILIENCE.....54
3.5.1 CBDRM.....54
3.6 DISASTER RISK MANAGEMENT (DRM).....56
3.7 GLOBAL DECLARATION FRAMEWORKS ON DISASTER AND RISK MANAGEMENT.....59
3.7.1 International Decade for Natural Disaster Reduction (IDNDR) (1990–1999).....61
3.7.2 Yokohama Strategy and Plan of Action for a Safer World (1994).....63
3.7.3 International Strategy for Disaster Reduction (ISDR).....64
3.7.4 Millennium Development Goals (MDGs).....66
3.7.5 Hyogo Framework for Action (HFA) (2005–2015).....68
3.7.6 Sendai Framework for Disaster Risk Reduction (SFDRR) (2015–2030).....70
3.7.7 Paris Agreement on Climate Change (2015).....73
3.7.8 2030 Agenda for Sustainable Development (SDGs).....76
3.8 DISASTER MANAGEMENT IN SOUTH AFRICA (SA).....79
3.9 FRM GOOD PRACTICES.....80
3.9.1 Europe.....80

3.9.1.1 The Netherlands........81
3.9.2 North America........83
3.9.2.1 The United States of America (USA)........83
3.9.3 South America........85
3.9.3.1 Argentina........85
3.9.4 Asia........86
3.9.4.1 Hong Kong and Singapore........87
3.9.5 Africa........90
3.10 INTEGRATED FLOOD RISK MANAGEMENT (IFRM)........91
3.11 CONCLUSION........92
CHAPTER 4........93
RESEARCH METHODOLOGY........93
4.1 INTRODUCTION........93
4.2 QUALITATIVE RESEARCH METHODOLOGY........93
4.3 QUANTITATIVE RESEARCH METHODOLOGY........94
4.4 RESEARCH DESIGN........94
4.4.1 Quantitative Research Design........95
4.4.2 Qualitative Research Design........95
4.5 PHASES OF THE STUDY........96
4.6 STUDY AREA........97
4.7 SAMPLING........100
4.7.1 Qualitative Sample Size........101
4.7.2 Quantitative Sample Size........103
4.8 DATA COLLECTION........105
4.9 DATA ANALYSIS........109
4.9.1 Quantitative data analysis........109
4.9.2 Qualitative data analysis........110
4.10 PILOT STUDY........112
4.11 DATA VALIDITY, RELIABILITY AND TRUSTWORTHINESS........112

4.12 ANONYMITY AND CONFIDENTIALITY 114
4.13 ETHICAL CONSIDERATION..114
4.14 DELIMITATION OF THE STUDY..115
4.15 LIMITATIONS OF THE STUDY 116
4.16 CONCLUSION 118
CHAPTER 5...119
DATA ANALYSIS AND INTERPRETATION OF FINDINGS...............................119
5.1 INTRODUCTION 119
5.2 QUANTITATIVE DATA ANALYSIS 119
5.2.1 Response rate 119
5.2.2 Demographic information 120
5.2.2.1 Gender 120
5.2.2.2 Age 121
5.2.2.3 Marital status 123
5.2.2.4 Education 125
5.2.2.5 Occupation 126
5.2.2.6 Household size...128
5.2.2.7 Property type...129
5.2.2.8 Community residency (Years)..131
5.2.2.9 Ownership status 132
5.2.2.10 Basic income..133
5.2.3 Impacts of flood 134
5.2.3.1 Impacts of flood on property 134
5.2.3.2 Estimated cost of damage caused by flood disasters 143
5.2.3.3 Help received during flood disaster 145
5.2.3.4 Impact of floods on individual...145
5.2.4 Flooding occurs only as a result of nearby rivers and creeks 146
5.2.5 Other causes and factors contributing to flooding in the study area 147
5.2.5.1 Over-population as contributing factor 147

5.2.5.2 Poor infrastructure 148
5.2.5.3 Vulnerability of community members 149
5.2.5.4 Poor access to clean drinking water during floods 151
5.2.5.5 Infrastructure is affected due to flood disasters 152
5.2.5.6 Access to healthcare facilities is disrupted 154
5.2.5.7 Healthcare provision is interrupted during floods 155
5.2.5.8 Increase in disease outbreak during flood disaster 156
5.2.5.9 Water sources in the community are affected 159
5.2.5.10 Floods impact livelihood negatively 160
5.2.5.11 Security of community against flood disaster 161
5.2.5.12 Response to flood disasters by the government 162
5.2.6 Exposure to floods 163
5.2.6.1 Relationship between respondents' home closeness to water bodies and likelihood of falling ill after flooding. 168
5.2.6.2 Relationship between the adequacy/functionality of the community drainage system and the loss of property to floods 170
5.2.7 Flood management 172
5.2.7.1 Flood prevention and mitigation measures 172
5.2.7.2 Respondents' flood preparedness 174
5.2.7.3 Flood response plan by eThekwini disaster management centre 177
5.2.7.4 Relief measures by the eThekwini DMC 178
5.3 QUALITATIVE DATA ANALYSIS 182
5.3.1 Thematic analysis 182
5.3.2 Response rate 188
5.3.3 Respondent consent and demographic data 188
5.3.4 Analysis and interpretation of results collected from disaster managers and practitioners 190
5.3.5 Analysis and interpretation of result collected from ward councillors and ward committee members 204

5.3.6 Analysis and interpretation of results collected from senior disaster management officials 212
5.4 DEVELOPMENT OF FRAMEWORK FOR INTEGRATED FLOOD RISK MANAGEMENT (IFRM)....................218
5.4.1 Achieving the plan for the IFRM framework development 218
5.4.1.1 Control of the extent and frequency of flood disaster 218
5.4.1.2 CBDRM 219
5.4.1.3 Adoption of international good practices and policies 219
5.4.2 Objective 6 – Develop A FRM Framework for the Study Area 219
5.5 IFRM FRAMEWORK 224
5.6 APPLICABILITY OF THE FRAMEWORK 228
5.7 CONCLUSION 228
CHAPTER 6....................229
CONCLUSION AND RECOMMENDATIONS 229
6.1 INTRODUCTION 229
6.2 CONCLUSION 229
6.3 SUMMARY OF FINDINGS 230
6.3.1 Summary from quantitative analysis 230
6.3.2 Summary from qualitative analysis 234
6.3.2.1 Summary of findings from disaster management practitioners. 234
6.3.2.2 Summary of findings from ward councillors and ward committee members 236
6.3.2.3 Summary of findings from senior disaster management officials 236
6.4 RECOMMENDATIONS 238
6.5 AREAS FOR FURTHER RESEARCH 240
REFERENCE LIST 241
APPENDICES 282
APPENDIX 1: DURBAN UNIVERSITY OF TECHNOLOGY ETHICS APPROVAL 282

APPENDIX 2: PERMISSION TO CONDUCT RESEARCH 283
APPENDIX 3: APPROVAL LETTER TO CONDUCT RESEARCH......................284
APPENDIX 4: LETTER OF INFORMATION AND CONSENT TO CONDUCT INTERVIEW 285
APPENDIX 5: LETTER OF INFORMATION AND CONSENT FOR QUESTIONNAIRE SURVEY 288
APPENDIX 6: RESEARCH QUESTIONNAIRE 291
APPENDIX 7: INTERVIEW GUIDE...301
APPENDIX 8: PHOTOGRAPHIC REPRESENTATION OF STUDY AREA.......309
APPENDIX 9: TURNITIN REPORT...310
APPENDIX 10: EDITOR'S LETTER..311

LIST OF FIGURES

Figure 1.1 Relative population exposure to 15cm or more flood inundation risk at the country level (%) 11
Figure 1.2 Annual averages of spatial distribution of flood disasters from 1990 – 2016 13
Figure 2.1 Conceptual framework for Integrated Flood Risk Management in urban settlement in the eThekwini Area 29
Figure 3.1 A journey through time and space 61
Figure 4.1 Map showing location of eThekwini Metropolitan Area (a.k.a. Durban) 98
Figure 4.2 Map showing topography of eThekwini Metropolitan Area 100
Figure 4.3 Qualitative data analysis flowchart 112
Figure 5.1 Distribution of Respondents' Age range by study area 123
Figure 5.2 Distribution of Respondents' educational attainment 126
Figure 5.3 Distribution of Respondents' Occupation 128
Figure 5.4 Distribution of Household Size 129
Figure 5.5 Community residency (Years) 132
Figure 5.6 Basic Income 134
Figure 5.7 Study Area vs. flood frequency on property 141
Figure 5.8 Study Area vs. Estimated cost of damage on property 144
Figure 5.9 Percentage distribution of response on flooding is due to nearby rivers 146
Figure 5.10 Percentage distribution of response on overpopulation as a cause of flooding 148
Figure 5.11 Percentage distribution of response on infrastructure as a cause of flooding 149
Figure 5.12 Percentage distribution of response on vulnerability of community members to flooding 150

Figure 5.13 Distribution of access to clean drinking water during flood disaster ... 151
Figure 5.14 Impact of flood disaster on infrastructure ... 152
Figure 5.15 Impact of flood disaster on access to healthcare facilities ... 155
Figure 5.16 Impact of flood disaster on healthcare provision ... 156
Figure 5.17 Increase in disease outbreak during flood disaster ... 157
Figure 5.18 Frequency of interaction between flooding occurrence yearly and its impact on disease outbreak ... 159
Figure 5.19 Response on effect of water sources in the community during flood disaster ... 160
Figure 5.20 Response on effect of negative impact of flood on livelihood ... 161
Figure 5.21 Response on security of community against flood disasters ... 162
Figure 5.22 Response on prompt response by Disaster Management officials during flood disasters ... 163
Figure 5.23 Percentage distribution of individual vulnerability ... 164
Figure 5.24 Percentage distribution of closeness to water bodies ... 165
Figure 5.25 Percentage distribution of respondents who lost family members to flood ... 166
Figure 5.26 Percentage of respondents who have lost property to flood ... 166
Figure 5.27 Percentage of response on functional drainage system ... 167
Figure 5.28 Percentage of respondents who have fallen ill after flooding ... 167
Figure 5.29 Frequency of interaction between home closeness to water bodies and likelihood of falling ill after flooding ... 168
Figure 5.30 Frequency of interaction between the adequacy/functionality of the community drainage system and the loss of property to floods ... 170
Figure 5.31 Percentages of response on flood disaster risk preventive and mitigation measures ... 173
Figure 5.32 Percentage response on flood mitigation activities in study area ... 174
Figure 5.33 Percentage response on community participation in flood mitigation activities ... 174

Figure 5.34 Percentages of response on early warnings through flood forecast 175
Figure 5.35 Percentages distribution of medium of flood forecast in the study area 176
Figure 5.36 Percentages of response on flood preparedness.................................... 177
Figure 5.37 Percentages of response on flood disaster risk concerns 177
Figure 5.38 Percentage of response on flood response plan by DMC 178
Figure 5.39 Percentage of response on municipal incentive for flood Preparedness 179
Figure 5.40 Percentage of response on flood relief package after the flood Disaster.. 180
Figure 5.41 Thematic analysis map 186
Figure 5.42 Integrated Flood Risk Management Framework for EMA................... 223

LIST OF TABLES

Table 1.1 Flood risk categories 10
Table 2.1 Interview and questionnaire guide for flood risk assessment 32
Table 2.2 Interview and questionnaire guide for storm water management........ 37
Table 4.1 Qualitative sample size........ 103
Table 4.2 Quantitative sample size 105
Table 4.3 Appropriateness of research data collection 106
Table 5.1 Response Distribution of the study area........ 121
Table 5.2 Gender Distribution across the Study Area........ 122
Table 5.3 Marital status across the Study area 124
Table 5.4 Property type in the Study Area........ 131
Table 5.5 Ownership Status........ 133
Table 5.6 Statistics on impacts of flood on property 135
Table 5.7 Age of property........ 136
Table 5.8 Flood frequency on property........ 137
Table 5.9 Duration of flood inside property 138
Table 5.10 Estimated cost of damage to property 139
Table 5.11 Cross tabulation of study area versus flood frequency on property 140
Table 5.12 Chi-square test for study area versus flood frequency on property........ 142
Table 5.13 Cross tabulation of study area versus Estimated cost of damage on property........ 143
Table 5.14 Chi-square Test for Study Area vs Estimated cost of damage on property........ 144
Table 5.15 Confirmation of any help received during flood disaster........ 145
Table 5.16 Descriptive statistics........ 153
Table 5.17 Correlations between poor infrastructure contributing to floods and the impact of infrastructure during flooding 153
Table 5.18 Crosstabulation on relationship between the frequency of

flooding and its potential impact on disease outbreak 157
Table 5.19 Chi-Square Tests for yearly flooding frequency vs. Increase in disease outbreak 158
Table 5.20 Statistics on responses to exposure of community members to flood disasters 164
Table 5.21 Chi-square tests of the relationship between respondents’ home closeness to water bodies and likelihood of falling ill after flooding .. 168
Table 5.22 Crosstabulation of Community drainage system and loss of property to flood 170
Table 5.23 Chi-square tests of the relationship between the adequacy of the community drainage system and the loss of property to floods 171
Table 5.24 Crosstabulation of Municipality incentive for flood versus Flood risk concerns 180
Table 5.25 Chi-square tests on Municipality incentive for flood versus Flood risk concerns 181

LIST OF ACRONYMS AND ABBREVIATIONS

CBDRM	Community-Based Disaster Risk Management
DMC	Disaster Management Centre
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
EMA	eThekwini Municipal Area
EWS	Early Warning System
FDRM	Flood Disaster Risk Management
FEWS	Flood Early Warning Systems
FRM	Flood Risk Management
FRMC	Flood Risk Management Component
GHG	Green House Gasses
HFA	Hyogo Framework for Action
IDNDR	International Decade for Natural Disaster Reduction
IFRC	International Federation of Red Cross and Red Crescent Societies
IFRM	Integrated Flood Risk Management
KZN	KwaZulu-Natal
MDGs	Millennium Development Goals
NGO	Non-governmental Organization
PPC	Policy and Practice Component
RC	Resilience Component
RWH	Rainwater Harvesting
SA	South Africa
SAWS	South African Weather Services
SDGs	Sustainable Development Goals
SFDRR	Sendai Framework for Disaster Risk Reduction
SSA	Sub-Saharan Africa
SuDS	Sustainable Urban Drainage Systems

UN	United Nations
UNISDR	United Nations Office for Disaster Risk Reduction
US	United States
WHO	World Health Organization
WMO	World Meteorological Organization

RESEARCH OUTPUT

i. Assessment and prediction of floods using Standardized Precipitation Index – A case study of eThekwini Metropolitan Area. Olanrewaju, C. C; Reddy, M. Published in Journal of Flood Risk Management DOI: 10.1111/jfr3.12788

ii. Review of Flood Disaster Risk Management in six West African megacities. Olanrewaju, C. C; Reddy M. 17th International Conference on Environmental Science and Technology. Athens, Greece

iii. Vulnerability of Informal Settlements to Flood Disasters: A Review of Public Health Implication. Olanrewaju C. C; Reddy M. 18th International Conference on Environmental Science and Technology. Athens, Greece.

iv. Flood mitigation in eThekwini Municipal Area – Empirical evidence using the Artificial Neural Network. Olanrewaju, C. C; Reddy, M; Olanrewaju, O. A. (In progress)

CHAPTER ONE
INTRODUCTION AND BACKGROUND

1.1 INTRODUCTION

In the past decade, floods have accounted for two-thirds of all natural hazards, affecting more than 730 million people and resulting in billions of US dollars in damages and fatalities to thousands of people (IFRC 2018; WMO 2021). The major factors that cause floods include extreme rainfall and anthropogenic activities such as rapid urbanisation and deforestation (Kasiviswanathan, He and Tay 2017; Alborzi *et al.* 2022). This confirms findings from a study by Li *et al.* (2016) that flood disasters are mainly due to naturally occurring environmental causes such as hydrological, climatic and vegetation characteristics, which include human activities such as destruction of vegetation and occupation of flood prone areas. Major flood disasters have occurred in urban areas around the world due to heavy rains, projected to be more frequent with increasing intensity as a result of the climate change impact (Fatti and Patel 2013; Williams *et al.* 2019).

The World Bank Group (WBG) affirms these affected areas are expected to experience more flooding in the future (WBG 2021). Southern Africa is likely to show a pattern of increment in extreme rainfall, particularly in convective precipitation areas (Engelbrecht, Engelbrecht and Dyson 2012; WBG 2021; Mahlangu 2022). Extreme rainfall in eThekwini municipal area (EMA) causes river, urban, flash and coastal floods (Davis 2016; Olanrewaju and Reddy 2022).

1.2 BACKGROUND OF STUDY AREA

Floods in the EMA are very destructive, with devastating and fatal impacts due to the vulnerability of community members and lack of adequate capacity to manage these disasters. Lack of clear strategies in place to reduce vulnerability to flood risk and weak implementation strategies to integrate all stakeholders of disaster risk management (DRM) are also seen as further reasons for the devastation of flood disasters in South Africa (SA)

(Mkhulisa 2017). The flood disaster of 2019 was particularly severe in the Kwa-Zulu-Natal (KZN) Province, with eThekwini municipality bearing the brunt of the flood disaster, recording 51 fatalities, as well as causing damages estimated at approximately 658 million Rands (Collins 2019).

In 2022, the municipality recorded more than 400 fatalities, displacement of thousands of households and damages in billions of South African Rands (CNN 2022; IFRC 2022; Magidimisha-chipungu 2022). An examination of flood risk in the selected flood prone areas and identification of factors causing vulnerability to floods are important in flood resilience. Also important in reducing losses from floods, is the examination of the current urban flood risk management (FRM) practices of disaster managers and other DRM stakeholders of the EMA. This is very beneficial in improving FRM practices by enhancing the efficiency of disaster managers and other key stakeholders involved in disaster management.

This research focused on the development of an Integrated Flood Risk Management (IFRM) framework to improve the effectiveness of FRM in the study area. IFRM includes all programmes on flood preparation, flood prevention plans and reduction of flood impacts on people and the environment (Elias *et al.* 2013). This research sought to integrate storm water management, disaster resilience strategies adopted by community members and disaster risk reduction (DRR) approaches in a FRM framework. The mixed research approach was adopted in case study research of four strategically located cities, as representative of the entire EMA.

Questionnaires and interviews were used to collect information from purposively sampled community members and role players of disaster management respectively, to develop the IFRM framework. The IFRM framework is expected to promote DRR approaches, develop strategies to encourage and ensure a participatory approach of community members, as well as ensure the cooperation between different stakeholders of FRM to promote effective flood management in the study area.

1.3 CONCEPTUALISING AND UNDERSTANDING KEY TERMINOLOGY

1.3.1 Hazard

A hazard is a potentially damaging phenomenon, human activity or physical event that may cause damage to property, injury or loss of life. It may also cause economic and physical disruption or environmental degradation (UNISDR 2015a). According to the United Nations Office for Disaster Risk Reduction (UNISDR 2015a), hazards include physical conditions that may pose future threats. The origin of hazards can be natural or human-induced. Natural hazards can be hydro-meteorological, geological and biological in origin, while hazards brought about by human-induced processes include environmental degradation and technological hazards. Further to this, hazards can be characterised by their probability, intensity, frequency and location. A hazardous event is said to have occurred when a human-induced or natural phenomenon happens in a specific place, during a particular time period, as a result of the existence of a hazard (UNISDR 2015a). A disaster occurs when hazard combines with risk factors.

Hydrological and meteorological hazards are hazards that result from the state of the earth's atmosphere, as well as how it interacts with the oceans and lands, weather and climate the earth produces, and its resultant distribution of water resources (UNDRR 2020). In SA, it is monitored and forecasted by the South African Weather Services (SAWS). Flood hazard is a hydro-meteorological hazard. These are processes or phenomenon of hydrological, atmospheric or oceanographic nature that may lead to injury, morbidity or mortality, loss of livelihood, property and environmental damage or social and economic disruptions (UNDRR 2020). Other hydro-meteorological hazards include thunderstorms, drought, tropical cyclones (hurricanes and cyclones), and hailstones, as well as tornadoes, coastal storm surges and avalanches. The origins of these hazards are observed, monitored and forecasted by the national meteorological and hydrological services. Hydro-meteorological hazards can be a precursor to other hazards such as landslides and epidemics.

1.3.2 Disaster

Disaster is defined as an interference in the functionality of a society or a community due to the interaction of hazardous events with the vulnerable conditions and exposure resulting in widespread material, human, environmental and economic losses in a community (UNISDR 2015a). The effect of the disaster in the community or society is often extensive and could last for an extended time, exceeding the capacity of the society or community to cope and recover by itself and thus, may require assistance from external sources that could be national, neighbouring jurisdiction or international levels. Thus, disaster is a combination of hazard, exposure, vulnerability and insufficient capacity to cope with potential negative consequences, such as diseases, injuries, as well as negative impacts on physical, social and mental well-being of an individual, property damage, disruption or loss to services and environmental degradation (UNISDR 2015a).

1.3.3 Risk

Risk is the inability of an individual, society or community to cope with a particular situation or hazardous event (UNISDR 2015a). Risk is a function of hazard, vulnerability, exposure and resilience (Thywissen 2006). According to the UNISDR (2015a), risk is a combination of the probability of the occurrence of a hazardous event and its consequences. This is as a result of the interaction between hazards (natural or man-made), vulnerability, exposure and capacity (UNISDR 2015a). Risk could be said to be the result of the possibility of damage caused by a hazard as a consequence of vulnerability within a community (van Niekerk 2005). Thus, the effect of a hazard on communities will vary due to different types and levels of inherent vulnerabilities and different coping strategies adopted within that particular community.

1.3.4 Disaster Risk

This is defined as the potential disaster loss in lives and livelihood, infrastructure and service delivery to a community or society over a defined future period of time (UNISDR 2009). The concept of disaster risk reflects the continuous presence of risk conditions. According to the UNISDR (2015), disaster risk is expressed as the probability of loss to life, injury or damaged assets to a society, community or system in a specific time. However, with a good understanding of the prevailing hazard, socio-economic development and pattern of population, disaster risk can be assessed and mapped.

1.3.5 Disaster Risk Reduction (DRR)

DRR is aimed at strengthening resilience by preventing new risk, reducing existing risk and managing residual risk (UNISDR 2015a). The Sendai Framework for Disaster Risk Reduction (SFDRR) 2015-2030 is the globally endorsed policy of DRR set out by the United Nations (UN). SA is among the 187 UN-member states that adopted the SFDRR in 2015. The SFDRR, a non-legally binding framework, provides comprehensive guidelines on DRR efforts to government, Non-Governmental Organizations (NGOs), the private sector, and local authorities, along with academic institutions (Bricen˜o 2015). The SFDRR offers the National government the opportunity to improve its capacity to deal with disaster risk at all levels and access all scales and sectors (Aerts *et al.* 2018).

The SFDRR advocates for substantial DRR and losses in lives, livelihood and health in the physical, social, environmental, and economic, as well as cultural aspects of individuals, communities, businesses and countries (UNISDR 2015a).

1.3.6 Disaster Management

Disaster management is the organisation, planning and application of measures needed to prepare for, respond to and establish initial recovery from disasters (UNISDR 2015a). Management of disasters is focused on the creation and implementation of preparedness measures and plans necessary to decrease the impact of disasters and to ‘build back better’.

Although disaster management may not necessarily remove the threats, with appropriate application of disaster management plans, damage to life, infrastructure and livelihood can be prevented or reduced.

1.3.7 Disaster Risk Management (DRM)

The concept of DRM involves the application of DRR polices, processes and actions needed to prevent new risk, reduce existing risk and manage enduring or residual risk. Thus, leading to the strengthening of resilience (UNISDR 2015). The DRM policy, process and actions involve all activities necessary to avoid the creation of new risk, address pre-existing and immediate risk, thus reducing the impacts of disaster on societies and communities.

1.3.8 Vulnerability

Vulnerability plays a crucial role in the proper evaluation of flood impact. Hence, vulnerability is one of the defining components of disaster risk, namely:

Risk = Hazard (H) x Exposure (E) x Vulnerability (V)

Reducing vulnerability is one of the major ways to reduce risk, according to the International Federation of Red Cross and Red Crescent Societies (IFRC). Thus, vulnerability can be described as the reduced capacity of an individual or community to anticipate, cope with, resist and recover from the effect of a man-made or natural hazard (IFRC 1996).

While some definitions of vulnerability have included exposure and susceptibility to harm, it has been understood in recent times that exposure is not included in the susceptibility element of vulnerability, because it is possible to be exposed to natural hazards but not susceptible to them (UNDRR 2021b). An understanding of vulnerability overshoots more than merely analysing the direct impacts of hazards. Vulnerability involves, in a broader context, environmental and social conditions that limit the ability of people and communities to cope with impacts of hazards (UNDRR 2021). Vulnerability is a set of prevailing conditions determined by social, economic, physical and environmental factors, leading to increased susceptibility of a community to the impact of hazard (UNISDR 2015a; UNDRR 2017). These factors cause physical, social and economic vulnerability.

Physical vulnerability is determined by aspects such as levels of population density, remote locations of settlements, building materials used in the construction of houses and infrastructures, and so on. In the concept of flood hazards, physical vulnerability describes the inability of a built environment to withstand the impact of flood hazard.

Social vulnerability is defined as the susceptibility of social groups to the impacts of hazards, as well as their ability to adequately recover from them (Cutter 2006). The UNISDR (2021) defines social vulnerability as the inability of people, organizations and societies to withstand adverse impacts of hazards, as a result of the inherent characteristics in social interactions, institutions and systems of cultural value. Factors that cause social vulnerability include marginalisation, poverty, inequality, and discrimination, as well as social exclusion, to mention a few.

Economic vulnerability relates to the economic status of individuals, communities and nations. Some factors that cause social vulnerabilities include: vulnerability of rural livelihoods, uninsured informal sector, and the globalisation of business and the supply chain (UNISDR 2021).

1.3.9 Capacity

Capacity is defined as the combination of all the strengths, resources and attributes available within a community, society or organisation in the management and reduction of risks and the strengthening of resilience (UNISDR 2015a). Capacity includes societal coping abilities, as well as human knowledge and skills.

1.3.10 Resilience

This is the ability of a society, community or system exposed to hazards to have the capability to resist, absorb, recover from and accommodate the effects of a hazard in an efficient and timely manner, which also include the preservation and restoration of its essential basic structures and functions (UNISDR 2015). Resilience means the ability to spring back from a shock. The resilience of a community to flood hazards is determined by the degree to which the community has the resources and capabilities to organise itself before and during flood disasters.

1.3.11 Precipitation

Precipitation is the connection in the water cycle responsible for the delivery of atmospheric water in the earth (Advanced Remote Sensing 2020). Water vapour and water droplets suspended in the air build up in the atmosphere and are visible as clouds. Accumulation of vapours and other materials in the air make the clouds fill up, with precipitation then released from the clouds. Precipitation falls in different forms and amounts such as rain, snow, hail, and sleet or freezing rain, throughout the world. Most precipitation falls as rain (Advanced Remote Sensing 2020).

1.3.12 Framework

The term framework could have different meanings and varied interpretations. In general, a framework is a conceptual or real structure intended to serve as a guide or support for the construction of something that leads to an expansion of something useful (Lutkevich 2020). A framework is a set of factors that should be considered for a specific or particular phenomenon and having a suggested sequence in which to consider them (van Niekerk 2005). In addition, a framework also addresses the relationship between the different variables. For this study, a framework is a skeletal conceptual construct that forms an outline and foundation containing concepts, practices and values of the way of viewing or solving the flood disasters in the study area specifically, and other areas in Sub-Saharan Africa (SSA) vulnerable to flood hazards in general.

1.3.13 Disaster Management Good Practices

Good practice is an experience continuously successful when replicated in different contexts and can, therefore, be recommended as a model (Hare 2013). Sharing of good practices is encouraged, so a great number of people, institutions and countries can adapt and adopt it in solving similar situations. Capitalisation and knowledge sharing of good practices have a very important role to play in DRR and management (Gautam 2010). By sharing good practices on DRR and management from various countries around the globe, a long-lasting and real culture of prevention and management of disasters can be established.

1.4 GLOBAL OVERVIEW OF FLOODS

Flooding disasters are the most dominant natural hazard, affecting people globally, with 19 percent of the world population directly exposed to a 1 in 100-year flood risk. In addition, 89 percent of the 1.47 billion people exposed to flood worldwide, live in low and middle-income countries (Rentschler and Salhab 2020). In an examination of the number of people living under extreme flood risk in 189 countries, using high resolution flood and population data, Rentschler and Salhab (2020) show that 29 percent of the world population live in areas highly prone to flooding, of which the highest number of people exposed, live in South and Eastern Asia. The study also highlighted the significance of income level of the exposed population in the impact of flood disasters. It authenticates that income plays a relative relationship in people's resilience to flood disasters. Thus, in developed countries, mitigation strategies such as flood protection infrastructure and rapid government support systems in post-disaster situations reduce flood risk, as compared to developing and under developed countries.

A United Nations report (UN 2019)records that 2.2 billion people, which represent the world population estimates of 7.7 billion, are exposed to a significant amount of flood risk; signified by inundation of above 0.15 meter, making it one in five people globally being exposed to flood. According to flood risk categorisation by Rentschler and Salhab (2020), an inundation depth of 0.15 meters of flood and above (Table 1.1) pose significant risk to lives, particularly the vulnerable population.

Table 1.1: Flood risk categories (Rentschler and Salhab 2020)

FLOOD RISK CLASSIFICATION		INUNDATION DEPTH
LOW RISK	No risk	0 meters
	Low risk	$0 \geq 0.15$ meters
HIGH RISK	Moderate risk	$0.15 \geq 0.5$ meters
	High risk	$0.5 \geq 1.5$ meters
	Very high risk	≤ 1.5 meters

Figure 1.1 illustrates that India and China constitute the largest number of people exposed to flood risk, which comprises a third of all people exposed to flood risk, with the SSA region another hotspot of people exposed to flood risk.

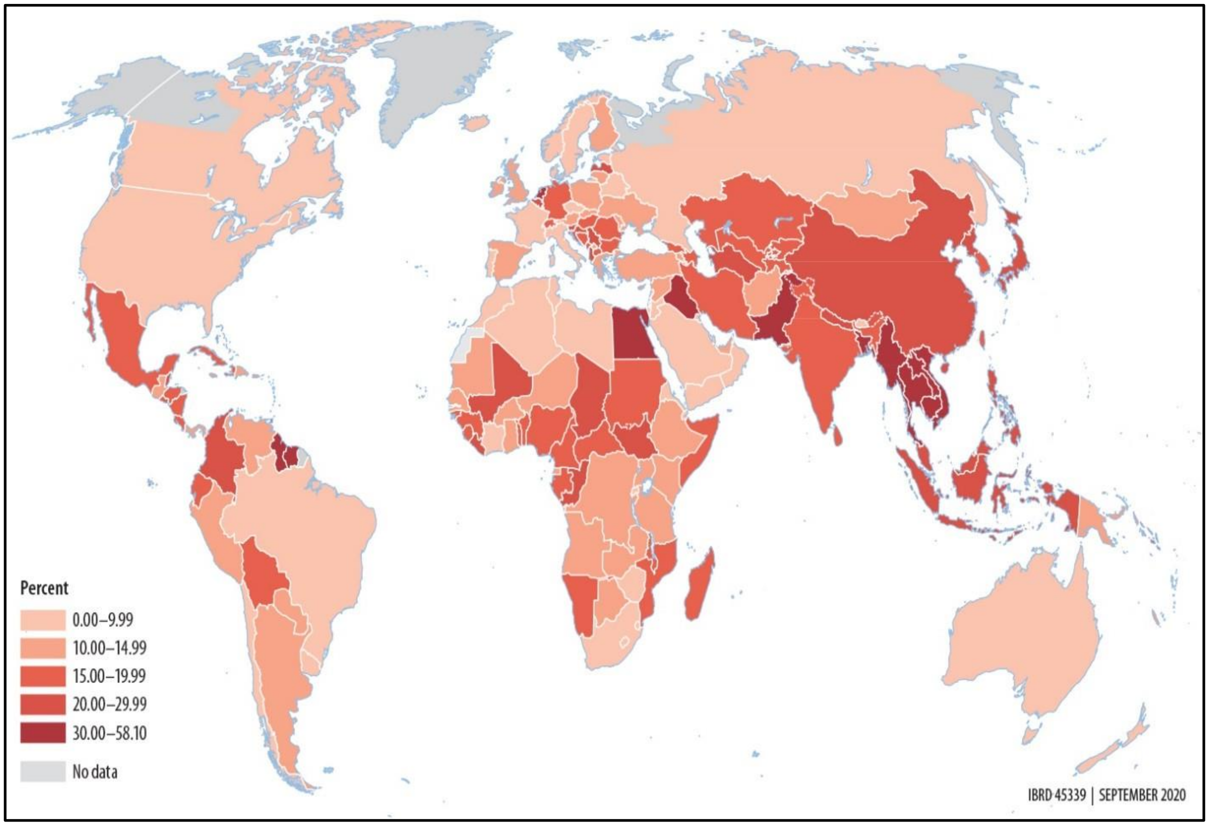

Figure 1.1: Relative population exposure to 15cm or more flood inundation risk at the country level (%)
Source: Rentschler and Salhab (2020)

Research by Rentschler and Salhab (2020) estimates at least 71 million people living in SSA are exposed to significant flood risk and extreme poverty, making them particularly vulnerable to long-term effects of floods on their well-being and livelihoods.

1.4.1 Overview of floods in Africa

Flood disasters in Africa account for 82.6 percent of all disasters, with an increasing trend of more than 16 percent from 2009–2010 (Balgah, Buchenrieder and Mbue 2015). Flood disasters in Africa are influenced by the ocean temperature increase and decrease phenomena of El-Nino and La-Nina, which lead to inter-annual variability. The larger the

La Nina phenomenon becoming more obvious, the higher the tendency of annual precipitation, causing more flood disasters, as is the case with Southern and West Africa (Li *et al*. 2016).

Regions in Africa are affected differently due to difference in economy, climate, hydrology and population size (Li *et al.* 2016). Furthermore, poverty is also implicated as one of the leading causes of flood disasters in the African continent. Matunhu (2012) in his research affirms increased level of poverty in Africa especially in impoverished communities forced people to live in vulnerable flood prone areas and thus exposing them to flood risk. Of the 132 million people estimated to live in flood risk areas, 55 percent live in SSA (Rentschler and Salhab 2020).

Li *et al.* (2016) carried out research of 55 African countries (49 continental and six Island countries) from 1990–2014 on spatial distribution patterns of four significant variables. These include average annual flood frequency, flood damage, total affected and total deaths of people, which showed flood disasters based on seasonal changes in different African regions, with the exclusion of North Africa, are related to precipitation (Figure 1.2). Precipitation is seen to be one of the main factors affecting the occurrence of flood disasters in different regions in Africa. Flood disasters are found to be highest in August; due to the location of the Nile Basin, floods occur from August to October in the North and Eastern parts of Africa.

According to Li *et al* (2016), in Southern Africa, the Zambezi and Orange rivers cause monthly trends in flood disasters, because of precipitation occurring mainly in the months of December to March. In the West of Africa, the region is divided into two sections, namely the Southern and Northern parts. The Southern part has a tropical rain forest climate, while the Northern part has a tropical temperate or semi-arid climate. The rainy wet season overlaps with the hot summer climate. Floods in the West of Africa occur mainly from June to September, where precipitation and runoff are higher. Central Africa lies in the Congo River Basin, with a tropical rain forest climate causing flood disasters from August to October with excessive rainfall (Li *et al*. 2016).

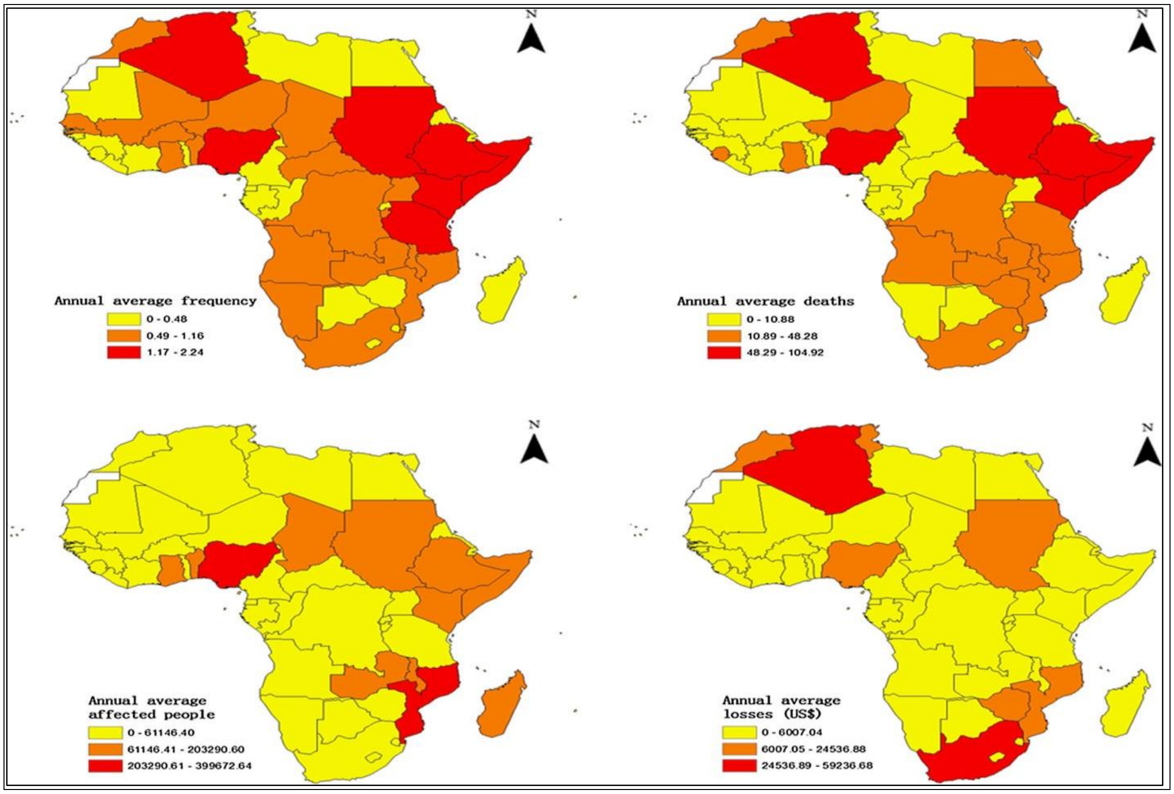

Figure 1.2: Annual averages of spatial distribution of flood disasters from 1990–2016 upload

Source: Li, *et al.* (2016)

The research also shows Nigeria (West Africa), Ethiopia, Somalia, Tanzania and Kenya (East Africa), as well as Sudan and Libya (North Africa) are flood prone areas, with the main causes of flooding identified as, among others, population, urbanisation rate, per capita GDP and runoff.

A study by Di Baldassarre *et al.* (2010) to assess the relationship between flood zones and flood disaster intensities, population growth and economic development in Africa, shows that a fast growing population, high concentration of people and unplanned settlement in flood prone areas led to high flood mortality. Most affected people are, on average, concentrated in the Eastern parts of Africa (Figure 1.2). Between the years 1990–2014, flooding occurred 774 times, causing casualties leading to death 369 times, with an upward trend over the years under study. This increase was seen to be faster in West Africa as compared to other African regions (Li *et al.* 2016), which is attributed to frequency of flood disasters and population density. High levels of poverty in East and Central African countries, in comparison to other African regions, lessen the economic losses from flood disasters (Stein 2010). More developed countries such as SA and Libya have higher economic losses (Li *et al.* 2016); which destroys and sets back development gains.

1.5 STUDY AREA DESCRIPTION

eThekwini is a metropolitan area located on the eastern coast of SA. It spans an area of 2 297km^2, inclusive of a narrow coastal plain stretch of 98km, dividing into major river valleys originating to the west of the city. With a population estimate of approximately 3 890 001, at an annual growth rate of 1.7 percent, it is the third largest city in SA, after Johannesburg (StatsSA 2016, 2019; Ethekwini Municipal 2018). The eThekwini metropolitan area includes urban and rural areas with 18 percent occupied by formal households, five percent informal and 10 percent peri-urban settlements. eThekwini metropolitan is coined from the Zulu name Durban.

For the purpose of this research, the eThekwini metropolitan area (EMA) will be simply described and interchangeable as Durban. Comprised of hilly and steep topography, river valleys, ravines and gorges, Durban has a sub-tropical climate. It has an annual precipitation of more than 1 000mm due to a significant amount of rainfall experience throughout the year, with temperatures ranging from 16 to 33 degrees centigrade (Turpie *et al.* 2017). Thus, Durban experiences sunshine almost throughout the year.

Durban comprises several cities and towns. The areas selected for study in this research include Inanda Township, uMlazi Township, Cato Manor Township and Clare estate.

These areas are strategically located in the North, South-West, West and Central parts of the study area, to depict inclusiveness.

1.5.1 Causes of floods in eThekwini

Flood frequency in eThekwini can be attributed to various factors primarily linked to climate change. Global warming leads to intense and frequent events that culminate in heavy rainfall. The geographical location of eThekwini also plays a role in flood frequency in the area. Several scientific studies have additionally shown the inability to integrate risk assessment and management in the design and development of cities has led to risk informed urban planning. These are discussed below

1.5.1.1 Precipitation

SA is one of the most diverse countries in the world, with 233 different ecosystems and 792 wetlands ecosystems (WWF-SA 2013). KZN is lined with water sources along the escarpment. These include the Caledon river, which feeds into the Orange river, supplying the interior of the province and the Southern Drakensberg, extending into the midlands, supplying the uMgeni and Mooi rivers. Other rivers include the Thukela, Mkomusi and uMzimkulu. These rivers service the communities around Durban. Prolonged and steady rainfalls as well as heavy, short rainfall enable the rivers to rise slowly or quickly respectively, bursting banks and causing coastal, riverine and urban floods (Davis 2016).

The topography of Durban entails steep and hilly slopes that reduce the amount of infiltration of water into the ground that enables the water to flow quickly down into the rivers, thereby causing overland flow, which may lead to flash floods. Heavy rainfall in hilly and mountainous areas can cause flash floods to occur within minutes. Due to the fast-moving nature of flash floods, it is disastrous. The flow of water can also cause flooding to occur downstream, even in the absence of heavy rainfall.

The high population of Durban has resulted in deforestation in order to make way for the expansion of the city. Deforestation involves the removal of tress that otherwise intercept rainfall and prevent soil erosion, thus decreasing the risk of flooding.

1.5.1.2 Temperature

Durban is known for its warm weather throughout the year. Temperature plays an important role in the hydrological cycle. Increased temperature results in increased atmospheric rates, which lead to more atmospheric pressure and subsequently, heavier rainfall (Eloff 2024). Research has shown temperature is a very important variable in the prediction of flood risk (Kaur and Singh 2011).

1.5.1.3 Urbanisation

Migration of people from rural to urban areas has led to speedy urbanisation, however, the cities are not growing with the people. According to Magidimisha-chipungu (2022), risk assessment and management is not being integrated in the design and development of cities. Construction of infrastructure, roads, bridges, houses and more, to accommodate the migration of people, has led to the formation of more impermeable surfaces. Lack of adequate housing has also resulted in the encroachment of flood prone areas for construction of living areas and disposal of debris into the water bodies, causing blockage and hindrance to proper water flow.

Insufficient proper maintenance of urban streams, dams and rivers as a result of illegal dumping also interferes with the proper flow of storm water, resulting in blockage during heavy rainfall (Meshgi *et al.* 2015). These interferences of proper water flow contribute to urban or storm water floods. Surface water floods also result due to the accumulation of water over the ground when drainage systems are overwhelmed to capacity (Falconer 2009). Climate change impacts in the presence of rapid urbanization further increase the vulnerability of urban poor to natural hazards such as floods (Williams *et al.* 2019).

1.5.1.4 Climate change

The risk of floods is increased with a warmer climate. Projections in climate change indicate significant increases in the intensity and frequency of floods (Ahern 2011). Extreme weather patterns as a result of long-term global climate change are implicated in flooding events occurring worldwide (UNEP 2020). According to the United Nations Environment Program (UNEP), extreme flood is triggered by intense precipitation of a long duration and high frequency (UNEP 2020). The UNEP asserts there will be more intense and more frequent extreme meteorological events due to climate change.

1.6 PROBLEM STATEMENT

The uncontrolled gathering of water in huge quantities is very destructive. This is the case in the study area, where flooding occurs on a yearly basis, causing extensive damage to infrastructure and houses, displacing thousands of people and resulting in fatalities. Floods in the study area are exacerbated due to overpopulation that has led to expanded density of settlements, thus straining infrastructure and reducing land absorption (Marsh 2019); poor waste management leading to blocked drainage systems, exacerbating floods and health hazards (Nnwanonyiri 2021); and occupation of flood prone areas which heightens exposure and economic vulnerability (Reichel 2019). These causes devastating effects on the people and environment. In July 2016, extreme rainfall caused flooding in Durban, with flood damage amounting to millions of Rands, leaving several dead and thousands displaced (Davis 2016). This trend of devastation continued in 2017, 2019 and 2022 (Olanrewaju and Reddy 2022).

There are no clear strategies in place to reduce vulnerability to flood risk, while implementation strategies to integrate all stakeholders of DRM are weak (Mkhulisa 2017). Research shows a weak transfer of information from the national to the district level, skill shortages and inadequate disaster management structures in district municipalities in SA, causing inadequacies in FRM (Zuma *et al.* 2012; SA Cities 2021). The increment in vulnerability to flood risk in the study area highlights the urgent need to find solutions to deal with the problem of effective FRM.

1.7 PURPOSE OF STUDY

Flood is a leading cause of damage among all natural hazards, bringing annual losses from floods to billions of US dollars and fatalities to thousands of people every year (IFRC 2018). Frequent flood disasters have been recorded in EMA through the decades causing extensive damage. Alexander (2002) described the 1999/2000 flood that occurred over most of SA as the most severe humanitarian disaster in the sub-continent. The 2009/2010 flood disaster in SA affected millions of people (SARCS 2011). The South African Red Cross Society (SARCS) records show KwaZulu-Natal (KZN) as one of the worst hit provinces, with household displacement of more than 1 800 (SARCS 2011). More recently, the flood disaster of 2019 and 2022 were particularly severe in KZN, with Durban bearing the brunt and recording several fatalities, as well as causing damages estimated at more than 658 million Rands (Collins 2019; CNN 2022).

When flood occurs amid vulnerability and a lack of adequate capacity within the community to manage it, this results in disasters leading to serious consequences to the natural environment and human life. Lack of clear strategies in place to reduce vulnerability to flood risk and weak implementation strategies to integrate all stakeholders of DRM are implicated as one reason for flood disasters in SA (Mkhulisa 2017). An examination of the current FRM practices within the EMA will be beneficial in improving FRM practices. This can be achieved through enhanced efficiency of disaster managers and other stakeholders involved in disaster management, while it will also improve resilience of community members to flood disasters.

1.8 RESEARCH AIM AND OBJECTIVES

The aim of the research was to develop an Integrated Flood Risk Management (IFRM) Framework for the EMA. The specific objectives of the research include the following:

i. Examine flood risk in the selected flood prone areas.
ii. Identify the factors that increase vulnerability of community members to floods in the study area.
iii. Examine the disaster management practices employed by disaster managers in urban FRM in the study area.
iv. Examine the role of key stakeholders to urban flood management in the study area.
v. Examine FRM good practices in other developing and developed countries.
vi. Develop a framework for IFRM in the study area.

1.8.1 Research questions

The research sought to answer the following questions:

i. What are the key factors that influence flood disasters in the study area and what is the trend of flood disasters in the study area from year 2000–2020?
ii. What are the factors that increase vulnerability to floods in the study area?
iii. What are the modalities of FRM adapted in line with global declaration frameworks?
iv. What are the roles of key stakeholders to FRM in the study area?
v. What are the FRM good practices employed in other countries?
vi. How can the theories, practices and findings of flood management in the study area result in development of an IFRMF in the study area?

1.9 CONCEPTUAL FRAMEWORK

Flood risk comprises different facets of problems with different physical, social, economic and hydrological impacts on vulnerable communities. Therefore, managing flood risk effectively will require a combined effect to reduce the impact of flood hazard and community vulnerability. This will involve a diverse array of management strategies (Mavhura 2019; Mai *et al*. 2020). In this research, to effectively manage flood risk in the study area, an integrated approach cognisant of different facets of physical and socio-economic factors was used by developing a conceptual framework of FRM. The concept anchors on the principle of integrating FRM with disaster resilience and good practices of disaster management, to obtain an Integrated Flood Risk Management (IFRM) framework for the study area.

FDRM involves controlling the extent and frequency of floods by undertaking flood and storm-water management activities. FRM is the holistic reduction of flood risk via evaluation and continuous societal analysis (Samuels *et al*. 2010). Approaches to FRM have focused on flood control through structural measures, such as flood infrastructure and controlling flood behaviour through adaptation of various laws and regulations (Morrison, Westbrook and Noble 2018). However, flood losses continue to increase, despite technological advances casting doubts on the efficacy of these approaches (Tanoue, Hirabayashi and Ikeuchi 2016; Mai *et al.* 2020).

Studies have shown over the years that none of the FRM strategies when used alone has been effective; this is due to the complexities in the dynamics of flood management (Di-Baldassarre *et al.* 2013). This research segment of the IFRM commences with the assessment of current and future flood risk in the study area. The assessment provides information on the occurrence of flood hazard (WMO 2008) and enables an understanding of the extent and frequency of floods in the study area and how they can be effectively managed.

To achieve sustainable FRM, strengthening community resilience is very important (Mai *et al.*, 2020). Community-based flood disaster risk management (CBFDRM) strategies involve measures adopted to strengthen community resilience to flood risk via the community's ability to prevent, reduce and cope with floods risk (Schelfaut *et al.* 2011). According to Schelfaut *et al.* (2011), flood resilience measures in a community are tied to improving the capacity of the community in each of the flood management cycles of prevention, mitigation, preparedness, and response, as well as recovery and rehabilitation.

It involves the participation of community members in collaboration with the government in FRM. This segment of the framework sought strategies to ensure a participatory approach of community members and cooperation between different stakeholders of FRM, with the aim of increasing resilience to floods through the disaster management cycle.

Social resilience to flood risk is a slow process that involves an evolution through the process of thinking, negotiating and development of frameworks to understand and manage risk (Grobicki, MacLeod and Pischke, 2015). Over the years, policies and practices have been put in place and tested; these span from the world summit for Sustainable Development in 2002, through to the World Conference on Disaster Reduction in 2005, to the Hyogo Framework for Action (HFA) 2005-2015 and the post-2015 international frameworks on DRR. Using these global milestones, an interconnection can be reinforced between floods, integration and water policy approaches and water management and long term sustainable development (Grobicki *et al.* 2015). This segment of the framework examines stakeholder's approaches and perspectives from around the world that put international good practices and policies into an IFRM framework for the EMA.

1.10 RESEARCH METHODOLOGY

The research adopted a pragmatic worldview in a multi-site study. Inquiries were drawn from both qualitative and quantitative approaches. The pragmatist emphasises the research problem, using all available approaches in understanding the problem (Rossman and Wilson 1985). The qualitative approach was employed to explore and understand the role of DRM stakeholders and the modalities adopted in line with good practices, as well as deduce the efficacy of disaster managers to flood risk in the study area. The quantitative approach sought to obtain the trend of flood disasters, factors that increase vulnerability of community members of the study area, in addition to ascertaining the key factors that influence flood disasters in the study area.

This research comprises a case study research design. The design allows for rich descriptions and insightful explanations. Data for this research were collected in a natural setting, emphasising the flood disaster within its real-world context. The in-depth information gathering was extensive and utilised multiple sources of both qualitative and quantitative information. This research developed an in-depth analysis of FRM in the study area from year 2000 to 2020.

1.10.1 Sampling

Non-probability sampling design was utilised for the research. This sampling type purposively draws respondents from the study area. The sampled respondents are the residents of the study area, drawn purposively to target respondents directly involved and able to produce data relevant to the study. The population sample for the quantitative data was drawn based on length of stay in the study area, age, ownership of property in the study area and frequent visits to communal centres. Key informants for the interview were purposively selected based on expertise in DRM of the study area.

1.10.2 Data collection and analysis

Both qualitative and quantitative data collection methods were used to gather data. The collection of both quantitative and qualitative data neutralises the weakness of either of the data collection procedures (Creswell 2014: 43). Data for this research were obtained using multiple sources, from a historical review of flood disasters between the years 2000–2020, a systemic literature review of the same period, as well as information gained through structured questionnaires and semi-structured interviews. Only participants and respondents who provided their consent by means of signing a consent form participated in the research.

The questionnaires were analysed using descriptive and inferential statistics. Descriptive statistics involve the use of statistics in collecting, describing and presenting the concept of interest via numerical data (coding). The descriptive statistics of the quantitative data include an information summary of the data, frequencies and relationships between categorical variables. Inferential statistics aim to test hypothesis on the probability regarding the likelihood a hypothesised effect, difference or relationship is true or not (Kotronoulas *et al.* 2023). The research sought to use inferential statistics to obtain concrete evidence to link poor infrastructure and service delivery to the trend and frequency of flooding. The coded data were passed through the Statistical Package for the Social Sciences (SPSS) v. 29 software for analysis.

The qualitative data were analysed using the framework analysis technique. Gale *et al.* (2013) report success in the use of this technique for analysis of semi-structured interview transcripts. The NVivo qualitative data analysis computer software was used in the analysis, which allowed the researcher to organise, classify and arrange information, as well as examine the relationships of the data.

1.11 JUSTIFICATION OF STUDY

Floods have been a recurrent phenomenon in the EMA, causing huge losses to lives, livelihood systems, properties, and public utilities, as well as infrastructures. The high risk and vulnerability to floods in Durban are highlighted by the area situated within coastal areas and very prone to floods. Floods are not always caused by extreme rainfall in the study area. Other phenomena that cause floods include steep slopes, impermeable surfaces, over-population and global warming (Olanrewaju and Reddy, 2022).

Flooding in Durban has continued to be more severe with every year. The flood in Durban during the Easter weekend of April 2019 was even more severe than the previous year, causing damage to 235 homes, with roads and bridges washed away and disrupting traffic, making it difficult to get prompt help to victims and at least 51 fatalities were recorded (News24 2019). Informal settlements in Durban were the areas worst affected. Approximately 200 homes in Quarry Road were washed away and at least 500 people displaced in uMlazi, one of the largest informal settlements in Durban (De-Greef 2019).

The selected flood prone areas include uMlazi Township, Inanda Township, Clare estate and Cato Manor, with all situated in different geographical areas of eThekwini municipality, thus, a very good representation of the entire study area.

1.12 DELIMITATIONS

i. The study focused only on the selected formal and informal settlements in the study area.
ii. Participants for the interview are mostly disaster local government officials of eThekwini Municipality.
iii. In-depth information of participants on flood disaster management may not be entirely truthful.
iv. Framework development was restricted to data from selected flood prone areas in Durban.

1.13 LIMITATIONS

i. Extensive research was hindered due to availability of funds.
ii. Lack of stakeholder co-operation slowed the research pace and hindered overall research output.
iii. Data availability limited overall research results.

1.14 SCOPE OF STUDY

The study was confined to FDRM in the EMA. It focused on four strategically located townships as representative of the entire study area. This enabled the capture of meaningful data that are relevant. It is important to note the study was restricted to stakeholders of FRM in the study area.

1.15 STRUCTURE OF DISSERTATION

The research is structured into six chapters.

Chapter 1: Introduction and Background

This chapter covered an introduction of the study, highlighting the study background, global overview of the study topic and in the African continent, a brief description of the study area and the causes of floods in the study area. The problem statement and study purpose, stating the research aim and objectives, were also discussed, along with a brief explanation on the conceptual framework, as well as the research methodology and design. In addition, the justification of the study and a brief scope within the field of context as well as the research output was documented.

Chapter 2: Conceptual framework

This chapter focuses on the conceptual framework of the study. It explains the progression of the procedure used in developing the IFRM framework and will highlight the concepts and theories used, thus providing direction to the research inquiry.

Chapter 3: Literature review

This chapter presents a literature review on urban floods and their impacts, vulnerabilities caused by floods and various resilience strategies employed, FRM good practices and FDRM. Also reviewed is the literature of FRM frameworks.

Chapter 4: Research methodology

This chapter details the research methodology approach and strategies adopted in the study. It will contain information relating to the data collection method, sampling techniques, pilot study, and statistical measures applied, along with validity and reliability of the research method, as well as information related to ethical considerations.

Chapter 5: Data analysis and interpretation of findings

This chapter explains the procedure for analysing the data collected and presents interpretation of findings.

Chapter 6: Conclusions and Recommendations

This chapter sets out the conclusions reached, expected benefits of the research to the study area in specific, and SA and SSA, in general. It also highlights recommendations useful for further research.

1.16 CONCLUSION

The chapter presented a background as well as a conceptual and methodological orientation of the study, outlining the rationale for the development of the IFRMF within the eThekwini municipality. The chapter also offered a brief discussion on the global overviews of floods and an outline of key terminologies used throughout the study. In addition, the research problem and aim and objectives that guide the study, as well as the research methodology and design used to carry out the study were, likewise, included in this chapter. Finally, this chapter provides a brief discussion of the study area, highlighting the causes of flooding in eThekwini and the justification for study. The following chapter presents the conceptual framework of the study, which depicts a roadmap to guide the researcher towards realising the study objectives.

CHAPTER TWO
CONCEPTUAL FRAMEWORK

2.1 INTRODUCTION

A conceptual framework depicts the researcher's roadmap in pursuing the problem being investigated, which Regoniel (2015) states aids in realising the study intent or objectives. Furthermore, it shows understanding of the connection between the study variables, while it is also deemed a pictorial representation of the researcher's reasoning. Regoniel (2015) additionally described a conceptual framework as a synthesis of concepts, interlinked to provide an all-inclusive understanding of the phenomenon under review. These interlocked concepts serve to provide a hypothesis with a firm foundation.

In this study, conceptual framework was used to arrange the various concepts in a logical structure, to aid in providing a visual display of the relationships in the study. According to Luse, Mennecke and Townsend (2012), the framework offers a simplified view of the specification and definition of concepts within the study problem. Several researchers have documented the importance of a conceptual framework. Akintoye (2015) affirms a conceptual framework is used when the existing theory of the study is not applicable or is insufficient. It assists in the identification and construction of the researcher's worldview on the phenomenon being investigated (Grant and Osanloo 2014). The conceptual framework is a simplified way the researcher uses to present solutions to the problems defined in the research (Akintoye 2015).

2.2 THE RESEARCH FRAMEWORK

According to the World Meteorological Organization (WMO) (2009a), the concept of Integrated Flood Management (IFM) is connected to the concept of sustainability. To achieve effective and efficient flood management, Topalović and Marković (2018) affirm the integration of various aspects, such as the environment, landscape and land-use, in an IFM approach ensures the protection and development of ecosystems. The WMO (2009b) highlights six core elements to be addressed by a comprehensive IFM plan. These include the management of the water cycle, management of risk and uncertainty, ensuring a participatory approach, and integrating a hazard management approach, as well as integrating land and water management and adopting flood protection measures and options. Putting these six core elements into perspective, this research focused on the IFRM concept, which combines FRM and mitigation principles to effectively manage flood risk in the study area. This approach merges and integrates various aspects that contribute to developing a holistic and sustainable FRM strategy.

The dimensions of the conceptual framework for the IFRM in this research are described under three categories that include:

i. FDRM
ii. Disaster resilience
iii. Disaster management good practices and policies

The integration is based on the principle of integrating FRM and storm-water management with disaster resilience via CBDRM aimed at reducing vulnerability and increasing coping strategies and disaster management good practices and policies (Figure 2.1).

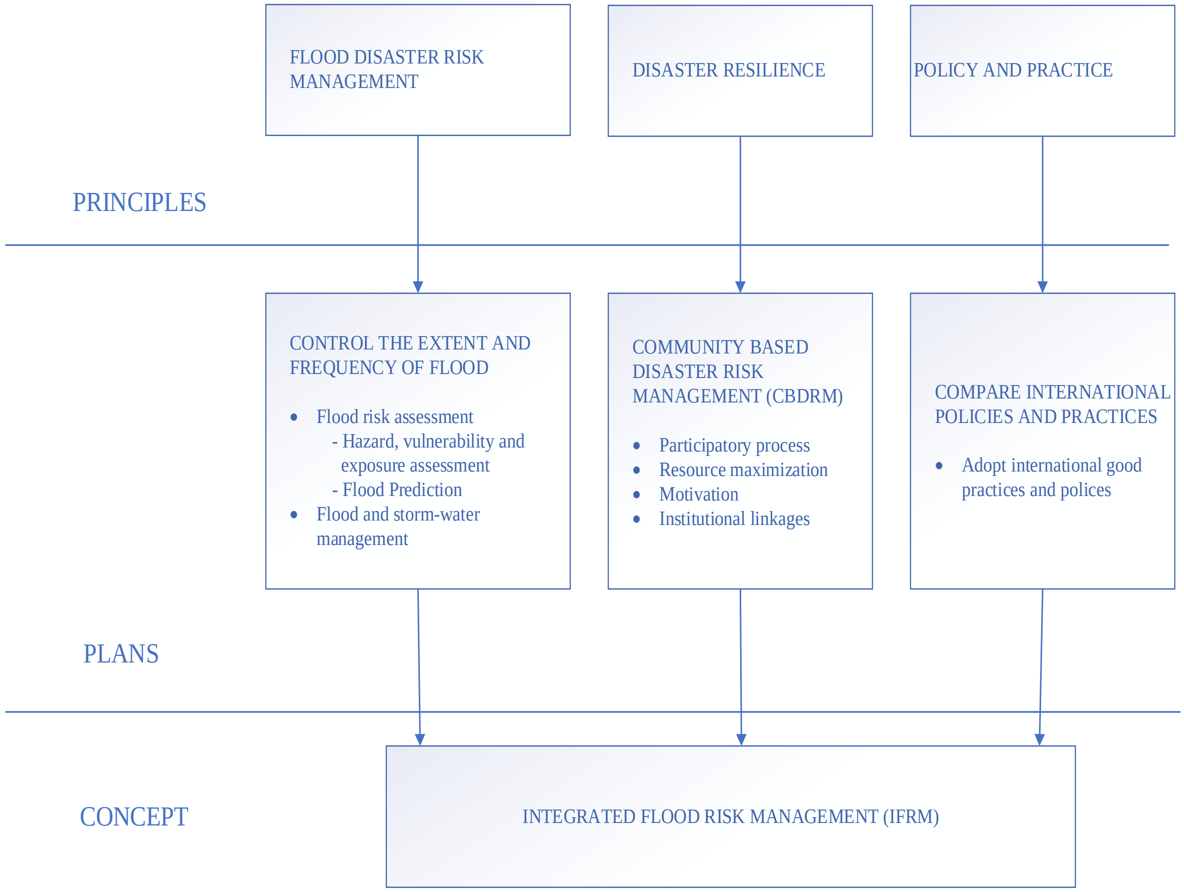

Figure 2.1: Conceptual framework for IFRM in eThekwini Area urban settlement

Source: Author's own conceptual framework (2024)

2.3 DIMENSIONS OF THE CONCEPTUAL FRAMEWORK

The categories of the conceptual framework and the expected relationship are discussed in detail, in addition to their characteristics and how they come together, to draw a coherent conclusion.

2.3.1 FDRM

FRM is defined as a continuous and holistic societal analysis, as well as the assessment and mitigation of floods (Schanze 2006). Absolute flood security is utopian; there is no perfect situation to flood risk avoidance. However, flood risk can be managed by mitigation via reducing flood risk to an acceptable level. This implies reduction of human and socio-economic losses caused by flooding, as well as taking into account the benefits from floods (Dogulu *et al.*, 2015). Flood risk has evolved over the decades from flood protection to FRM (Merz *et al*. 2010; Chiu, Raina and Chen 2022). This evolution has transcended from managing all flood events to risk-informed decision-making to integrated systems and approaches.

Various strategies of FRM have been adopted over the years. Plate (2002) described FRM approach as an integration of risk analysis (hazard determination, vulnerability analysis, risk determination), maintenance improvement (technical measures and non-technical measures), preparedness and disaster response. Schanze (2006) affirms FRM as a range of tasks from flood hazard prediction to assessment of societal consequences to measures of flood risk reduction. WMO (2008) affirms FRM as a continuous process of risk assessment, planning and implementation measures, as well as evaluation and risk assessment.

According to Tingsanchali (2012), integrated structural measures (dams, dykes, construction of flood bypass channels, dredging of drainage channels and so on) and non-structural measures (flood forecasting and warning, institutional arrangements, land-use control and more) are needed for FRM. Tingsanchali (2012) devised a framework for urban FRM using IFRM, total water cycle management and land-use planning. In addition, Dogulu *et al*. (2015) explains FRM to include implementation of collaborative and scientific approaches in real-world practice in-cooperating multiple actors in FRM from different disciplines.

Graveline and Germain (2022) proposed the integration of resilience into flood risk governance and policy, addressing the stability of institutions, participatory practices and sustainable FRM in a systems approach to FRM. Vitale (2023) highlighted the effectiveness of transiting from a risk- to a resilience-based approach to cope with flood risk. FDRM, in the context of this research, involves integrating two measures:

i. Flood Risk Assessment
ii. Flood and Stormwater Management

2.3.1.1 Flood Risk Assessment

Flood risk assessment encompasses assessments of hazards, vulnerability and exposure. These assessments estimate the expected consequences of a flood of a certain probability (Norén *et al.* 2016). Flood risk assessment in urban areas is multifaceted when compared to rural areas. This is due to its extensive development (Li *et al.* 2016). Floods are external events that affect society, where flood disaster is the result of interaction between the natural event (flood hazard) and the affected society (Norén *et al.* 2016).

FRM is, therefore, a process where the flood hazard, the society, as well as the vulnerability of the society are managed (Klijn, Samuels and Van Os 2008). Over the decades, various methods and strategies have been used for the assessment of flood risk (Meyer *et al.* 2012; Zelenakova 2012; Cirella *et al.* 2014; Paron and Di-Baldassarre 2014; Diaconu, Costache and Popa 2021; Maranzoni, D'Oria and Rizzo 2023). Flood risk assessment is performed by experienced and practicing flood risk managers and has been carried out in several European Union (EU) countries using questionnaires and interviews (Andersson-Sköld *et al.* 2013; Müller 2013; Munyai, Musyoki and Nethengwe 2019).

In SA, it is primarily the responsibility of the municipalities at national and local levels to prevent and manage disasters (Sithole 2023). In the aspects of floods, the protection of personal property depends on the owner of the property but the overall FRM is the responsibility of the municipalities. In this sub-section of the research, practical flood risk assessment in the eThekwini area is conducted by examining how flood risk is managed in the study area by flood risk managers. This was done by using certain important criteria on FRM in recent literature to assess its practicality in the study area and by so doing, investigate current FRM. To conduct this, key-persons responsible for FRM in the eThekwini municipal area were interviewed. Questionnaires were used to also assess the impact of flood hazard on the community, their property and livelihood and their predisposition to flood impact.

The criteria for interview questions are based on the concept of risk, which involves the combination of the probability and consequence of risk or the assessment of hazard, exposure and vulnerability. The consequences include direct and indirect loses (Norén *et al.* 2016), where the hazard component represents the probability and magnitude of flood, as well as other characteristics of flood. The exposure component represents the presence of people, their property and other economic, social and ecological values in the flooded area. The vulnerability component is the predisposition of the community to be adversely affected by the flood. This is determined by susceptibility, adaptive capacity (the preparedness of communities or individuals to combat hazard and reduce their negative impact) and the coping capacity of the individuals and communities (Norén *et al.* 2016).

The interview guide is based on the definition of risk. The objective of the questionnaire survey was to collect primary data to evaluate the degree of flood risk (Peiris 2015), and its impact on the community, their property and livelihood. The interview and questionnaire guide for flood risk assessment is outlined (Table 2.1).

Table 2.1: Interview and questionnaire guide for flood risk assessment

Component	Factor	Indicator	Reference	Data collection tool
Hazard	Type of hazard (flood)	• Cause of flood • Flood trend from 2000 – 2020 • Frequency of damage • Duration of flood	Norén *et al.* (2016).	Interview
Exposure	Demographical	• Population of people in flood prone area	Nasiri and Shahmohammadi-	Interview

		• Estimates of people affected by flood • Loss from flood • Cost of damage	kalalagh, (2013).	
	Economic	• Disaster management plans and budget • Flood relief dependence activities	Mai *et al.* (2020)	Interview

	Social	• Impact of flood on
		  ○ Livelihood
		  ○ Clean drinking water
		  ○ Health
		  ○ Sanitation
		  ○ Infrastructure
		  ○ Housing
		• Community involvement
			Norén *et al.* (2016)	Interview

	Physical	• Impact on infrastructure • Population density of area • Type of property • Age of property • Distance of river from house		Interview Questionnaire
	Environmental/ Ecological	• Land-use changes • Topography • Closeness to water bodies • Disaster management approach	Nasiri and Shahmohammadi-kalalagh (2013). Mai *et al.* (2020)	Interview
Vulnerability	Susceptibility	• Gender • Age • Marital status • Level of education	Kablan, Dongo and Coulibaly (2017)	

		• Occupation • Household size/Population • Type of property/House • Income • Access to clean drinking water • Access to healthcare provision and facility • Disease outbreak • Disaster response and management • Productivity • Infrastructure (drainage, roads, waste management)	Müller, Reiter and Weiland (2011).	Questionnaire
	Adaptive capacity	• Literacy rate • Government assistance • Flood awareness • Flood warning systems • Training and mitigation measures • Community participation	Veenstra (2013)	
	Coping capacity	• Preparedness • Social security • Past experience • Availability of drinking water • Income/employment • Communication • Financial flood support • Emergency services	Nasiri and Shahmohammadi-kalalagh (2013) Veenstra (2013) Balica, Wright and	

			van der Meulen (2012).	

Source: Author's own Table (2024)

The hazard component aims at estimating the probability that a flood of a particular intensity will occur over periods of years to decades. The knowledge of these will support risk management activities. Flood indicators such as intensity, frequency and duration are important to determine the severity of flood. The socio-economic component relates to the socio-economic system of the community or society. Social components relate to the presence of human beings and related issues. These social aspect will affect the effective ability of communities to cope and quickly recover from floods (Balica *et al.* 2012; Sobhaninia 2023). The physical components are indicative of the relationship between the physical components of the community and the vulnerabilities they cause. These physical components increase the potential of the damages accrued to floods and environmental degradation (Veenstra 2013).

The vulnerability indicators (Table 2.1) are important in assessing the effects of flood on the people. Flood duration, topography, river proximity etc. is used to assess the danger of a flood on the community (Veenstra 2013). The demography of the people in relation to mobility and health, will assess their ability to flee, as well as help rescue others in danger of floods. Flood protection measures indicate the need for government assistance in DRR and management. Adaptive capacities such as flood awareness, literacy level, warning systems, as well as mitigation measures, and so on, indicate the ability of people to acquire knowledge on flood and what to do in the presence of a disaster. Coping strategies adopted, such as preparedness, social security and emergency services, indicate a level of preparedness to recover from a flood disaster (Balica *et al*. 2012; Veenstra 2013).

2.3.1.2 Flood and Stormwater Management

Pluvial or surface water floods, as opposed to fluvial or groundwater floods, tend to cause economic and sanitary impacts in urban communities as rainfall exceeds ground and urban stormwater drainage system capacities. As they could be caused by extreme or small but frequent rainstorms, pluvial floods are of great concern in urban cities, made chronic in the presence of climate change and uncontrolled urban sprawl. Climate changes will disproportionately affect cities, which include coastal zones and flood plains (Andimuthu *et al.* 2019).

Stormwater management is a vital and basic infrastructural system in urban communities. The failure of proper stormwater removal results in negative consequences that will impact human health, the environment and livelihoods. Stormwater management in urban areas in SA predominantly focuses on runoff collection and subsequent channelling to the nearest watercourse. Currently, stormwater drainage in SA prioritises water quantity (flow), with minimum emphasis on environmental preservation such as erosion, pollution and siltation (Armitage *et al.* 2013; University of Pretoria 2023). To properly manage the flood hazard and design appropriate and adequate mitigation strategies, it is necessary to incorporate proper drainage and disposal of stormwater. This is essential for adequate control of runoff/drainage systems and infiltration of sewer systems, to reduce damage to infrastructure and water quality.

In this research, stormwater drainage models and measures in the study area were examined (Table 2.2). The reliability of existing models for stormwater drainage and their refurbishments, installation of new models and mitigation measures were assessed via a questionnaire survey of community members and semi-structured interviews with the flood management professionals of the study area. Questions were designed to illuminate the linkage between flood risk and stormwater and their impact on the management of flooding in the study area.

This sub-section, therefore, examines the stormwater drainage system, its impact on water quality and subsequent health of community members. It conceptually assesses the existing drainage technology and its effectiveness in the overall management of flooding in the study area. In addition, it will also obtain information on residents' knowledge of stormwater drainage systems and its impact on their health and livelihood.

Table 2.2: Interview and questionnaire guide for storm water management

Component	**Factor**	**Indicator**	**Reference**	**Data collection tool**
Stormwater	Drainage control	Structural 1. Conventional stormwater management techniques 2. Engineered infrastructure	Butler and Davies (2011) Nyawo and Tanyimboh (2020) CSIR (2005)	Interviews and Questionnaires
		Alternative measures 1. Sustainable urban Drainage System (SuDS) • Source control (Green roofs, rainwater harvesting (RWH), soakaways and permeable pavements). • Local control (swales, infiltration trenches and bio-retention areas). • Regional control (detention ponds, retention ponds and constructed wetlands)	Armitage *et al.* (2013)	Interviews and questionnaires

	Pollution	1. Human health 2. Environmental health 3. Waste management	Li, Jiang and Liu (2013) Venkataramanan *et al.* (2019)	Interview and questionnaires
	Stakeholder participation	1. Participatory programmes	Nickel *et al.* (2016) Morison and Brown (2010)	Questionnaires and interviews

2.3.1.2.1 Drainage Control

- Structural measures

i. Conventional stormwater management techniques

Poorly managed stormwater can cause flooding, infiltrate sewer systems and carry pollutants into local waterways. Conventional stormwater management is designed to quickly and efficiently remove runoffs, hence, addressing flooding and reducing risk (Butler and Davies 2011). However, in their research on the evaluation of stormwater management in urban residential complexes, Nyawo and Tanyimboh (2020) established that a conventional stormwater management system carries a suite of contaminants that includes heavy metals, litter from roads and more. Water policy in SA is progressive; however, conventional techniques and infrastructure in stormwater management continue to be in use by local authorities (Ward and Winter 2016).

ii. Engineered Infrastructure

The Council for Scientific and Industrial Research (CSIR) notes the hydraulic structures available to the engineers in the management of stormwater. These include highway bridges, culverts, spillways, and dams, as well as other urban drainage systems such as kerbs, roadside channels and erosion protection infrastructures (CSIR 2005).

- Alternative approach

An alternative approach to stormwater management is the Sustainable urban Drainage System (SuDS). This approach considers stormwater as part of the urban water cycle and the stormwater management component (Armitage *et al.* 2013). The SuDS operates by managing the surface water drainage system holistically, aligning with the principles of sustainable development. SuDS designs incorporate water quantity and water quality management, as well as enhanced amenities and biodiversity maintenance. In addition, SuDS mitigates negative environmental impacts of stormwater and stormwater benefits are identified. The presence of different SuDS options and their current state of use in the study area were examined. These different options include source, local and regional control.

- Source control

These are used to provide stormwater management as close as possible to its source, which will be within the boundaries of the property. Examples of source control include:

i. Green roofs

These are vegetative and roof gardens. They provide great benefits in densely urbanised areas (Wanielista, Matt and Hardin 2008). Structural appraisals suggest retrofitting green roofs is a very good option in stormwater management (Stovin 2010). The Green Roof Pilot Project (GRPP) initiated in Durban in 2004 by the eThekwini Municipality Environmental Planning and Pilot Protection Department (EPCPD), was aimed at exploring the benefits of green roofs in reducing temperature and stormwater runoff, thus improving the adaptive capacity of the city (van Niekerk, Greenstone and Hickman 2011).

ii. Rainwater Harvesting (RWH)

RWH is a process whereby stormwater from rainwater is collected, stored and utilized as a water supply (Armitage *et al.* 2013). RWH could be available in supplementing secondary water uses such as irrigation of gardens, as this method reduces stormwater discharge from roofs. This system is very useful during extreme rainfall events, as they assist in reducing initial runoff volumes and associated pollutants to receiving watercourses (McAlister 2007). RWH is achieved by strategically placing roof gutters and rainfall storage facilities (Armitage *et al.* 2013). A study conducted by Fisher-Jeffes, Armitage and

Carden (2017) in some selected catchment areas in SA, indicates RWH in the country has the potential to significantly reduce runoff volume emanating from rooftops by up to 44 percent. However, they also noted it is not a very economically viable option for the majority residential households, because of the high cost of installing and maintaining RWH systems. Thus, it is only viable for a small minority homeowners.

iii. Soakaways

Soakaways comprise an underground storage area packed with porous media or coarse aggregate that gradually discharges stormwater to the surrounding soil (Armitage *et al.* 2013). Multiple soakaways are often linked to drain larger areas such as highways. The type of material utilised to construct the soakaways and the cross-section determines the infiltration capacity of the device. However, rapid movement of water through soakaways leads to increased risk of groundwater contamination.

iv. Permeable pavements

This refer to pavements constructed in a design that enhances the infiltration of stormwater runoff through the surface into the underlying strata and sublayers (Armitage *et al.* 2013). Examples include gravel, concrete, brick pavers and porous asphalt. Permeable pavements can be designed in parking bays, walkways, residential driveways, as well as public service and private roads. Permeable pavers lead to a reduction in stormwater discharge rates and volumes from impervious areas and places where soil condition or foundation limit the infiltration process. However, this is not feasible in areas that are not maintained.

- Local control

Local control to stormwater management acts as a second line of defence against the impact of stormwater, such as in public areas and parks. Some approaches used in local control include:

i. Swales

These are shallow channels lined with grass. These channels have flat and sloped sides. Swales serve as an alternative option to roadside gutters and kerbs in residential areas with low density. According to Armitage *et al.* (2013), they offer larger stormwater storage capacity and very valuable in reducing peak stormwater flows and runoff volumes. Thus, swales serve as an open drainage system for stormwater runoff.

ii. Infiltration trenches

These are trenches excavated and filled with large granular materials or rocks. They are designed to receive stormwater runoff coming from adjacent properties, roadways and foot paths (Melbourne Water 2013). Stormwater stored in trenches infiltrates underlying soil over time and replenishes the groundwater. Infiltration trenches have been found very effective in removal of pollutants such as sediments, metals, organic materials and bacteria (Armitage *et al.* 2013). Infiltration trenches are, therefore, beneficial in increasing stormwater infiltration and recharge of corresponding groundwater, while it also decreases the frequency and extent of flooding.

iii. Bio-retention areas

These are also known as rain gardens. They are landscaped depressions made to manage rainfall from the first 2mm of rainfall, by passing the rainwater through natural processes of filtration, absorption, sedimentation, and infiltration, as well as detention (Armitage *et al.* 2013). These bio-retention areas incorporate stormwater management interventions such as temporary ponding areas, sand beds and grassed strips for infiltration. Bio-retention areas are used for managing stormwater runoff to parking lots, adjoining roadways and between residential plots.

- Regional control

This is the last line of defence against stormwater, comprising large-scale interventions constructed on municipal land. Armitage *et al.* (2013) explain regional control measures to include detention and retention ponds, as well as constructed wetlands. Detention ponds are temporary storage facilities that are ordinarily dry, while the retention ponds have a permanent pool of water, such as dam walls with weir outlet structure. The constructed wetlands have marshy areas of shallow water, partially or completely covered in aquatic vegetation. Detention ponds are very advantageous in reducing downstream flood peaks by temporarily storing large volumes of stormwater. Runoff from stormwater captured in retention ponds is reused for irrigation and domestic purposes.

2.3.1.2.2 Pollution

Cities with ageing sewer systems, poor drainage and extensive impervious surfaces are negatively impacted in the event of flooding. This can result in degradation of natural systems, in addition to affecting human health and productivity (Kennedy, Haas and Eyring 2011). Health consequences of flooding include physical health (waterborne and respiratory diseases, injuries, accidents and death), mental health (depression, stress and anxiety) and economic well-being (property drainage and loss of productivity) (Venkataramanan *et al*. 2019). Stormwater provides storage for large amounts of pollutants and is a leading cause of poor water quality (Jiang *et al.* 2015). In most cities, stormwater empties into rivers, creeks and other water bodies, thus exposing humans and the environment to pollutants. For stormwater management to achieve its full potential, it is crucial to examine associated human and environmental health risks (Jiang *et al.* 2015).

2.3.1.2.3 Stakeholder participation

Stormwater management offers many benefits in the reduction of flood risks. Nickel *et al.* (2016) assert a very important element in this is stakeholder participation in decision-making, with respect to management of stormwater at neighbourhood level; such as the use of green roofs, swales, artificial ponds, and pervious surfaces, as well as soakaways and so on. To successfully manage stormwater, the acceptance and alliance of internal and external stakeholders is required, such as those involved in decision-making, for instance, district administrators, environmental protection managers, urban developers, and facility managers, as well as property owners (Nickel *et al.* 2016).

Morison and Brown (2010), in their research on qualitative comparison between eight different environments in Australia, found stormwater management inadequate in many cities due to poor community support. This finding was corroborated by Sera (2019) almost a decade later, showing one of the challenges in effective management of stormwater was due to weak collaboration and communication between stakeholders. Recent research indicated inadequate local participation and unclear management responsibilities as among factors that hinder effective stormwater management (Knapik, Brandimarte and Usher 2024)

2.3.2 Disaster Resilience

Floods cannot be prevented but the effects on the vulnerability of communities at risk to floods can be reduced. The characteristics of a resilient community to flood risk refers to the ability by communities to prevent, reduce and cope with flood risk. A resilient community is aware and knowledgeable, they are sufficiently prepared, respond better in the event of floods and recover faster from flood disasters (Schelfaut *et al.* 2011). Past experiences have shown that acknowledging the existence of flood risk is not synonymous with reduction of the risk, rather, knowledgeable and well-prepared communities are better positioned to prevent harm and reduce the impacts, in comparison to unprepared or less-prepared communities.

In the past decades, the top-down approach to DRM neither improved local capacities and resources nor addressed the specific needs of communities vulnerable to floods. These limitations in the top-down approach has led to the emergence of people-based DRM (ADPC 2007). According to the WMO (2017), floods are better managed using a grass-roots or bottom-up approach, as opposed to the top-down approach. A participatory approach with communities, towards mitigating flood impacts is very valuable, as shown by Buba *et al.* (2021) in their research on participatory assessment of the flooding impact in some communities of Lokoja, Nigeria. Community-based participation ensures local communities are well-equipped with tools and skills to cope with disasters through initiatives geared to flood management (WMO 2017).

Several factors are responsible for the active participation of community members. Strategies needed to involve communities in flood management activities depend on socio-economic conditions, characteristics of floods and institutional set-up. These factors are essential in understanding the relationship between floods and communities (WMO 2017). The impacts of floods have great influence on the social and economic welfare of people such as source of livelihood, education, employment, productivity, public service facilities, social structures (ethnicity, religion, class and language). These impacts aggravate vulnerabilities of community members and influences the community's capacity and willingness to participate in FRM.

A WMO (2006) report affirms understanding the social and economic features of community members is essential to achieving true participation in flood management activities. These factors define the community's vulnerability and coping strategies with floods. Community connectedness is a critical factor in the ability of a community to cope and recover after a disaster (Dufty 2013)

The concept of flood resilience in this research provides a practical means for identifying tangible measures needed to reduce vulnerability and increase coping strategies via strengthening of community resilience. This research, therefore, utilised the strategic approach employed by Haider (2009) to organise and strengthen community participation in flood management activities. These strategies involve the following:

2.3.2.1 Participatory process

The participatory process is an essential element of community-based risk management that ensures the building of a culture of safety and sustainable development. This process addresses local vulnerability specific to communities, by acknowledging the full potential of available local resources and capacities. It uses the active engagement of community members in all stages of FRM activities. Flood assessments and planning by flood experts will not work effectively without local community member participation (WMO 2017). Several studies conducted by the WMO have shown casualties and losses are relatively reduced in communities with a high level of participation and motivation to cope with floods.

2.3.2.2 Resource maximisation

Flood management strategies need to adopt indigenous knowledge inherent in the community, as cultivating and promotion of indigenous knowledge is important in IFRM (WMO 2017). According to the UNCRD (2011), local authorities in cooperation with community members in the Bicol region of eastern Philippines, who live in the presence of an active volcano in mount Mayon, have achieved a zero-casualty level. External support is focused on enhancing the inherent coping strategies comprising local resources and capacities.

2.3.2.3 Motivation

Vulnerable communities are faced with high priority necessities such as sanitation facilities, employment, security, and water supply, among others, as compared to flood issues (WMO 2017). These communities exhibit low participation in flood risk matters, thus making them more vulnerable to floods. To avoid this and maintain community resilience, motivation is essential. This may include socio-economic incentives (flood insurance), social dialogue, capacity building, and systematic awareness and training (flood education and awareness and development of coping skills), along with increased active involvement, such as sustainable ownership of flood management activities.

2.3.2.4 Institutional linkages

Combating the risk accrued by floods requires cooperation between communities, regional and state authorities. This is because of the high scale of the threat and the level of investments required (WMO 2017). The absence of local and national government resources and donor funding can hamper continuance of community-based activities. Thus, it is very important that community initiatives link with government structures, where the government is responsible for external or donor funding, as well as launching community-driven programmes.

2.3.3 Policies and Practices

In the early 21st century, flooding across countries in Europe caused huge casualties and damages. This motivated the drafting and implementation of the best-practice document by the United Nations and Economic Communities of Europe (UN/ECE) on sustainable flood prevention. The general consensus is that floods are part of nature, society has become vulnerable to natural hazards and flood protection is never absolute (UN/ECE, 2003).

Basic principles and approaches for international good practices, as put forward by UN/ECE (2003), include:

i. Promotion and harmonisation of changes in land-use practices and water policies.
ii. Promotion of environmental protection and conservation of nature.
iii. The shift from defensive action against hazards to FRM and coping strategies against floods.
iv. Measures and instruments should be developed to reduce risk accrued to flood damages.
v. Structural measures against floods. These have been used for decades and remain important elements for the protection of human health and safety. However, it should be noted flood protection is never absolute and generates a false sense of security.
vi. Mitigation and non-structural measures should be employed for long-term reduction life and property vulnerability. These are potentially more efficient and sustainable in the long-term.

vii. Efforts for avoiding floods and the associated impacts should be focused in large urban areas, because the majority population, infrastructure and goods is found in urban areas. It should also be noted that overflowing of rivers is not the only cause of urban floods. Urban floods can also be as a result of rainfall intensities and inappropriately managed sewage systems.
viii. All community members who suffer from the consequences of floods should be responsible for reducing their vulnerability to floods. The authorities must also work with community members to foster flood resilience.
ix. Solidarity in tackling flood risk is very important, however, flood management should be within boundaries.

According to Grobicki *et al.* (2015), climate change is an ever-present reality and, over the years, the authenticity of this statement has become evident. Impacts are experienced more through water-related disasters, such as floods and droughts; hence, there is an urgent need to integrate policy and practices in building disaster resilient societies.

Some approaches and perspectives from around the world include the following:

i. Global policies have advanced over the years and frameworks developed to understand and manage risk. Policies and practices are being put in place and tested. These policies and practices progressed from the world summit for sustainable development in Johannesburg 2002 for the development and implementation of Water Resource Management (IWRM). This was based on the three pillars of economic efficiency, social equity and environmental sustainability (UN 2002).
ii. The HFA 2005-2015 agreed, during the first world conference on Disaster Reduction in 2005 within the International Strategy for Disaster Reduction (ISDR), to make a safer world from national hazards and reduction of disaster losses (UN 2005a).
iii. The United Nations Convention to Combat Desertification (UNCCD) adopted a 10-year strategic plan to reserve and prevent desertification and mitigate the effect, in

an effort to support poverty reduction and environmental sustainability (UNCCD 2007).

iv. The third world climate conference held in 2009 provided countries with a global framework for climate services (WMO 2009c).

v. The third world conference on DRR in Sendai in 2015, which is a precursor of the post-2015 development agenda and the Sustainable Development Goals (SDGs) that should run from 2015-2030 (Grobicki *et al.* 2015).

These global frameworks set milestones to reinforce the connectivity between floods, water-policy approaches integrated with water management and long-term sustainability development (Grobicki *et al.* 2015). Policies in Europe such as Water Framework Directives (WFD 2000/60/EC), as well as the IFRM through Flood Directive (2007/60/EC), have driven more formalised approaches to integrated water resource management (Cumiskey *et al.* 2019).

This section of the research described and incorporated best practices to protect, prevent and mitigate the adverse impact of flood events on people, their livelihoods and properties.

2.4 CONCLUSION

This chapter extensively discussed the conceptual framework, illustrating the roadmap of the research and providing a hypothesis with a firm foundation. In this chapter, several concepts were arranged in a logical structure, thus providing a visual display of the relationship in the study. The various dimensions of the conceptual framework for the IFRMF, which include FDRM, disaster resilience and disaster management good practices, are discussed. Also illustrated and explained are the interview and questionnaire guide, highlighting indicators (survey questions) and the rationale for their use. The next chapter will review the literature related to floods to provide an overview of the current knowledge that will aid in identifying relevant theories and gaps in existing research, to aid in the development of the IFRM framework.

CHAPTER THREE
LITERATURE REVIEW

3.1 INTRODUCTION

The main purpose of this chapter is to review literature related to floods in urban areas, their impacts, vulnerabilities, and resilience, as well as the various FRM strategies adopted to minimise the damages accrued to risk. A review of literature is a study of scholarly sources on a specific topic. A literature review provides an overview of current knowledge, which allows the researcher to identify methods, relevant theories and gaps in the existing research (McCombes 2021). This literature review utilised relevant publications from journal articles and books and critically analysed these to identify themes, debates and gaps. By analysing, synthesising and critically evaluating the literature, a clear picture of the state of knowledge in the field of IFRM is provided.

To achieve a holistic literature search, the ways communities manage disaster risk were reviewed, along with the various disaster management global declaration frameworks put in place over the years to improve the management of disaster risks. In addition, disaster management in SA, in particular the National Disaster Management Framework and the recently launched eThekwini Municipality Flood Early Warning Systems (FEWS) and its benefits to FRM in the study area, are examined.

This chapter also performed a critical review on disaster management good practices across the continents of the world, in order to integrate good practices into risk management, to be used in the IFRM in the study area. Finally, the existing IFRM is reviewed and gaps identified. The literature review is divided into eight subsections, each identifying gaps and providing solutions that can be incorporated into an IFRM framework for the study area. This literature review, furthermore, describes the relationship between this research and prior research in the field of IFRM, highlighting the relevance and originality of the problem being researched.

3.2 URBAN FLOODS AND IMPACTS

Over the years, floods are mostly considered an external event that impacts society resulting in decisions focused on flood control using technical solutions. However, with an increasing understanding, flood disasters are seen as a result of interaction between the natural event and the affected society (Norén *et al*. 2016). Through the years, there has been a gradual shift from flood control to FRM, due to the realisation that the flood phenomenon should be considered alongside its impact on community and the vulnerability of the society (Schanze 2006).

Flood risk has increased up to three times due to urbanisation, thus affecting a large number of people in densely populated clusters, leading to infrastructural and economic loss (Rafiq *et al.* 2016). Climate-related disasters and human-induced climate change wreak destruction on people and their property (Predo 2010). Moreover, climate change projections are shown by Williams *et al.* (2019) to indicate a significant increase in the intensity and frequency of floods. The research by Williams *et al.* (2019) affirms the vulnerability of urban communities to natural hazards has increased as a result of rapid urbanisation and climate change, leading to weakening of urban resilience. Seemuangngam and Lin (2024) also agree that urbanisation and land use changes have increased the vulnerability of people to floods. This research sought to verify these findings the in EMA, which comprises highly dense urban cities.

Floods have economic, social and environmental consequences. These vary and are dependent on the flood duration, location, and speed, as well as the depth and vulnerability of the affected individuals, in addition to the natural and built environment (Waghwala and Agnihotri 2019). Waghwala and Agnihotri (2019) affirm that urbanisation and land use changes have increased the vulnerability of people to floods.

Doocy *et al.* (2013), in their historic and systematic review on the human impacts of floods, found an estimate of more than 500 000 deaths, in excess of 300 000 injuries and approximately three million people affected by flood between 1980 and 2009. Their research ascertained the primary cause of death was from drowning. Elaborating further, the research suggested motor vehicles and male gender were associated with increased mortality in the developed countries, whereas in low-income countries, female gender is linked to higher mortality rates. Most flood-related deaths are thus seen to be in heavily populated and less developed countries (Yari *et al.* 2020). This is consistent with a review by Strömberg (2007), stating mortality from flood disasters varies by severity of the event, level of economic development and region. Countries with more resources have capacity to prepare and respond to impending flood events (Yari *et al.* 2020).

Research conducted by Otto, Weichselgartner and Bubeck. (2017) grouped flood impacts into direct and indirect tangible and intangible impacts. In their research, they found the direct damage caused by physical contact between flood waters and human beings, as well as economic and cultural assets, are the most immediate and apparent impacts of floods. According to Otto *et al.* (2017), direct flood damage amounts to billions of US dollars. Furthermore, their findings elucidate that the impacts of floods on people and communities experiencing property damage and loss of important personal belongings have long-term consequences and indirect negative psychological effects on victims. Increasing population and economic assets in coastal areas cause coastal flooding to wreak devastating havoc, due to their destructive force in terms of tidal energy and waves (Newton and Weichselgartner 2014). This is the case in the EMA, with its dense population and coastal location.

3.3 CLIMATE CHANGE AND FLOOD RISK

There are several factors such as weather and anthropogenic activities that have been identified as the cause of floods, which makes connecting climate change to floods a very delicate attempt Seneviratne *et al.* (2012). However, Seneviratne *et al.* (2012) affirm climate change has a great and rising influence on several water-related variables that contribute to floods. This authenticates findings by Morita (2011) that global climate change is expected to affect future patterns of rainfall. Thus, these authors extrapolate that global warming does not directly induce floods but exacerbates many flood-causing factors. As example, a report by the US Global Change Research Program (USGCRP 2017) explains coastal flooding in the United States of America (USA) has doubled over the decades.

Denchak (2019) highlighted some key ways climate change increases flood risk. These include: heavier precipitation caused by a warmer atmosphere, which holds and subsequently dumps more water in the form of rainfall; increased frequency of strong storms leading to more frequent hurricanes; and, global rise in sea levels amplifying storm surge. Climate change impacts on floods show extreme precipitation increases with water availability, as water for precipitation increases at a rate of 6-7 percent per degree rise in temperature, in proportion to saturation concentration (Tabari 2020).

Findings by the UNEP (2020) show rising global temperatures result in more energy in the earth's system. High air temperatures increase evaporation and subsequently cloud formation. The air can hold more moisture content at higher temperatures, thus leading to an increase in intensity, duration and frequency of precipitation. According to UNEP (2020), the global average temperature is 1.1 percent higher than at the start of the last century. This shows extreme flooding will be concentrated in areas with a built environment, where humans have built on flood plains and low-lying coastal regions. This will lead to more extreme flooding in towns and cities where flooding already occurs, as global warming increases the likelihood of extreme weather events and flood risk in urban areas.

Da Silva, Alencar and de Almeida (2020) concur with the UNEP (2020) findings that climate changes, as a result of global warming, make dealing with flooding very complex, due to the variability of temperatures, thus leading to more frequent and severe impacts. Consequently, decision-makers, disaster managers, stakeholders, experts and more, need to consider climate change in urban area flood management, due to the severity of flooding.

3.4 FLOOD VULNERABILITY

Unplanned and rapid urbanization increases the vulnerability of urban poor communities to flood (Williams *et al.* 2019). Increase in vulnerability is also attributed to the dense concentration of important crucial physical assets, energy installations, functioning industries and infrastructure such as bridges, roads, tunnels and more. The annual risk of floods in SA is 83.3 percent, with a high population vulnerability as a result of its geographical location and economic factors (Zuma *et al.* 2012). These findings were authenticated by Munyai *et al.* (2021) in their research on the vulnerability and adaptation to flood hazards in rural settlements of the Limpopo province in SA. Coastal cities such as Durban are susceptible to river flooding and storm surge that increase vulnerability.

Several vulnerability drivers are concealed and isolated from their triggering events. These drivers of vulnerability include biophysical, social and economic vulnerabilities (Mavhura 2019). Communities are vulnerable to flood disasters that significantly impact infrastructure and the livelihood of communities (Musyoki, Thifhulufhelwi and Murungweni 2016). The research on two communities in Limpopo province by Musyoki *et al.* (2016) indicated an increase in the level of education, household income, as well as access to grants decreased vulnerability of households to flood.

This affirms study findings by Predo (2010) that household access to grants and credits was inversely and considerably linked to their level of vulnerability to risks from floods. It was further indicated that households with access to grants and credit used these to reduce their vulnerability to floods and these resources eventually assist recovery and adaptation, as well as increased coping from the impacts of disasters. This authenticates a review of the elderly, poor and marginalised groups in societies by Otto *et al*. (2017) that found these groups are more vulnerable to effects of flooding, because of their minimal human, social and financial coping capacities.

Coastal cities such as Durban are susceptible to river flooding and storm surge that increase vulnerability (Newton and Weichselgartner 2014; Munyai *et al.* 2019). Knowledge of the study area vulnerability factors is key in reducing disaster risk and promoting a culture of resilience, while also assisting in targeted and cost-effective mitigation measures and enhanced efficacy in FRM.

3.5 DISASTER RESILIENCE

To understand, as well as influence how stakeholders respond to disaster risk and disasters, it is important to have a combined knowledge of the hazards people experience and their perceptions. Irrespective of the community structure, resilience to disasters can be built through effective decision-making rooted in knowledge, via experience and perceptions (Nkombi and Wentink 2022; Nurjanah *et al.* 2023).

The efforts of government in Southern African countries to cope with the impact of flooding in communities are often limited and affected by people's perception of floods, which influence response (Musyoki *et al.* 2016). The proposed framework incorporates community participation in FRM, in line with the findings of Masud *et al.* (2018) that demonstrated when an individual can perceive flood risk and understand the seriousness of the issues confronted, it would prompt more noteworthy attitude change.

3.5.1 CBDRM

Communities are the most affected in the event of a disaster, hence they remain the most valuable source in understanding how disaster risk and its accompanying vulnerabilities are created and can be reduced (Van Niekerk and Coetzee 2012). Van Niekerk *et al.* (2017) affirm a better understanding of vulnerability and its dynamics, as well as exposure to hazards and resilience can be gained only when the process of knowledge creation is inherent in those directly affected. CBDRM is a participatory process actively engaged in the identification and assessment, as well as the management and planning, for hazards and vulnerabilities (Krummacher 2014; Nkombi and Wentink 2022).

Community involvement in DRR aims to address issues, challenges and problems faced locally from the viewpoint of those who experience them. Thus, empowering the community in the DRR process is very important. According to Chhoun (2016), CBDRM is based on total DRM principles, which spans from assessment of risk, mitigation, and preparedness, to response and rehabilitation, as well as the application and adoption of indigenous knowledge to risk coping and risk reduction.

Indigenous knowledge has been argued as highly significant in DRR. Planning development and developmental strategies are, however, unsuccessful in the absence of implementation of local knowledge (Mutasa 2015). Local communities are, furthermore, empowered through the use of indigenous knowledge, which improves community participation and enlightenment in DRR (Dube and Munsaka 2018). Rai and Khawas (2020) proposed in their research that integrating indigenous knowledge and scientific knowledge will result in hybrid knowledge in DRR.

In recent times, CBDRM has been recognised in the field of DRR as a multi-stakeholder in the management of disasters (Krummacher 2014). As explained by Krummacher (2014), community members are often the first line of defence in preparing for and responding to disasters, hence educating, sensitising and preparing local communities regarding the precautionary and preventive actions in the case of specific hazards, which will assist in reducing the loss to life and property. Involvement of local communities in DRR will lead to identification of specific vulnerabilities and needs via direct consultation, as these communities understand local context and realities around them better than outsiders.

DRR, nevertheless, offers many challenges such as the unclear link between the CBDRM approach and the governmental approach, unavailability of resources to empower local communities in DRR and lack of DRR legislation at sub-national and community level (Krummacher 2014; Hosseini *et al.* 2017). For an inclusive and effective DRR and management, the CBDRM (indigenous knowledge) and governmental (scientific knowledge) approaches need to be integrated.

3.6 DISASTER RISK MANAGEMENT (DRM)

Globally, communities have been facing an increase in the frequency of disasters leading to direct and indirect risks (Haigh and Amaratunga 2010). This is exacerbated by extreme weather conditions as a result of climate change (WHO 2023). In addition, it has become necessary to reduce the risk from disasters and develop a resilient community. It is important for disaster management practitioners to learn from lessons, in order to adopt good practices. In this research, among its objectives, was to review the good practices employed by other countries and communities in urban risk management against those used in the study area.

The knowledge acquired will be valuable in improving the FRM performance level. Lack of knowledge and effective information sharing on disaster management strategies is a major reason behind poor performance of current disaster management practices (Seneviratne, Baldry and Pathirage 2010; Oktari *et al.* 2020). According to Seneviratne *et al.* (2010), identifying success factors is an enabler in the successful management of disasters. In their review to capture the good practices for successful disaster management of the Asian tsunami in Sri-Lanka, McCallum et al. (2016) identified six key factors (technological, political, legal, environmental, social and functional) necessary for success.

New technologies are transforming the way information is collected and analysed through the disaster management cycle (Poblet, Garcia-Cuesta and Casanovas 2014; Iacovitti 2022). Crowdsourcing, as well as social media services (for instance, twitter) have recently been used more frequently to monitor public reaction to floods and other disasters (Nielsen *et al.* 2024). Also very effective is the Volunteer Geographical Information (VGI) tool used to compliment official humanitarian channels of relief operations (McCallum *et al.* 2016). The effectiveness of the VGI tool is shown in the review by Norheim-hagtun and Meier (2010) of the Haiti earthquake, where live interactive maps were created as the earthquake happened and many lives were saved.

Schnebele, Cervone and Waters (2014) used volunteered geographical data and crowdsourced photos, in combination with geo-statistical interpolation in their study, in order to create an estimation of flood damage caused by Hurricane Sandy in New York city. Further to this, a review by Clark (2015) highlighted the earthquake that hit Nepal, which was mapped by volunteers in 48 hours. Governments of least developed countries (LDCs) and developing countries have low technological and human capacity in disaster risk monitoring, where the advent and popularity of mobile technology and its usage has brought a change that has saved lives in many disasters (McCallum *et al.* 2016).

Doocy *et al.* (2013) noted extensive monitoring of floods, coupled with improved mitigation practices and effective communications with governmental authorities and vulnerable populations, has great potential in reducing flood mortality. This is consistent in the review by Strömberg (2007) that suggested building capacity and systems to prepare for, detect and respond to floods in less developed countries should be a priority. Promulgation of the Disaster Management Act of 2002 and the National Disaster Management Policy of 2005 of SA, integrated DRR into all spheres of government using a decentralised approach. However, having good legislation and policy does not mean there will be good practice (van Niekerk 2014). The proposed IFRM framework allows this gap to be adequately addressed, through the DRR good practices arm of the framework, which focuses on FRM through the phases of the disaster management cycle.

The understanding of the governing of flood risk without a good application of flood risk interventions and good DRR practices leads to overall poor FDRM. This is because, flood risk governance is complementary to flood risk interventions and DRR; necessary in achieving a collaborative response between all structures involved in FRM. Botha and van Niekerk (2013) assert there is a need for strong governance structures at both national and local levels that are capable, inclusive of all DRR stakeholders, and accountable. The research by Botha and van Niekerk (2013) recognised disasters cannot be addressed in silos.

Research of communities at high risk of flood in SA show the Government follows a top-down process, where local government officials instruct community members what to do, without gaining their opinion of what should be done (Botha and van Niekerk 2013; Monyepao and Uwizeyimana 2018). Also discovered in the research by Botha and van Niekerk (2013), is the lack of cooperation between government departments concerning disaster prevention.

Monyepao and Uwizeyimana (2018) showed in their study that a top-down approach made stakeholders feel bullied and excluded from intervention processes. Nonetheless, a study conducted by Zuma *et al*. (2012) on the response to flooding that occurred in 2010-2012 in SA, which examined the functionality and drawbacks of the disaster management system, found the response was adequate at the national level but highly inadequate at district municipalities. This was attributed to lack of disaster management structures and shortage in skills. The research findings proposed the strengthening of vulnerability and risk.

In other research conducted by Taing, Armitage, and Spiegel(2011), technical solutions are found to be implemented without input from local communities and inadequate training support to complement technical solutions, which led to failed implementation of engineered solutions. Research by Tingsanchali (2012) showed flood disaster management activities in developing countries are dealt with by government, with very limited participation from non-governmental agencies and private sectors. Tingsanchali (2012) further reported that flood disaster management activities are carried out independently, without proper integration and coordination.

This research proposes ways to enhance the coordination and participation of all stakeholders, in order to increase the effectiveness of disaster management in the EMA. Research by Musyoki *et al*. (2016) indicated various local government units were actively involved only after the disaster occurred. These measures are seen to be temporary and short-term. Lack of adequate implementation of long-term strategies is attributed to insufficient capacity for long-term strategic planning. These shortcomings in strategic planning can be addressed using an integrated framework, whereby good DRR practices following guidance from the global declaration frameworks as they are upgraded, are imbedded in flood and storm water management at the planning and prevention phase of disaster management.

3.7 GLOBAL DECLARATION FRAMEWORKS ON DISASTER AND RISK MANAGEMENT

Over the decades, several global frameworks have been developed for DRR and sustainable development. International legal frameworks are vital tools in DRR implementation, as they establish principles and standards, followed to understand and manage risk and achieve resilience in communities. These policies and practices persistently progressed, aimed at achieving risk-informed sustainable development. This progress over time and space is illustrated (Figure 3.1) below.

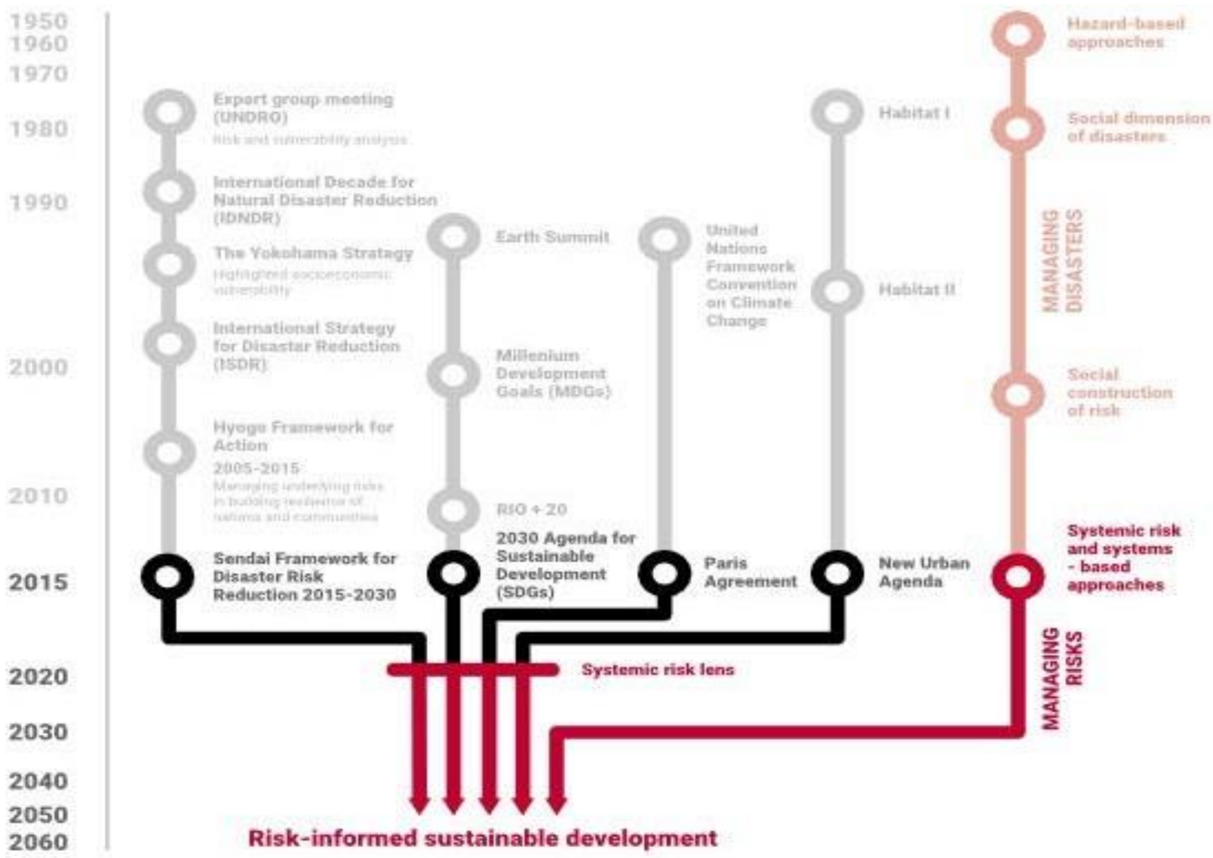

Figure 3.1: A journey through time and space

Source: UNDRR (2019)

The bold section of the arrows in the image depicts currently active frameworks. This literature review will trace and discuss the frameworks directly focused on DRR, which include the international decade for Natural Disaster Reduction (IDNDR), the Yokohama Strategy, the International Strategy for Disaster Risk Reduction (ISDR), the HFA (2005-2015) and the Sendai Framework (2015-2030), as well as those with very strong linkages to DRR and its implementation in urban areas.

3.7.1 International Decade for Natural Disaster Reduction (IDNDR) (1990–1999)

Communities around the world suffered gross losses from natural disasters such as floods, droughts and desertification. To protect these communities from natural disasters, the UN launched the IDNDR 1990-2000, with the objective to reduce the loss of life, social and economic disruption and property damage caused by natural disasters, particularly in developing countries (Pisano 1998).

The IDNDR set several goals that include the improvement of capacity of each country to mitigate the impacts of natural disaster; application of existing scientific and technical knowledge through appropriate guidelines and strategies; addressing critical gaps in knowledge through fostering of scientific and engineering endeavour; dissemination of new and existing technical information; and, development of measures to assess, predict, prevent and mitigate natural disasters, through awareness creation, training and programmes of technological transfer and technical assistance; as well as evaluation of the effectiveness of the programme (Pisano 1998).

Notwithstanding these measures, natural disasters prevailed. According to the United Nations Development Program (UNDP) human development report (UNDP 1996), poor land management practices such as overgrazing, overcultivation, deforestation and poor irrigation drainage contributed to increased drought and desertification, causing lost productivity of up to $42 billion each year globally and $9 billion in Africa alone. Flood disasters increased quicker than other disasters as a result of increasing flood risks, changing local ecosystems and rapid development.

Pisano (1998) noted, while drought is the leading cause of death with 74 000 reported in 1996, floods occurred more frequently and caused most economic losses. According to the World disaster report 1997, between 1991-1995, floods caused approximately $203 billion in losses, which amounted to almost half the economic damage caused by disasters (IFRC

1997). Other water-related disasters such as landslides and fires continued to increasingly ravish communities during the IDNDR.

Irrespective of the several disasters that continued to increase during this international decade, the IDNDR brought about much awareness and numerous recommendations intended to promote disaster reduction around the world. Study conducted within the socio-economic context of disaster vulnerability in the African region, to identify the prime causes of poverty-related high disaster vulnerability levels, concluded most African countries will remain in the deadlock of poverty-vulnerability-environmental degradation-poverty cycle; unless they receive the utmost attention from policy makers and more donor agency support for preventive approaches in disaster reduction (UNISDR 1999).

Another study, based on disaster resilient infrastructure and the reduction of physical disaster impacts from natural hazards, advocates the need for regional planning, whereby state-of-the-art infrastructural designs and construction, particularly in the development schemes, transportation infrastructure, resettlements and so on, as the best way to achieve disaster resilient infrastructure (UNISDR 1999).

A study conducted by the UN University, in cooperation with the centre for Disaster Mitigation Engineering, emphasises the importance of disaster reduction technology in all phases of the disaster management cycle. The study stressed the need to adopt technologies such as Remote Sensing (RS), Geographic Information Systems (GIS), telecommunication technologies, and global positioning systems (GPS), disaster information systems and more, in disaster reduction and land-use planning, in determining the possibility of a particular hazard turning into a disaster. This would assist decision-makers in sustainable long-term planning and the promotion of disaster mitigation capacity (UNISDR 1999).

At the end of the decade, it was recommended education for disaster reduction must be integrated in the successor programme of the IDNDR to foster international and regional cooperation, good practices and exchanges of resources. Other recommendations include empowering local communities to remove some vulnerability causes, hence, reduce the impact of future extreme natural disasters, and structural engineering, as well as emerging financial measures, must be included to manage the financial risk associated with natural disaster, as these are important aspects for its prevention and the need for pro-active health emergency planning (UNISDR 1999).

3.7.2 Yokohama Strategy and Plan of Action for a Safer World (1994)

The Yokohama Strategy and Plan of Action for a Safer World (Yokohama Strategy) was adopted in 1994, following the UN World Conference on Natural Disaster Reduction (WCNDR). The Yokohama Strategy is the first document with guidelines for prevention, mitigation and preparation in the event of a disaster and its impacts (Tozier de la Poterie and Baudoin 2015).

The Yokohama Strategy was developed from the IDNDR (1990-2000) and the WCNDR in 1994, out of concern for the disruption to development and human lives and livelihoods caused by natural disasters. The framework adopts several principles, strategy and plan of action on risk assessment, disaster prevention and preparedness, as well as development and strengthening of capacities, early warnings, reduction of vulnerable along with environment protection as a component of sustainable development. It provides recommendations for action on activities at community and national level, as well as activities at the regions, sub-regional and international levels, with particular emphasis on bilateral arrangements and multilateral cooperation (IDNDR 2000).

Review of the Yokohama Strategy over the 10 years showed the DRR advanced both in sophistication and scope. Records prove a developed culture of prevention to reduce social, physical, economic and environmental vulnerability, as well as the impacts of hazards, through enhancement of local and natural capacities (UN 2005b). The review also showed evidence of better public and official understanding of a more effective means to address vulnerability to current and emerging disaster risk, as disaster is a combination of political, economic and environmental consequences. In addition, a strategic approach to disaster reduction was developed, such as DRR integration into development and participation of local communities and the public sector in DRR, among others. The principle of the Yokohama Strategy was valid as a guide in policy framework development to foster local and national capacities in disaster reduction (Botha and van Niekerk 2013).

The strategy was significant in international and multilateral agreements related to DRR, such as initiatives pertinent to achieving sustainable development, particularly as it relates to the Millennium Development Goals (MDGs). However, several gaps and challenges were observed, for example; a lack of systematic implementation of strategy in governance structures, establishment of standards in risk identification, early warnings, and assessment and monitoring, as well as education and knowledge management, reducing underlying risk factors and lack of adequate preparedness for effective response and recovery (UN 2005b). It is evident, although the decision-makers know what to do and, in some cases, have resources, much more must be done by all stakeholders to put their intentions into actions, for the world to become safer from disasters.

3.7.3 International Strategy for Disaster Reduction (ISDR)

The UN created the ISDR as a successor to the IDNDR in the year 2000 to adopt the need to proceed from mere protection against hazard to include a process involving awareness, assessment and management of risk (UN 2005). The ISDR was established within the UN, intended to promote activities geared towards reducing social vulnerability and risk accrued by natural hazards and its related environmental and technological disasters.

The ISDR was formed to help create nations, organizations and communities that are disaster resilient by advocating the idea that disaster reduction must be mainstreamed into development (Coppola 2015). Thus, the UN ISDR system uses a global approach in the reduction of disasters. It seeks to involve all communities and individuals in the goal of reducing loss of live, environmental damages and socio-economic setbacks as a consequence of natural hazards (Tadokoro 2015). The goal of the ISDR in the long-term, was to ensure communities become resilient to disasters and consequently, saving lives as well as economic, social and environmental assets.

The ISDR promoted four objectives as a tool geared to achieving its goal of attaining disaster reduction for all (Coppola 2015). These objectives include:

i) Ensure more people, government, NGOs, and regions, as well as organizations, civil societies and others are informed of risks, vulnerability and natural hazard management, by increasing public awareness about risk, vulnerability and disaster reduction. It is believed this will increase the implementation of disaster reduction measures in all society sectors.

ii) Ensure public authorities are committed to implementing disaster reduction policies and actions. This is anchored on the fact that the more decision-makers at all levels are committed to disaster reduction policies and actions, the quicker communities vulnerable to natural hazards will benefit when disaster reduction policies and actions are applied.

iii) Inspire inter-disciplinary and inter-sectoral partnerships, as well as the expansion of risk reduction networks. The ISDR postulates that the more information on research and practices is shared by disaster reduction entities, the more progress will be achieved in the global body of knowledge and experience. Collaborative efforts are key to sharing a common purpose to making the world’s nations more resilient to hazard impacts.

iv) Ensure scientific knowledge on disaster reduction is improved. This is geared towards the fact that the more that is known of the causes and consequences of natural hazards and related environmental and technological disasters on societies, the more prepared people and communities will be.

The UNISDR is the organiser and global coordinator for DRR. Its role is primarily in coordination, knowledge and advocacy in core DRR areas. This UN office coordinated the three World Conferences on Disaster Risk Reduction (WCDRR). The first WCDRR adopted the Yokohama Strategy and Plan of Action for a Safer World in 1994. The second conference was convened in 2005 and adopted the Hyogo-Framework for Action (HFA): Building Resilience of Countries and Communities to Disasters was a successor to the Yokohama Strategy, with the third WCDRR in 2015 that adopted the SFDRR (2015-2030), a successor of the HFA.

3.7.4 Millennium Development Goals (MDGs)

Nations around the world renewed their commitments in year 2000 to creating a better, safer and free world. This commitment birthed the MDGs, with key areas of human development identified, as well as provisions of a framework for coordinated action and clear targets to measure progress set. The MDGs is an extraordinary partnership among 191 nations to improve the lives of hungry and poor people across the world (Muñoz 2008). The MDGs is the most supported poverty reduction target established by the world (Cannon 2007).

When the nations signed the MDGs in year 2000, DRR was not included in their attainment strategies, however, the millennium declaration recognised disasters could impede development. Thus, a commitment to intensify collective efforts by individuals and communities to reduce the number and effects of natural and man-made disasters was included in the General Assembly Resolution (UN 2000). Nevertheless, DRR was not included in the formulation of the goals. This draws a focus on the possibility of MDG attainment.

It is a reality that poverty and vulnerability go hand-in-hand but do not necessarily overlap. In other words, not all disasters affect the poorest, yet the poorer the people, the more they are exposed and susceptible to hazards, hence, they suffer greater loss and exhibit a lower capacity to cope and recover from the impact of the disaster. White *et al.* (2005) and Hallegatte *et al.* (2020) affirmed disaster can induce poverty, making the poor even poorer and unable to fight disasters, in spite of all the programmes initiated for MDG achievement. Consequently, risk reduction efforts can help decrease poverty by aiding the lessening of the impoverishing effects of disasters; however, for this to happen, an in-built proactive focus on addressing the disaster risk is required (Hallegatte *et al.* 2020).

Reports by the Department for International Development (DFID) noted many countries would not meet the first goal of the MDGs, which is to half poverty and hunger by 2015 (White *et al.* 2005). This was confirmed by the UN MDG review that noted progress was uneven across countries and regions, and the poorest and disadvantaged, which constitute the most vulnerable, were being left behind (UN 2015). Progress reports from various countries noted the progress of the MDGs, particularly goal one, was impeded by disasters. These adversities affected the poor directly through macroeconomic impacts such as physical damage to infrastructure, productivity and stock capital and indirectly, in the longer-term, by productivity, macroeconomic performance and growth.

Revenues are diverted for disaster response, leading to fiscal impacts affecting the provision of social services by the government and increased food prices. Examples of some other MDGs affected by disasters include school closures and the high dropout rate from schools (MDG2), increase in domestic violence and sexual harassment leading to poor health (MDG3-5). Disasters such as flood can lead to drowning, starvation and diseases and children are the most vulnerable (MDG4); they also increase migration of people from rural to urban areas, leading to increased slum dwellers and informal settlements (MDG7) (White *et al*. 2005).

All these gaps in the MDGs led to the adoption of a 10-year plan by 168 governments in 2005 at the WCDRR in Kobe, Japan to make the world safer from disasters. This was known as the HFA, with the key goal to substantially reduce disaster losses by 2015 in the lives and economic, social and environmental assets of communities and countries (Cannon 2007). With the principal priority for action and practical means for achieving resilience to disasters for vulnerable communities, it became increasingly obvious disasters are one of the major factors holding back the progress of the MDGs. Thus, mainstreaming DRR into the MDGs is the key to achieving these goals.

3.7.5 Hyogo Framework for Action (HFA) (2005–2015)

The WCDRR held on 18 to 22 January 2005 in Kobe Japan, heralded a global blueprint for DRR efforts with a 10-year plan. The HFA (2005–2015), with the theme of building the resilience of nations and communities to disasters, was a unique opportunity to promote a systematic and strategic approach to reducing vulnerabilities and risk to hazards (UN 2005c). The HFA is subsequently referred to as the Framework for Action.

Having reviewed the Yokohama strategy and identified gaps, expected outcomes and strategic goals were agreed at the conference, leading to the adoption of five priority for action areas in the HFA. Included in these areas are guiding principles on practical means for achieving resilience to disasters for vulnerable communities in the context of sustainable development (UNISDR 2015a).

These priority for action areas include:

i) Ensuring DRR is made a national and local priority with a strong institutional basis for implementation. The achievement was geared through community participation, assessment of existing human resources and allocation of resources for development. Further to this, the implementation of DRM programmes, policies, laws and regulations of DRR in all sectors, a clearly prioritised budget for action and third, development of national institutional and legislative frameworks.
ii) Identification, assessment and monitoring of disaster risk as well as enhancement of early warning through carrying out national and local risk assessment, development of timely and understandable EWS, along with capacity building,

regional cooperation and compilation and standardisation of emerging risk in the region.

iii) Use of knowledge, innovation and education to build a culture of safety and resilience at all levels by the management and exchange of information, education and training for all.

iv) Reduction of underlying risk factors by management of the environment and natural resources, development of social and economic practices, land-use planning, as well as other technical measures.

v) Strengthening of disaster preparedness for effective response at all levels through reinforcing policies, promoting and supporting dialogue, preparing and review of disaster preparedness, and the firming and development of coordinated regional approaches, as well as engaging in active participation with all stakeholders and promoting the establishment of emergency funds.

The adoption of the HFA and its implementation marked a milestone in taking national and local DRR efforts to a higher and recognisable level. It strengthened international cooperation through regional strategies, plans and policy development. The framework drove sufficient progress in developing institutions, legislations and policies for DRR. In addition, stakeholders strengthened their capacity for assessment, identification of risks, as well as disaster preparedness, response and early warnings (UNDRR 2019).

The HFA experienced limitations in the management of underlying disaster risks in most countries. A review by the UNDRR (2019) showed institutional, legislative and policy frameworks did not sufficiently facilitate the mainstreaming of disaster risk consideration in development decisions. Therefore, exposure to hazards increased at a faster rate than a decrease in vulnerability in both the higher and lower income countries. Also noted were the emergence of new risks at a faster rate than the reduction of existing risk.

In 2015, when the HFA implementation ended, it was recognised by UN member states that the HFA efforts had not produced expected reduction in economic impact and physical losses (UNDRR 2019). It was concluded by the member states that the national and international attention must shift its focus from protecting economic and social development against external shocks, to the transformation of growth and development to manage risk in a holistic manner. In view of this, the Sendai Framework was developed as a successor to the HFA.

3.7.6 Sendai Framework for Disaster Risk Reduction (SFDRR) (2015–2030)

The SFDRR (2015-2030), simply known as the Sendai Framework, was developed on elements that ensured continuity, with progress by states and other stakeholders under the HFA through the introduction of some new initiatives and innovations. The Sendai Framework reflects on new challenges that characterise the present world, which Zia and Wagner (2015) identified to include climate change, development of new techniques and expertise in EWS and the field of risk prediction and increased globalisation.

The Sendai Framework was the first post-2015 development agenda agreement by UN member states providing concrete actions to protect development gains from disaster risk. It works concurrently with other 2030 agenda agreements, which include but are not limited to the Paris Agreement on Climate Change, the New Urban Agenda and the SDGs. The Sendai Framework, being the third UN world conference endorsed by the UN General Assembly in 2015, advocated for the substantial reduction of disaster risk and losses in lives, livelihoods and health, as well as in the physical, environmental, social and economic assets of persons, businesses, communities and countries. This became the set goal for the framework (UNISDR 2015b).

The framework adopts a shift from disaster management to DRM, defined seven global targets and a set goal on preventing new risks, reduction of existing risk and the strengthening of resilience. In addition, the framework acknowledges the state has the primary role of DRR but recommends responsibility should be shared with other stakeholders, including local government, the private sector and other stakeholders. Thus, it built in a set of guiding principles that include institutional engagement of all-of-society and all-of-state.

The Sendai Framework aims to achieve its outcome or set goal from 2015 to 2030 and to realise this, it acknowledges the need for involvement and a strong commitment of the government in every country, as well as the mobilisation of support through international co-operation to provide the means of implementation, according to the priorities of every country and nation. The framework also broadened significantly to focus on both man-made and natural hazards and related technological, environmental and biological hazards and risks, while also promoting health resilience (UNISDR 2015b).

The following are articulated in the Sendai Framework:

i) The need for better understanding of disaster risk in all dimensions of hazard characteristics, exposure and vulnerabilities.
ii) The strengthening of disaster risk governance that should include national platforms.
iii) Accountability for DRM.
iv) Preparedness geared towards "Build Back Better".
v) Recognition of stakeholders and their roles in DRM.
vi) Avoidance of the creation of new risks by the mobilisation of risk sensitive investments.
vii) Resilience of health infrastructure, workplaces and cultural heritage.
viii) Strengthening global partnership and international cooperation as well as risk informed donor policies and programmes that include financial support and loans from international finance institutions.
ix) Recognition of global and regional platforms for DRR and mechanism for unity across agendas.

Using the experience gained during the implementation of the HFA, as well as pursuance in attainment of the expected outcome and goal, the SFDRR focused its action across global, regional, national and local levels in four priority areas, as follow: understanding disaster risk; strengthening disaster risk governance to manage disaster risk; investing in DRR for resilience and enhancing disaster preparedness for effective response and to 'Build Back Better' in recovery, rehabilitation and reconstruction (UNISDR 2015b).

The midterm report submitted by the UN General Assembly on the progress of the Sendai Framework (UN 2023), which reviewed progress made towards meeting the goal, global targets and priority for action areas reveal the general understanding and management of disaster risks had progressed at the midpoint of the framework implementation. This was shown by the positive results evident at local, national and regional levels. However, the current speed of implementation was not sufficient, and several countries were lagging in achievement of the expected outcome of the framework by 2030. The review also noted the progress made was unequal as a result of diversities in income levels, geographies and scales. This was seen particularly among the most vulnerable nations.

Concerning the four PAs of the Sendai Framework, progress was recorded as countries were seen to have enhanced their capabilities in disaster risk assessment and analysis at all levels (UN 2023). There was, however, a need for more progress in understanding drivers of risk creation and systemic risks. The increase in the number of countries with national DRR strategies that struggle to implement these strategies at local levels is notable. Also noted was the inadequacy of finances to run DRR strategies. It was, furthermore, observed disaster response remains the focus in many nations, as opposed to disaster prevention and preparedness, while post-disaster resilience and opportunities to "build-back-better" are missed.

There are varied reports across nations on the progress of attaining the global targets. Of note, is the minimal assistance from international cooperation to aid developing countries in development projects and support of DRR actions. Noteworthy, is the increase in the number of countries that had reported the use of multi-hazard EWS and the access to suitable risk information and assessment.

The mid-term review of the Sendai Framework highlighted a shift in momentum toward the whole-of-government and the whole-of-society approaches. There is, however, still a collective failure to prioritise risk reduction in political, environmental, economic and societal decisions. This is seen in the persistence of risk creation surpassing risk reduction efforts. The UN (2023) report on the Sendai Framework concluded with a recommendation of addressing risks before they become major shocks and the involvement of multi-sectoral and multi-disciplinary risk governance with firmer legal frameworks, better tools and availability of data, as well as risk prediction and adequate financing for prevention and preparedness.

3.7.7 Paris Agreement on Climate Change (2015)

The climate of the earth is changing and global climate is projected to experience more change over the centuries (Maccracken 2019). This change will, according to Maccracken (2019), increase in magnitude in the next few decades and this increase will depend basically on the amount of Green House Gasses (GHGs) emitted globally and on the sensitivity of the earth's climate to the emissions. Human activity is said to be the primary reason for this climate change. There is a consensus in the scientific world that unmitigated carbon emissions will lead to global warming of several degrees by the year 2100, which will result in high negative consequences on the regions of the earth (Maccracken 2019).

The climate change impacts include increased global air, ocean temperature rise, rise in global sea level, and wide spread reduction in snow and ice cover, as well as changes in ocean and atmospheric circulation and changes in regional weather patterns leading to changes in seasonal rainfall patterns. Changes in rainfall patterns result in more severe and frequent storms that cause flooding and landslides, disruption in livelihood and several mortalities and morbidities, as well as a variety of other risk to humans and other forms of life on earth. A significant reduction in the emission of GHGs will keep the global annual average temperature rise to 2^0C or less, which is agreed to be a safe limit. However, without intervention at reduction in GHGs emissions, the increase could reach 5^0C or more in this century.

Climate change became a global emergency transcending national borders making it an urgent issue that required international cooperation and coordinated solutions at all levels (Barston 2019). To deal with climate change and all its negative impacts, leaders from around the world converged in Paris in December 2015 at the UN Climate Change Conference, known as the Conference of Parties (COP) and reached a breakthrough called the Paris Agreement. Under the United Nations Framework Convention on Climate Change (UNFCCC), also known as COP21, the Paris agreement is the most significant climate change convention to date. It is a legally binding international treaty, enacted in November 2016 with 194 countries. The Paris Agreement stems from meetings on climate change, such as the 1992 Earth Summit and Kyoto Protocol of 1997 that extended to 2020.

The Agreement set long-term goals meant to guide all nations on the following:

i. Reduce global GHG emissions substantially to stall global temperature increase to well below 2^0C above pre-industrial levels and strive to limit to 1.5^0C above pre-industrial levels. These were agreed would significantly reduce the impacts and risks of climate change.
ii. Periodic assessment of the collective progress geared to achieving the purpose of the agreement and its long-term goals.
iii. Provision of finances to developing countries mitigating climate change, the strengthening of resilience and the enhancement of climate change adaptive abilities.

The Paris Agreement provided pathways for developing countries to receive assistance from developed countries in mitigation and adaptation efforts, as well as create a framework for the transparent monitoring and reporting of climate goals of countries. It also aims to reach global net-zero emissions. This is when the amount of GHGs emitted is equal to the amount removed from the atmosphere (attainment of climate neutrality) by the second-half of the century (Maizland 2023). The Agreement is a five-year cycle of climate actions meant to increase every five years, in an ambitious pattern. The assessment of the progress toward implementing the agreement every five years, is known as the global stocktake.

Since the Paris Agreement was enacted, there has been mixed progress towards emission targets. Several studies have noted the continued carbon emissions increase. The earth is now roughly 1.1^{o}C warmer than in the 1800's, global surface temperature has increased faster since 1970 than any other 50-year period over the last 2 000 years, with Green House concentrations at their highest levels in two million years (Maza, de la M. *et al.* 2020). In 2023, the first global stocktake was released, which warned governments of the failure of the world to be on track to meet the long-term goals of the Paris Agreement (Maizland 2023).

Scientist are of the opinion flooding will intensify, with increased human activity warming the earth and GHGs at the current rate (Swain 2023). Coastal flooding will continue to increase with the surging rise of sea level, as ice sheets and melting glaciers add to the volume of the ocean. Precipitation will increase and become extreme, leading to an increase in flash floods. This is because, as atmospheric temperature gets warmer, there is increased evaporation intensifying atmospheric moisture that is eventually released as snowfall or rainfall.

It is also suggested by researchers that flash floods will become more severe with shorter time lags and higher magnitudes, making them more dangerous and destructive (Maizland 2023). However, some breakthroughs have been recorded, such as in the commitment to establish a loss and damage fund at the COP27 held in Egypt in 2022. This fund is used to address inequality of climate change by aiding poorer and more vulnerable countries that are the least responsible for global emissions of GHGs, yet, are the most severely impacted by the effects of climate disasters.

3.7.8 2030 Agenda for Sustainable Development (SDGs)

The 2030 Agenda for SDGs, also known as the 2030 Agenda, comprises 17 SDGs, 169 targets and 231 indicators directed towards shaping global and national development policies, as well as providing opportunities and novel intentions for bridging the gap between development and human rights, as outlined by the UN Office of the High Commissioner for Human Rights (OHCHR 2023). It provides the framework for global and national development actions. The agenda was unanimously adopted in 2015 by all UN member states and will run through to 2030.

The SDGs propose to realise the human rights of everyone and transform the world. It is an action call to put an end to poverty and inequality, protect the planet and ensure every human being enjoys health, justice and prosperity, while ensuring no one is left behind (McInnes 2018). According to McInnes (2018), the 17 SDGs and their 169 targets are ambitious, wide-ranging and interconnected.

The 2030 Agenda offers an all-encompassing vision for sustainable development. The vision implies the agenda and its goals are global, covering both developed and developing countries, is based on equity and respect for human rights, and relies on approaches that promote sustainable financing, monitoring and evaluation, as well as scientific research and innovation. Further to this, the 2030 Agenda anchors the principles of equality and non-discrimination, committed to "leaving no one behind" and reaching the most vulnerable people first. Leaving no one behind implies challenges faced by African countries, Land Locked Developing Countries (LLDCs), countries undergoing conflicts and after conflict situations and middle-income countries must be prioritised and solved. The SDGs include the following, as documented by the UN (2015):

- Goal 1: No poverty. This goal aims to end poverty in all its forms and in everywhere.
- Goal 2: Zero hunger. This goal aims at ending hunger, achieving food security and improved nutrition, while promoting sustainable agriculture.
- Goal 3: Good health and well-being. This goal ensures people of all ages live a healthy life.
- Goal 4: Quality education. This goal aims to ensure inclusive and equiTable quality education, while promoting a lifetime of learning opportunities.
- Goal 5: Gender equality. This SDG goal is geared towards achievement of gender equality and empowerment of all women and girls.
- Goal 6: Clean water and sanitation: This is to ensure the availability and sustainable management of water and sanitation for everyone.
- Goal 7: Affordable and clean energy: This is to ensure access to affordable, reliable and sustainable and modern energy for all.
- Goal 8: Decent work and economic growth. This goal aims to promote sustained, inclusive and sustainable economic growth, as well as provision of full and productive employment and decent work for all.
- Goal 9: Industry, innovation and infrastructure. This is achieved through building resilient infrastructure, promoting inclusive and sustainable industrialisation and fostering innovation.
- Goal 10: Reduced inequality. This goal aims to ensure the reduction of inequality within and among countries.
- Goal 11: Sustainable cities and communities: The aim here is to make cities and human settlements inclusive, safe, resilient and sustainable.

- Goal 12: Responsible consumption and production. This goal aims to ensure consumption and production patterns are sustainable.
- Goal 13: Climate action. This is aimed at ensuring urgent actions are taken to combat climate change and its impacts.
- Goal 14: Life below water. This ensures conservation and sustainable use of the oceans, seas and marine resources for sustainable development.
- Goal 15: Life on land. This aims to ensure the protection, restoration of terrestrial ecosystem and promotion of their sustainable use, with forests sustainably managed, desertification combated, land degradations halted and reversed, as well as the halting of biodiversity loss.
- Goal 16: Peace, justice and strong institutions. This goal aims to ensure peaceful and inclusive societies for sustainable development, provision of justice for all and the building of effective, accountable and inclusive institutions at all levels.
- Goal 17: Partnerships for goals: this goal aims to strengthen the means of implementation and revitalise the global partnership for sustainable development.

Achieving the SDG journey has passed the halfway mark. Some progress has been made, such as the drop in neonatal mortality rate, however, many challenges made achieving the goal in many areas a herculean task (Reynolds 2023). SDG 13, which focuses on climate action, faces formidable obstacles. It remains a debate whether this goal is achievable. Years of progress were halted in the year 2020 as a result of the Covid-19 pandemic. Millions of people died, the poverty level was increased, jobs were lost, and education halted, with many developmental gains reversed (Guterres 2020). Economic disparities, unequal access to healthcare and education, along with conflicts, discrimination and scarcity of resources, as well as hurdles in politics, continued to place more barriers to achievement of the SDGs, since interdependency of the goals means a shortfall in one will affect the others.

3.8 DISASTER MANAGEMENT IN SOUTH AFRICA (SA)

SA experiences wide-area and regional, as well as flash floods (IFRC 2011; Munyai *et al.* 2021). Structural and non-structural measures are used to manage floods in SA. Non-structural methods have, however, been found to be difficult to implement, due to rapid urbanisation and its subsequent high density of informal settlements in major urban cities (IFRC 2011; Nkoane 2019; Lyse Comins 2023). The coming into law of the Disaster Management Act of 2002 and the National Disaster Management Policy of 2005 integrated DRR into all spheres of government using a decentralised approach. Nevertheless, having good legislation and policy does not mean there will be good practice.

This is in line with research by van Niekerk (2014) that critically analysed the Disaster Management Act and Policy Framework via analysis of the perception and attitude of senior governmental officials in all levels, the private sector and academia. The research findings show the weakest area of the disaster management act and policy framework is the lack of clear directives and guidance to local municipalities. The research also showed assignment of DRM functions at all levels of government is challenging, due to inadequate funding, as well as insufficient capacity and knowledge for DRR. This confirms the findings of Zuma *et al.* (2012), in the examination of the functionalities and drawbacks of the current disaster management system, as constituted by the Disaster Management Act of 2002, using the response to flooding occurring between December 2010 and February 2011 in SA.

This is further highlighted by research by Kunguma, Ncube and Mokhele (2021) on communication plans for municipalities that also show disaster managers in SA were struggling with implementation of the disaster management Act (57 of 2002). The research found the response was adequate only at the National level. Development planning in local government is the most important asset for development (Botha *et al.* 2011), however, findings have shown the absence of DRR in development planning at all levels of government in SA and although DRR is recognised as crucial for sustainable development, it is not always fully integrated (Van Riet and Van Niekerk 2012; Mavhura and Manyena 2019). This research sought to evaluate the good practices employed in urban FRM in the study area.

3.9 FRM GOOD PRACTICES

Good practices for FRM enable an understanding of flood behaviour and a better understanding of flood risk, effective communication and mitigation of flood risks. It ensures informed decisions on FRM and development investments. Flood management measures around the world offer an interesting perspective to assist in reviewing and comparing methods used in SA. Various methods are in place across the continents, with varying levels of success. This research examined some interesting, enlightening ways continents and their countries are using to protect themselves and their citizens from flooding with good success.

3.9.1 Europe

Europe is the second smallest continent in the world and occupies approximately one-fifth of the world's total land area (Windley *et al.* 2024). It consists of 44 countries, some which include Russia, the United Kingdom, Germany, and France, as well as the Netherlands, Sweden, Spain, and Monaco, in addition to the Holy Sea. Europe is bordered in the north by the Arctic Ocean, in the south by the Mediterranean Sea, the Black Sea, The Caspian Sea and the Kuma-Manych Depression and in the west by the Atlantic Ocean. The eastern boundary runs around the Ural Mountain and terminates at the Northern Caspian Coast.

Floods have been found to be the most common and costly natural disaster in Europe (EC 2023). According to the European Commission (EC), floods are becoming more frequent as a result of climate change and are expected to cause greater economic damage. The EU aims to reduce and manage flood risk to the environment, economic activity, cultural heritage and human life, where the right measure will be the use of IFRM and its focus on sustainable water management, thus adopting all measures that strengthen the resilience of nature and society to extreme weather events (EC 2023) . Thus, EU countries have been directed under the Flood Directive (FD) law (2007/60/EC) to assess all flood prone areas; carry out flood mapping to know the flood extent, as well as humans and assets at risk in the areas, and take coordinated and adequate measures to reduce the flood risk, while also carrying the public along in the planning process (EC 2023).

A core group from the EU, led by Netherlands and France in their guide to best practices on flood prevention, protection and mitigation, postulates a prerequisite for efficient and effective flood management is the in-depth knowledge of prevailing hazards and risks, which include adequate information on the type of flood, the probability of a particular flood event, the magnitude or extent of the flood, and the flow velocity or water depth, as well as the probable extent of damage. They emphasised the indispensability of flood maps to provide information regarding hazards, vulnerabilities and risks, and the implementation of necessary prevention and preparedness measures (Martini and Loat 2007).

To make this work, member states of the EU must work together and coordinate the development and implementation of FRM plans at the river basin level, so as not to allow flood problems to pass from one area to another. The UNDRR acknowledges the Netherlands' flood management as a climate adaptation model for the world (UNDRR 2021a). The Netherlands stands as a prime example of success, with its good practices discussed in this research.

3.9.1.1 The Netherlands

The Netherlands is a densely populated country with a low elevation, where approximately two-thirds of its area is vulnerable to flooding. Notable improvement in its flood management system has made the Netherlands world-renowned, after severe flooding in the North sea in 1953 claimed 1 800 lives (Harrison 2017). This could be attributed to the Netherlands having a well-developed system for FRM. They have put in place well-developed legal responsibilities in the event of failure in achieving the goal of the Flood

Directive, in addition to also providing sufficient opportunities for public participation, which has motivated the public interested in participating openly in flood risk awareness. They are strongly integrated at all levels, with appropriate coordination mechanisms between the national and regional levels, and are open to more diversification, risk-based approaches and multi-layered safety development (Priest *et al.* 2016; Chan, Yang and Mitchell 2022).

The Netherlands has put some remarkable measures in place in the management of flood risk. These include: the ‘room for River’ scheme, which features various steps used to embrace the flow of water in the country and reimagine the landscape, in order to provide better protection from flooding. The measures include relocation of dykes, lowering the depth of floodplain levels and relocating inhabitants living alongside rivers inland, to allow free passage of water through the Dutch waterways. The use of protective dykes along the coastline and many Dutch rivers represents the preventive and proactive measures being used against the threat of floods (van Herk, Zevenbergen, and Gersonius 2014.

For effective urban flood management, a multi-layered approach is used that involves prevention and preparation strategies. In the prevention approach, building permits are not granted in high flood prone areas and policies are developed to prevent rebuilding in these areas. In preparation, among other plans, is the evacuation plan to move people to higher grounds (UNDRR 2021a).

Another approach used in the Netherlands for FRM is the Delta programme. This approach is an elaborate system of dams, storm surge barriers, sluice gates, dikes and other protective measures. These systems enable cooperation of experts in water management, authorities from all levels of government and civil society (van Buuren 2019). The Delta programme allows the Dutch people to be protected from water related disasters, as well as live with water as it flows through its natural and manufactured waterways.

3.9.2 North America

North America is a continent in the Northern and Western hemisphere. It is the third largest continent in the world, comprising 23 countries (Zelinsky *et al.* 2024). North America is bordered in the north by the Arctic Ocean, in the south by the Caribbean Sea, in the east by the North Atlantic Ocean and on the west by the North Pacific Ocean. Some countries in North America include the USA, Mexico, Canada, and Guatemala, as well as the Dominican Republic, Cuba and Haiti. The USA has put together some best practices to managing floods with great success.

3.9.2.1 The United States of America (USA)

Best practices used in the USA fall into two main categories, which include management of flood warning systems and stormwater management. According to a report by Totten and Orlikoff (2022), best practices for managing flood warning systems include:

i. The utilisation of multi-dimensional analysis by incorporating a wide range of variables in order to have a better understanding and anticipation of flood related threats. In this case, incremental and cumulative data on rainfall and current water levels or flood stages are incorporated. In other instances, forecast information from the National Weather Service may be used. This results in meaningful analysis and prediction of water levels needed for measurement.

ii. Collaboration involves giving out and receiving data from international agencies within or outside their boundaries, thus sharing flood-related information with the public and emergency respondents.

iii. Being attentive and keeping an eye on the field. This could be achieved through human patrols or cameras and is used to anticipate incoming data and provide context for it. This approach becomes very valuable when water level sensors return inaccurate data or the data do not tell the entire story, in which case the shortcomings are corrected using visual field observations. Cameras can provide real-time checks on the data being received.

iv. Looking beyond your boundaries. This helps in anticipation of threats before they occur, which enables anticipation of what to expect.
v. The use of automated alerts to anticipate what is happening before it happens. It is proactive to set alarms that will make you aware of what is happening before it happens. For example, setting an alarm for approaching severe weather or upstream activities taking place outside the country/province or state boundaries.
vi. The continuous evaluation and improvement of warning systems is a very valuable practice in the management of flood risk.

During the 2022 flooding in Dallas/Fort Worth, the area received more than its entire seasonal average within a single day. Despite numerous flooded areas, the city did not suffer a single fatality, because they used the good practices discussed above (Totten and Orlikoff 2022). Stormwater good practices were also used in Santa Cruz County to avert a terrible flood disaster. These stormwater good practices enabled flood management response to be faster and more effective before, during and after flood occurrences. They include:

i. Multi-dimensional risk assessment that involves monitoring a wide range of variables for better understanding of flood related threats through a large network of rain gauges, sensors and weather stations, as well as rainfall data collected through conventional data.
ii. Obtaining data from neighbouring cities.
iii. Real-time automated responses.
iv. Remote visual confirmation of flooding.
v. Post-response evaluation and analysis.

The USA has used these FRM good practices to reduce fatalities and damages accrued to floods and have proposed its adoption and application in other North American countries.

3.9.3 South America

South America is the fourth largest continent in the world, with more than 420 million people. It comprises 12 countries, two dependent territories, one internal territory and several islands. Some of these countries include Argentina, Brazil, Colombia, and Chile, as well as Venezuela (Ramos 2018). South America is bordered in the north and east by the Atlantic Ocean, on the west by the Pacific Ocean and the north-west by North America and the Caribbean Sea. South America lies in a region known as Latin America, consisting of all the Portuguese, French and Spanish speaking nations of the South and Central America, as well as the Caribbean. The entire continent of South America, central America, Mexico and the Caribbean are known as Latin America. Latin America is prone to hydrometeorological disasters that cause economic losses and threaten life and livelihood. Argentina has implemented effective FRM approaches that have reduced losses due to floods.

3.9.3.1 Argentina

Over the decades, with support from the World Bank projects, Argentina has implemented successful and effective FRM projects, reduced vulnerability, improved infrastructure and balanced nature-based (green) and traditional infrastructure (grey) solutions (Mundial 2023). Presently, people are learning to live with water instead of fighting against it, according to Mundial (2023).

Argentina developed a long-term strategy aimed at reducing risk and mitigating the effects of floods through non-structural and structural measures. The approach, as Mundial (2023) points out, included:

i. Preventive strategies geared toward developing grey infrastructures, particularly defences and relocation of vulnerable communities.
ii. The inclusion of green infrastructure and nature-based solutions to harness natural processes and ecosystem services thus enhance water retention and reduce peak flow. This approach creates wetlands, linear parks, rain gardens and green roofs.

Measures geared toward a holistic management across major basins in Argentina include the development of technical tools and analysis at the river basin level. These measures strengthen policy, regulatory and institutional capacities to manage flood risk efficiently, and reduce vulnerabilities in communities through programmes aimed at specific groups such as women, as well as through flood early warning systems (FEWS).

iii. An integrated approach combining grey and green infrastructure, while capacities in the government are built for effective FRM. This led to a reduction in flood impacts, lowered investment costs and offered multi-faceted benefits. This approach shifted the paradigm from viewing water as a risk, to living with water and recognition of the environmental, economic and social value of water when properly managed.

These approaches have enabled Argentina to integrate flood risk prevention into management plans and land-use planning. It also enhanced flood preparedness with emphasis on management and non-structural methods. There were also flood mitigation efforts through construction of reinforced flood defence systems and drainage networks. In addition, post-flood challenges are addressed, which included reconstructing and rehabilitating key infrastructure, strengthening of flood defences to protect economically significant provinces and relocation of the lowest income population to areas with reduced risk to floods.

3.9.4 Asia

Asia comprises 48 countries, some of which include India, Bangladesh, and Iran in the south, China, Hong Kong, Singapore and Japan in the east, Turkey, Syria and Nepal in the South, and Thailand, Malaysia and Cambodia in south-eastern Asia, with Tajikistan and Kyrgyzstan in central Asia. It is the world's most diverse and largest continent. The highest and lowest points of the earth are found in Asia, while it is also the continent with the longest coastline and has the worlds' widest climate extremes (Şengör *et al.* 2024).

In the north, Asia is bordered by the Arctic Ocean, on the east by the Pacific Ocean, and in the south by the Indian Ocean. On the south-west of Asia is the Red Sea, while Europe is on the west of Asia. Due to the rapid growth of socio-economic activities along Asian coastlines, the cities are becoming highly populated. Asian cities also suffer from intensive rainstorms, typhoons and storm surges at an increasing level (Chan *et al.* 2018). Asian cities, particularly those located in coastal areas, are prone to numerous types of floods, with extreme consequences, because of rapidly growing economic development and population.

This research examined the FRM good practices from Hong Kong and Singapore and how they developed and adopted many flood mitigation measures that enabled them to reduce flood impacts. In addition to building structural flood control measures, these countries introduced an integrated approach to FRM. They incorporated FRM practices to reduce risk, supplemented the reliance on an engineering-based measures approach with holistic and flexible approaches that considered the human dimension of FRM (Chan *et al.* 2018).

3.9.4.1 Hong Kong and Singapore

These Asian countries used traditional flood management practices that involved developing urban drainage systems known as the Drainage Master Plan (DMP) to manage large volumes of surface runoff during storm events. In addition, channelisation to increase the high-volume discharge capacity was done to major natural water-ways. Streams were altered by deepening, widening and strengthening, as well as lining the rivers and streams with concrete (Chan *et al.* 2018). In their review, Chan *et al.* (2018) showed that Hong Kong and Singapore have more than 8 000km and 2 000km of hard-engineered drainage infrastructure in Singapore and Hong Kong respectively. This traditional flood management practice has been extremely successful. Another traditional method adopted was the coastal reclamation, sea walls and breakwater approach to prevent sea water overtopping in extreme tidal and surge events. This is used as coastal flood prevention in urban flood prone areas and has proved to be extremely successful.

Second, Singapore and Hong Kong adopted FRM frameworks to address lingering vulnerabilities to flood and to control floods. These measures included basin-wide planning, enhancing flood preparedness and intertwining of flood management with SDGs. These are discussed below, as explained by Chan *et al.* (2018).

- Basin-wide planning

In this measure, Hong Kong implemented an Outline Zoning Plan (OZP) and the Drainage Impact Assessment (DIA). This policy required all developments, needing a change in land-use specified in the OZPs or other government development plans, to seek approval from the Town Planning Board. A DIA required in the event of the project significantly affecting the drainage situation, will have mitigation measures that will not increase the flood risk in the area. Other policies were also enacted, such as the Land Drainage Ordinance (LDO), for responsible governmental institutions to gain access to private lands to perform water course maintenance within the private land. This proved very valuable in the removal of obstructions and garbage blocking the easy flow of water through the drainage basins and preventing flooding.

Singapore's National Water Agency known as the Public Utilities Board (PUB) explains that, the Source-Pathway-Receptor approach was adopted to cover the entire drainage system and address flood protection along pathways or drains used for the conveyance of stormwater, spaces generating runoffs known as source, and spaces where potential floods can occur known as receptors (PUB 2024). This reduces runoff from development sites into the public drainage system. The receptor solutions can be categorised as structural and non-structural measures aimed at protecting infrastructures from floods.

- Enhancing flood preparedness

This involves non-structural methods such as boosting flood preparedness and awareness of inhabitants. In Singapore, there is a Short Message Service (SMS) as alert service for local inhabitants desiring water levels in specific major waterways and rescue notifications when heavy rains are expected, which sends out flood warnings and alerts through social media. In Hong Kong, residents opted in to the rainstorm warning system receive real-time rainfall data, storm and typhoon information through mobile apps, radio, television channels and internet web pages (PUB 2024). To enhance preparedness, the Hong Kong government carries out emergency response drills in disaster prone areas. The Emergency and Storm Organization was established by the Singapore government to allow senior engineers to deal with emergency issues and coordinate drainage levels to clean blocked drains, to ensure performance of stormwater runoff, as well as hydraulic structures and flood water pumping stations.

- Intertwining of flood management with SDGs:

The Singapore and Hong Kong government adopted green and environmentally friendly approaches to manage floods. In Hong Kong, this includes promotion of nature conservation such as vegetation channel embankments to enhance diversity of micro-habitats and aesthetic value, the use of geo-fabric and gabion reinforcement grass lining to stabilise side slopes, instead of concrete wall retention of river meanders, and the use of unlined embankment and channel beds to assist flora and fauna colonisation. The Singapore government achieved a green and environmentally friendly approach through launching of the Active, Beautiful and Clean water (ABC) programme (Chan *et al.* 2018).

The ABC water programme is a strategy to improve the quality of water and life by harnessing the full potential of water bodies through the management of stormwater, using the SuDS and Water Sensitive Urban Design (WSUD) approaches (Chan 2019). The "Active" component in the programme is aimed at creating new community spaces around water bodies. The "Beautiful" component involves the improvement of aesthetical aspects of water bodies and local waterways and the "Clean" component seeks to improve the quality of urban runoff. Soft and green water features such as green roofs, bio-retention systems, swales and constructed water lands are used to replace or compliment traditional drainage infrastructure (Chan 2019).

3.9.5 Africa

Africa is the largest and the most populous continent after Asia (Dickson *et al.* 2024). It comprises a fifth of the total land surface area of the earth, with 54 countries in it, among which are Morocco, Tunisia and Libya in the north, and SA, Namibia and Zimbabwe in the south, with Kenya, Uganda and Ethiopia in the east and Nigeria, Benin and Ghana in the West. The African continent is bordered in the north by the Mediterranean Sea, in the South by the mingling waters of the Indian and Atlantic Oceans, in the east by the Indian Ocean and the Red Sea and in the west by the Atlantic Ocean.

Diverse climatic conditions are experienced in Africa, with floods one of the major natural hazards with very high impact (Lumbroso 2020). Findings by Dickson *et al.* (2024) show Africa is rapidly urbanising. The urban population is expected to triple from 584 million in 2018 to 1.5 billion in 2050. Urban flooding in Africa is very challenging and requires transformative change. Many approaches have been put forward to manage flooding in the continent, however, the continent still suffers devastations from flood as a result of poor risk assessment and management.

FRM practice in Africa has grown in urban areas and large river basins such as the Nile, Zambezi, Congo, and lake Chad, as well as Senegal, where there is very rapid population growth in the flood plains. Suggestions from the Global Centre for Adaptation (GCA) (2021) analysis on international good practices applicable to Africa include the following:

i. There should be a holistic understanding of flood risk, which should include understanding of the flood types, causes and likelihood of flood events, as well as the vulnerabilities of the communities in flood prone areas.

ii. Careful planning of traditional structural flood reduction infrastructure in highly vulnerable areas, such as densely populated areas, because of the high cost of these infrastructures and their importance in flood reduction.
iii. Planning and preparedness are the most essential and cost-effective non-structural FRM measures. These measures, when incorporated in FRM, significantly reduce losses to life and property caused by flood disasters. Land-use planning and management in rapidly growing urban areas will allow for flood-informed land-use planning and early prevention of construction in high-risk zones.
iv. Nature-based solutions such as preservation of wetlands and natural flood plain storage, management of vegetation cover and forest, to mention a few, will reduce flood risk with lower cost and greater flexibility.

The GCA emphasised the importance of river basins and water catchments upstream. They explained a very good practice in flooding downstream will be to manage upstream properly.

3.10 INTEGRATED FLOOD RISK MANAGEMENT (IFRM)

The concept of IFRM involves integrating FRM with other aspects of water management and spatial planning (Samuels *et al.* 2010). IFRM goes beyond flood protection and incorporates non-structural measures of prevention and preparedness (van Herk *et al*. 2014). IFRM is characterised by reduction of flood occurrences, reduction of harmful consequences should a flood occur, and promotion of sustainable development (van Herk *et al*. 2014). Nations have physical and institutional structure to battle floods and their consequences, however, the likelihood for flood damage is increasing as a result of increase in economic and social development (Samuels *et al.* 2010).

Societal response to flooding has evolved over the years from providing defences to developing and implementing policies and practices for FRM (Samuels *et al.* 2010). Thus, there is a shift from flood management to FRM. Research carried out by Samuels *et al.*

(2010) illustrates the complexity of FRM as a procedure that involves many facets with varying perceptions and objectives. The research unveiled that flood precautionary measures and defences are largely regarded as the principal responsibility of public institutions rather than a shared responsibility with people affected. This research, however, strengthens FRM by incorporating community involvement and good practices of DRR in a conceptual framework, providing a comprehensive approach. Developing a framework for IFRM in the study area will guide all key stakeholders in cost effective and efficient DRM, thus minimising the loss of lives and property.

3.11 CONCLUSION

This chapter covered literature topics in and around floods and various FRM strategies needed to minimise flood damages. The literature was obtained from relevant publications and books and critically analysed to identify themes and gaps. One of the sections reviewed in this chapter includes urban flood risk and the impacts in communities, which revealed that unplanned and rapid urbanisation increases vulnerability of urban communities to floods, as well as the dense concentration of crucial physical assets, energy installations, functioning industries and infrastructures. The literature review additionally showed that eThekwini, being a coastal city, was susceptible to river flood and storm surge as a result of its location.

Other sections in this chapter reviewed include disaster resilience and the important role of CBDRM in risk reduction, DRM and the global declaration frameworks on disaster and risk management as well as FRM good practices from around the world focusing on Europe, North America, South America, Asia and Africa. Finally, the chapter reviewed literature on IFRM. Identified the gaps to aid in formulating an improved and effective IFRM. The subsequent chapter covers the research methodology used in the research.

CHAPTER 4
RESEARCH METHODOLOGY

4.1 INTRODUCTION

Research methodology is the technique or specific procedure used to identify, select, process and analyse information on the research topic. Mehta (2023) describes research methodology as the scientific and systematic approach utilised to collect, analyse and interpret data meant to answer research questions or test hypotheses. Several types of research methodology are used by researchers, depending on various criteria such as nature of the research question, goals of the study and available resources. Commonly used research methodologies include; qualitative, quantitative, mixed-methods, case study and experimental research methodology.

The correct choice of research methodology approach is a crucial step in conducting meaningful, valid and reliable research intended to justify the aim and objective of the research. This section highlights a detailed explanation of how the data were collected and analysed and allows for critical evaluation of the study's overall validity and reliability. This research utilised both a quantitative and qualitative research methodology approach. This mixed methods strategy was adopted to ensure the research is comprehensive.

4.2 QUALITATIVE RESEARCH METHODOLOGY

This research methodology approach involves the collection and analysing of spoken or written words and textual data. It is descriptive and based on people's opinion, irrespective of facts. The approach evaluates people's attitude, behaviours, knowledge and opinions on the research topic (Mehta 2023). Qualitative research methodology is based on the quality of the phenomenon and focuses on collecting data on respondent viewpoints, feelings and impressions and not on the data size.

This research approach is an interactive process that requires people who can speak boldly and share their perspective. It seeks to understand the experiences of the respondents as much as possible. Qualitative data are usually collected through interviews, focus groups and observations using carefully selected participants. This research utilized a qualitative research methodology in order to understand the perceptions of stakeholders concerning FRM in the study area.

4.3 QUANTITATIVE RESEARCH METHODOLOGY

This research methodology is used to test the importance of the research hypothesis (Mehta 2023). In this approach the focus is on collecting, testing and measuring numerical data from a large sample of participants. The research methodology includes surveys, simulations, laboratory experiments and mathematical calculations, to mention a few. The critical factor in this research methodology is the measurement, amount or quantity. This research methodology is objective and quicker, as software programs are utilised when analysing data. The data collected are analysed using statistical analysis and comparisons. Commonly used methods employed to gather quantitative data include questionnaires, databases, organisational records, and tests, as well as surveys.

Number-based research measures attitudes, performance and behaviour in numbers, making data easier to interpret. These data can effectively be converted into charts and graphs, making it difficult for the researcher to influence the interpretation of the result. It measures the relationship between variables (Mehta 2023). This study used a quantitative research methodology to obtain the objective opinions of a large number of respondents in the study area regarding FRM.

4.4 RESEARCH DESIGN

A research design is an inquiry or blue print with specific direction for procedures (Creswell 2014). Bouchrika (2023) describes research design as a framework comprising the methods and procedures utilised to collect, analyse and interpret data. A good research design ensures the data collected addresses the research problem accurately and clearly and in the absence of biases. It is the overall plan for connecting conceptual research problems with the relevant achievable empirical research. Simply put, a research design is a research strategy that helps in providing the structure and direction of the research toward a favourable result. Research design is divided into two broad categories namely quantitative and qualitative research designs. Choosing the best research design is essential for an excellent result.

4.4.1 Quantitative Research Design

This design is aimed at answering the questions to how, where, when and who throughout the research. The outcome of the quantitative analysis is easily represented in the form of statistics, numbers, charts and graphs. Quantitative research design includes experimental, quasi-experimental, descriptive and correlational research (Creswell 2014). According to Creswell (2014), experimental and quasi-experimental designs allow the researcher to test the cause-effect relationship, and the descriptive and correlational research designs allow the researcher to measure variables and describe the relationship between them. The correlational and descriptive research designs paint a clear picture of characteristics, trends and relationships depicted in real life. This research utilised descriptive research design to obtain an insight into the trend of flood disasters and its management in the study area.

4.4.2 Qualitative Research Design

This design type involves gaining a rich and detailed understanding of a specific phenomenon or context (Mccombes and Bhandari 2023). Some common types of qualitative research design as documented by Mccombes and Bhandari (2023) include the following:

i. Case study – this involves a detailed study of specific subjects such as place, organization or event. Data in this design can be collected through a variety of sources and this research focuses on gaining a holistic understanding of the case.

ii. Ethnography – this design involves the study of a specific group or community. Data are collected through close observation and extended immersion. This design focuses on describing and interpreting beliefs, social dynamics and conventions.
iii. Grounded theory – this design aims to develop a theory inductively by analysing qualitative data systematically.
iv. Phenomenology – this design aims to understand events or phenomena by describing the experiences participants have lived in.

This research utilised case study research design. A case study research design entails the in-depth examination of a specific case for a period of time (Leedy and Ormrod 2010). This study focused on flood disasters in Durban and intensively sought how flood risk can be managed, by integrating other measures alongside storm water management. The design was selected by the researcher in a desire to derive an in-depth understanding of the study area in its real-world context and with a hope of acquiring new knowledge regarding the study area that will activate the research and provide more understanding of the real issues causing floods. It also allowed for rich descriptions and insightful explanations. According to Yin (2016), case study research design is confined by the time and activity by which a variety of data collection procedures of detailed information is collected over a sustained period of time. This design allowed the researcher to explore multiple bounded systems through detailed and in-depth data collection over a period.

4.5 PHASES OF THE STUDY

The research was conducted in three phases. Phase one involved the aspect of FDRM that utilised quantitative and qualitative data collection instruments, in the form of questionnaires and semi-structured interviews, respectively. These were used to assess flood hazard in the community, the exposure of the community members to the hazard and their vulnerabilities, as well as the management of flood and storm water via information on drainage systems and the subsequent health impact on community members.

Phase two used questionnaires and semi-structured interviews to ascertain the resilience of community members in the study area to disasters. Information was obtained on the participation of community members in FRM, the presence of motivations such as socio-economic incentives and training, and the presence of linkages between community initiatives and government structures. Phase three comprised the retrospective review of flood management across the world, with the view of obtaining good practices that can be adopted in the study area.

4.6 STUDY AREA

The EMA, created in the year 2000, is one of the 11 municipalities located in the KZN province of SA. KZN is in the Southeast of the country, with a long shoreline on the Indian Ocean (Figure 4.1).

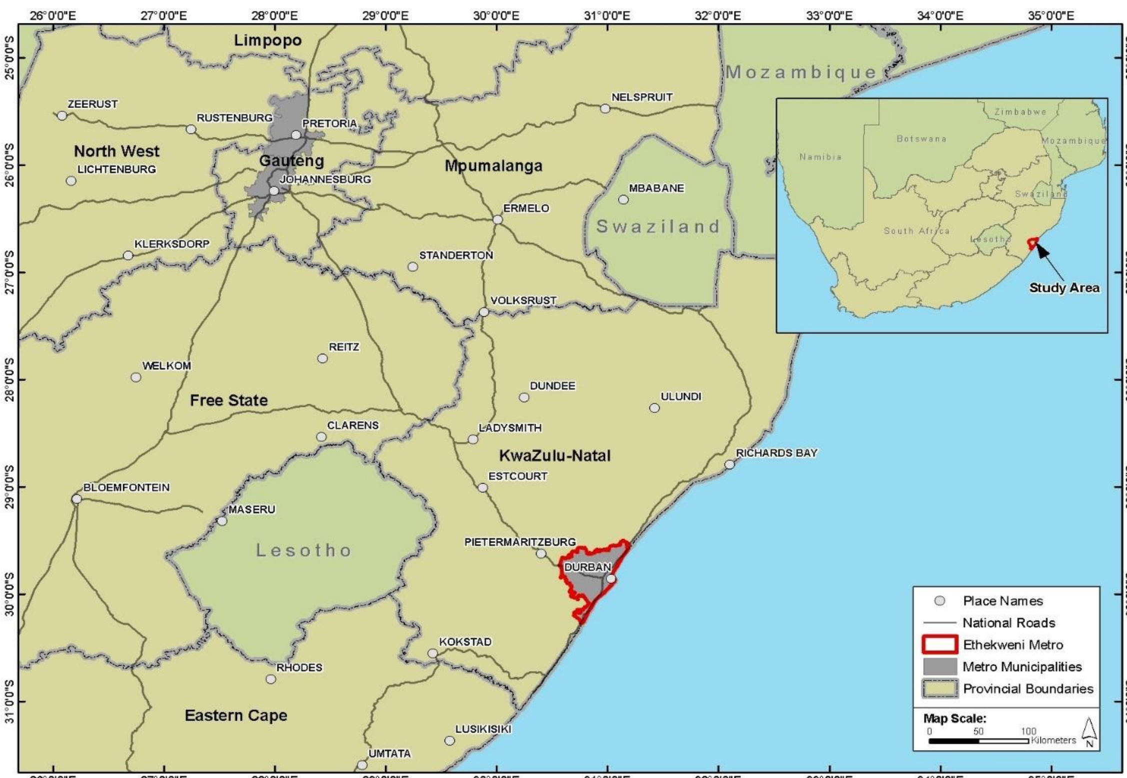

Figure 4.1: Map showing location of eThekwini Metropolitan Area (EMA) (a.k.a. Durban)
Source: Turpie *et al.* (2017)

The EMA is sprawled over approximately 2297km^2 and extends from the Tongati river in the North to the aMahlongwa river in the south. Bounded in the eastern edge by 98km of Indian coastline, the EMA extends 50km inland to the west at Cato Ridge. It is bordered in the North by Ilembe municipality, and south and west by Ugu and uMgungundlovu district municipalities respectively (Turpie *et al*. 2017), comprising approximately 37 cities and towns, featuring a rugged topography with hills and valleys (figure 4.2). The rugged interior is intermingled with flat sandstones and tabletops ranging in size from expansive areas located in Kloof, Hillcrest and Waterfall areas to isolated smaller areas upland, such as the Matabatule, Inanda and Fudu mountains (Turpie *et al.* 2017). The EMA has approximately 45 percent rural area, 30 percent peri-urban and 25 percent urban area (Figure 4.2).

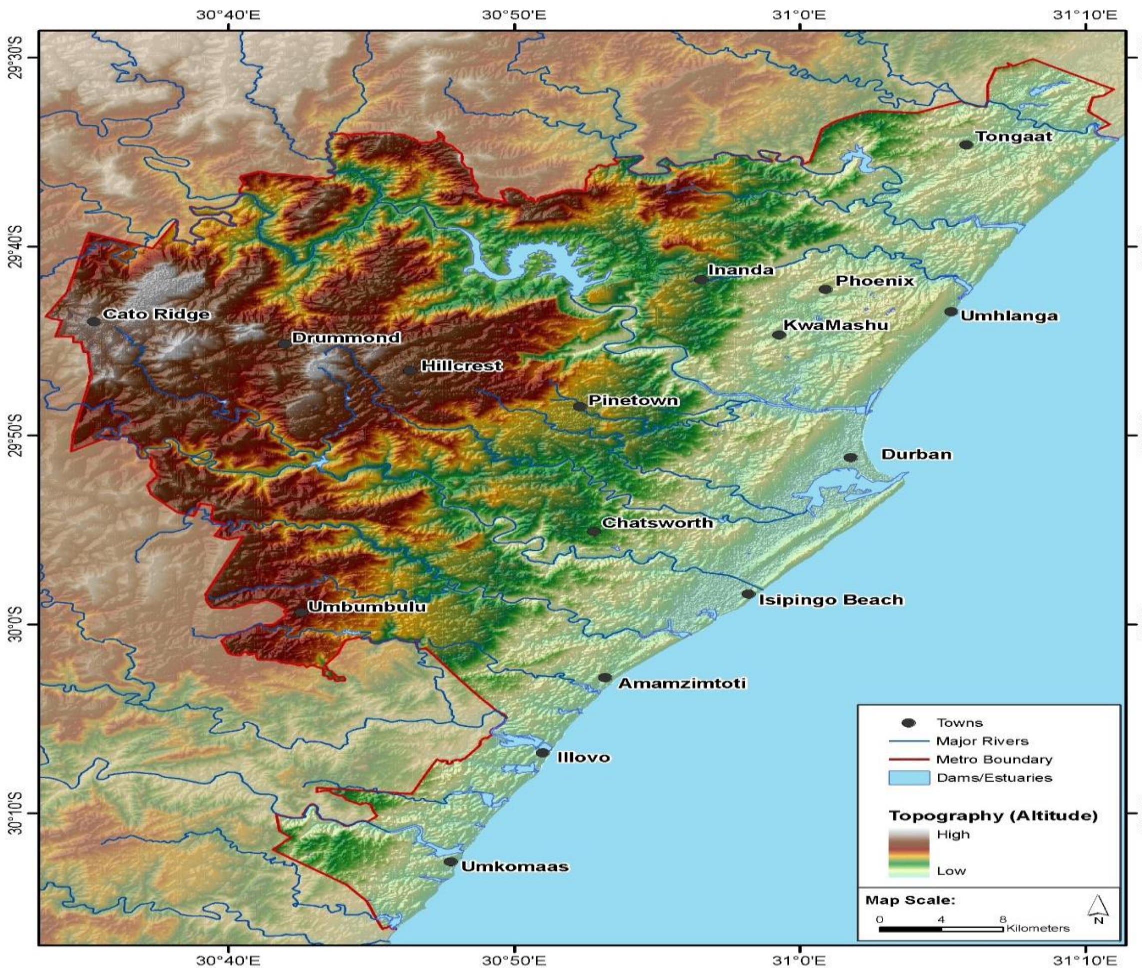

Figure 4.2: Map showing topography of eThekwini Metropolitan Area (EMA)
Source: Turpie *et al.* (2017)

The EMA, also known as Durban, has a sub-tropical climate with wet, humid summers and mildly dry winters (Roberts and Donoghue 2013). Durban has a mean annual precipitation of more than 1 000mm, with the rainy season between September to March. Most rainfall occurs during the summer months, where rainfall tends to be highest in the south and along the coast of Durban. However, rainfall seasons are greatest in the west (Turpie *et al*. 2017).

As the largest city in the KZN province and the third largest city in SA, with a population of approximately 3 987 648, the EMA accounts for 34.7 percent of the total KZN province population, with 50.3 percent women and 49.7 percent men (Metropolitan SDF 2021).

Furthermore, 74 percent of the population are African, 17 percent are Indian, seven percent are White and two percent are Coloured. The EMA has an average household size of 3.3 and roughly 30 percent of its population is below the age of 15 years, with approximately 63 percent below 35 years, in addition, 8 802 households are headed by young people and children between the ages of 15 to 19 years. Women headed households account for 42.14 percent (Metropolitan SDF 2021).

EMA is the main economic seat in KZN and contributes over half of the province employment, income and output. Durban has a port which is the busiest cargo port in SA and the busiest container port in the Southern hemisphere. Assessment carried out in 2016 through the StatsSA Community Survey (StatsSA 2016) shows 2.2 million residents live below the poverty line and approximately 17.1 percent of the population has no income. This has led to the formation of informal settlements along river systems and accessible natural areas.

4.7 SAMPLING

How representative a sample of a population is will depend on the sample frame, sample size and sample design (Fowler 2014). Population is the total collection of individuals required to understand or draw a conclusion, with Litt (2010) explaining a clearly defined population of interest is a very fundamental constituent of research design. This is because the conclusions resulting from a research design is because of the way the population is being defined.

Obtaining information from the entire population of eThekwini would be very expensive and near impossible for the researcher, therefore, a sample of the research that offers large and meaningful data to represent the entire population in solving the problem of the research, was used. Thus, the representative sample can make precise conclusions on the population, based on the information obtained. It is, therefore, not obligatory to study all possible cases to understand the phenomenon of flood disasters in the study area. However, care was taken to determine an appropriate sample size that was not too small to lack the precision to provide reliable answers to investigated questions and affect performance, and not too large to cause a waste in time and resources.

A population sample is a part or section of the population being studied (Huck *et al.* 2010). The population selected for the research include Inanda Township, uMlazi Township, Clare estate and Cato Manor. According to documentation by StatsSA (2011), Inanda Township is situated 21km north of Durban with a total area of 26.81 km^2. The Inanda population is 158 619 people, with a population density of 5 900 persons/km^2. uMlazi Township is located south-west of Durban, covering an area of 47.46km^2, a total population of 404 811 people and a population density of 8 500 people/km^2, making uMlazi the fourth largest township in SA after Soweto, Tembisa and Katlehong. Cato Manor and Clare estate are situated 5km west of Durban city centre and central Durban respectively, with a population of 5 996 people for Cato Manor and 6 190 people for Clare Estate.

The sampled respondents are residents of the study area, purposively drawn, and aimed at targeting respondents directly involved, who could produce data relevant to the study. The population sample for the quantitative data was drawn based on period of stay in the study area, age of respondent, ownership of property in the study area and frequent visits to communal centres. Key informants for the interview were purposively selected based on expertise in DRM of the study area.

4.7.1 Qualitative Sample Size

The population of disaster management practitioners and officials in the EMA comprises a small group of people. The respondents were segmented into similar psychographic qualities to ensure the exploration of ideas from specific subsets (Table 4.1). Thus, the sample size was homogenous in nature and focused on interviewing a defined number of participants in order to explore themes, opinions and ideas. The data size needed to reach saturation for the purposively sampled respondents was carefully considered.

According to Morse (2015), saturation in qualitative research is the most common guiding principle for assessing adequacy of purposive samples. Morgan *et al.* (2002) found out in their study that the first four to six interviews produced the majority information, and little or no new information was gained as the sample size increased. Similar results were obtained from interviews conducted by Francis *et al*. (2010). Based on these findings, the sample size for each segment was five respondents (Table 4.1). However, provision was made to accommodate more to enhance credibility, as more respondents are known to provide credibility to research findings (Creswell 2014).

Table 4.1: Qualitative sample size

S/No	Disaster Management key Stakeholders	Sample size
1	Head of disaster management centre (eThekwini)	1
2	eThekwini Disaster Managers/Practitioners	5
3	eThekwini Disaster Management Officials	
	i) Engineering Unit	1
	ii) Development Planning and Environmental Management Unit	1
	iii) Housing Unit	1
	iv) Water and Sanitation department	1
	v) Parks, Recreation and Culture Unit	1
4	eThekwini Municipality Ward Councillors	5
5	Members of Committee	
	Inanda Township	1
	uMlazi Township	1
	Cato Manor Township	1
	Clare Estate	1
	TOTAL	20

Saturation for the qualitative research was reached at 15 respondents. At this point, data began to duplicate itself and no additional insights were identified, making further collection redundant, thereby signifying the collection of an adequate sample size.

4.7.2 Quantitative Sample Size

Miaulis and Michener (1996) expound that sample size is determined by considering the population size, sample error or level of precision, degree of variability in the attributes being measured, and confidence level or risk, as well as the study purpose. Fowler (2014) recommends the determination of sample size should be related to the analysis plan for a study. Different strategies and approaches are used to determine sample size. According to Isreal (2012), these approaches include census for small populations, calculation of sample size by use of formulas, initiation of sample size of similar studies and the use of published Tables.

This research utilised the published Tables. The Table entails three components that include determination of the margin of error the researcher is willing to tolerate, determination of the confidence level for the margin of error and an estimation of the percentage of the sample that will respond in a given way (Creswell 2014: 205). The positive and negative deviation allowed on the survey results for the sample are known as the confidence level. The confidence interval or margin of error and the confidence level determine the data accuracy.

Assuming the population for Inanda, uMlazi, Cato Manor and Clare Estate is represented as w, x, y and z, the total population of the study area was:

$w + x + y + z = 158{,}619 + 404{,}811 + 5{,}996 + 6{,}190$
Total Population = 576 616 people.

For the purpose of this research, sample size determination was achieved through the use of the Krejcie and Morgan sample size Table. Krejcie and Morgan (1970), which uses the formula (1) below to determine sample size.

$$s = \frac{X^2 NP(1-P)}{d^2 (N-1) + X^2 P(1-P)} \quad (1)$$

Where:

s = required sample size

X^2 = the value of chi-square for one degree of freedom at the confidence level desired

N = size of the population

P = proportion of the population (This is also assumed to be 0.50 as this provides the maximum sample size)

d = the accuracy degree expressed as a proportion.

For a total population of 575,616, there is thus a margin of error (confidence interval) of +/- five percent, 95 percent confidence level for the margin of error and a 50 percent chance the sample contains the required characteristics, where the sample size for the research, according to the Krejcie and Morgan 1970 sample size Table, was 384.

Based on the population of the selected cities/towns in the study area, the questionnaire respondents were determined using a ratio of 1:2:3:4. The larger the population, the more the respondents. Using this reasoning, the questionnaire distribution is shown in Table 4.2

Table 4.2: Quantitative sample size

Urban Suburb	Participant Category Urban Residents	Population	Sample size
uMlazi Township	South-West of Durban	404,811	154
Inanda Township	North of Durban	158,619	115
Clare Estate	Durban central	5,996	77
Cato Manor Township	West of Durban	6,190	38
Total		575,616	384

4.8 DATA COLLECTION

The research used a mixed method of data collection to understand the research problem more thoroughly. A combination of quantitative and qualitative data collection methods in one study is known as triangulation (Rossman and Wilson 1985). Yin (2016) describes triangulation as the use of at least three ways to collaborate or verify a particular event, fact or description reported in a study. The collection of both quantitative and qualitative data neutralises the weakness of either of the data collection procedures (Creswell 2014).

Triangulation enables the researcher to improve and validate the accuracy of conclusions through the reliance of multiple data sources (Rossman and Wilson 1985). The qualitative data provided numerical information on trends and patterns, while the qualitative data provided rich descriptions and explanations of the trends. This strengthened the overall validity and reliability of the research. The appropriateness of the research data collection method is shown in Table 4.3.

Table 4.3: Appropriateness of research data collection

Objectives	Research orientation	Data collection methods and tools	Data source
1. Examine flood risk in the selected flood prone areas.	1) Quantitative 2) Qualitative	1) Questionnaires 2) Historical and literature review 3) semi-structured interview	Purposively sampled residents in study area Secondary data from study area within the period under review from: SAWS, Aerial and satellite photos, internet sources, research and newspaper publications and articles.

			Purposively sampled stakeholders of DRM in study area. i. Disaster Management Practitioners ii. Senior Disaster Management Officials Ward Councillors and Ward Committee Members
2. Identify the factors that increase vulnerability of community members to floods in the study areas. 4. Examine the role of key stakeholders in urban flood management in the study area.	1) Quantitative 2) Qualitative	1) Questionnaire 2) Semi-structured interviews	Purposively sampled residents of study area Purposively sampled stakeholders of DRM in study area. i. Disaster Management Practitioners ii. Senior Disaster Management Officials iii. Ward Councillors and ward committee members
3. Examine the disaster management practices employed by disaster managers in urban FRM in the study area.	Qualitative	Semi-structured interviews	Purposively sampled stakeholders of DRM in study area. i. Disaster Management Practitioners

			ii. Senior Disaster Management Officials iii. Ward Councillors and ward committee members
5. Examine FRM good practices in other developing and developed countries	Quantitative	Literature review	Secondary data: Internet sources, research and newspaper publications and articles.
6. Develop a framework for IFRM in the study area	Triangulation	Development of framework for IFRM	Data analysis

Source: Author's own Table (2024)

Structured questionnaires (Appendix 2) were used to collect information from purposively sampled residents of the study area, whose livelihoods and property are affected yearly by flood disasters. This provided the researcher a quantitative or numeric description of attitudes and trends of a population through the study of a sample of that population (Creswell 2014: 296). According to Fowler (2014), structured questionnaires are used with to generalise from a sample to capture the entire population.

Although respondents that can read English were preferred, a language interpreter, however, accompanied the researcher in the case of people that could not read or understand English. Selected respondents were 18 years and older. The respondents were expected to tick the appropriate boxes and complete the questionnaires in approximately 10–15 minutes. The questionnaires were collected immediately after completion. An appropriate day and time were selected to exclude rainfall or other harsh weather conditions.

Qualitative data collection was done using semi-structured interviews (Appendix 1) enabling the collection of detailed views from stakeholders of disaster management. Open-ended interview questions allowed for discussion with participants to produce deeper insight into the problem, as opposed to a direct question and answer method. Participants are disaster managers and other disaster management officials who participated through face-to-face or telephonic interviews prepared by the researcher. The interview questions elicited information on the efficacy of DRM.

Creswell (2013) explains qualitative interviews provide opportunities for generating good understanding from in-depth explanations. Three interview guides were administered for the interview. The questions in these guides were formulated according to the level of expertise of the disaster management officials in disaster management. These prevented the overshadowing of the data intentionally or inadvertently by disaster management officials specialised in the field. These categories shown in Table 4.1 include:

i) Disaster Management Practitioners
ii) Senior Disaster Management Officials
iii) Ward Councillors and Ward Committee Members

The interviews between researcher and participants took place in the municipality offices and telephonically, according to the preference of the participants, at a mutually agreed time and lasted for a maximum of 30 minutes. Notes and a recorder were used for the interview. Qualitative data were collected until diversity, depth and nuances of the issues were obtained.

Snowball sampling was also used during the interview to gain more insight on the problem. Yin (2016) describes snowball sampling as when new data are obtained as an offshoot of existing ones. During the interview the researcher learnt of some individuals outside the confines of flood disaster management in Durban, who participate in flood disaster management in other municipalities in KZN, with additional useful information incorporated into the key informants. However, little or no extra information was obtained. Only participants and respondents who gave their consent by means of signing the consent form took part in the research.

Secondary data using historical and systematic literature reviews were employed to review existing research on flood disaster and FDRM in view of understanding the current flood disaster in the study area from the year 2000 to 2020. In addition, the knowledge gap identified needed to be filled to further understand the issues potentially important for further exploration, using primary data (questionnaires and interviews). These secondary data include historical reports of rainfall variables from the SAWS, aerial and satellite photos (Appendix 3), internet sources, as well as research and newspaper publications and articles from the past 20 years (2000–2020).

4.9 DATA ANALYSIS

Marshall and Rossman (1990) define data analysis as a process of obtaining order and meaning from collected data. The data obtained were arranged into manageable patterns, themes, trends and relationships in such a way to increase understanding of the aim and objectives of the research.

4.9.1 Quantitative data analysis

This involved the use of statistics to analyse the variables, collected through questionnaires, with a view of making sense of the numerical information. Descriptive and inferential statistics were used. Descriptive statistics were used to generate summaries of the sample in a data set. This was to show what is typical for the sample. This information is reported as frequencies, displayed in Tables and graphs, which condense the information and present it in an easily comprehensible and visually attractive way. Other descriptive information reported includes the measures of central tendencies (mean, median and mode) and measures of dispersion (standard deviation).

Inferential statistics were used to make inferences on the trends, relationship with other variables and impact of flooding on the population. In order to ascertain significant trends, the Chi-Square test was used to test and compare associations between two categorical variables in the population. The Pearson's coefficient was used to show the linear correlation between two variables. The quantitative data were analysed using SPSS v. 29

4.9.2 Qualitative data analysis

Qualitative analysis is the process of converting qualitative data into insights. These data are subjective, rich and consist of in-depth information presented in the form of words. Bogdan and Biklen (1982) defined qualitative data analysis as the process of systematically searching and arranging non-textual materials collected by the researcher via interview transcriptions, audio and video recordings or observations and notes, to increase understanding of the phenomenon.

The process, which basically involves categorisation or coding, entails making sense of a large volume of data by reducing the amount of raw information, then identifying the significant pattern and finally, deducing meaning from the data and ultimately building a logical chain of evidence (Patton 2002). The technique provides a clear step-by-step pattern of analysis: transcription; interview familiarisation; coding; and development of working analytical framework; as well as application of analytical framework; charting data into a framework matrix; and, finally, data interpretation.

The textual data used in this research were obtained from semi-structured interviews. The data analysis process in this research is shown in the flowchart (Figure 4.3).

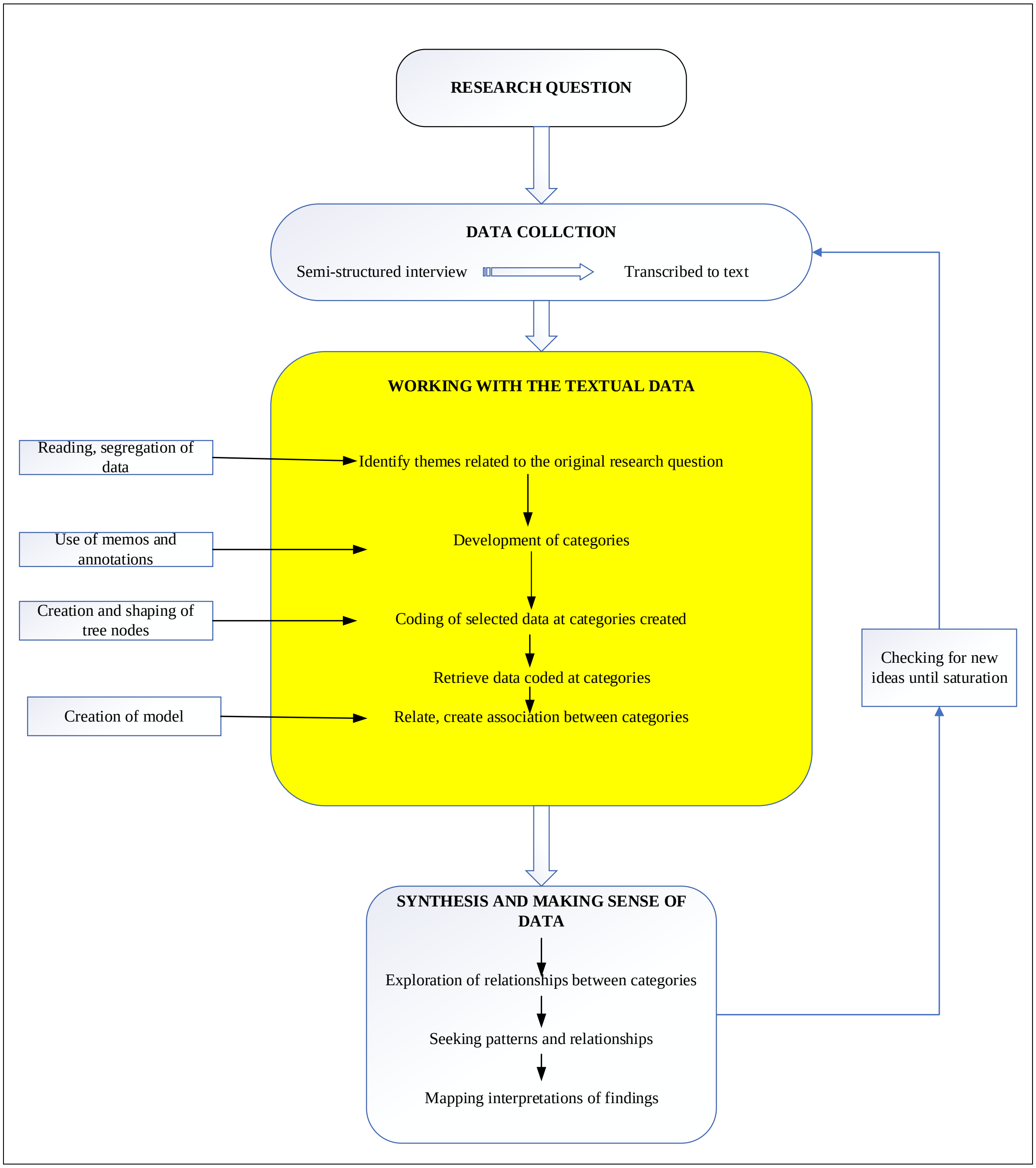

Figure 4.3: Qualitative data analysis flowchart

Source: Wong (2008)

The Nvivo software version 14 was used in this research to speed up the process of grouping data according to categories and retrieving coding themes, as well as to help maximise efficiency of the process. Nvivo is a computer-assisted qualitative data analysis software (CAQDAS) developed by QSR International. The software, other than allowing for qualitative enquiry beyond coding, sorting and retrieval of data, was also designed to integrate coding with qualitative linking, shaping and modelling (Wong 2008).

4.10 PILOT STUDY

A pilot study or pretesting involves a variety of activities, used to evaluate the capacity of the survey instruments for data collection, the capability of the technique and the adequacy of the overall procedure (Caspar *et al*. 2017). It is a technique used to check that questions developed in questionnaires, surveys and psychometric scales are understood by respondents and participants and achieve what is meant to achieve, thus helping to identify obstacles and increase methodological and social reliability (Hilton 2017).

Pretesting of the data collection tools was carried out using the field method approach, through a respondent debriefing method (Caspar *et al*. 2017). The researcher carried out a field pilot study on two ward councillors of the study area using semi-structured interviews and with five community members, who were administered the questionnaires to complete. Thereafter they were probed verbally in line with the questionnaire questions and their responses on specific questions were collected. In this way, the researcher ensured the questions were well understood for the semi-structured interview and questionnaires and could be applied. This method was selected, because it is cost-effective and identifies question-specific problems. Another advantage of the method is it constitutes part of the research and takes place in the study area, providing confidence in the result. Moreover, no ambiguous, superfluous or offensive questions were identified, allowing the research to proceed with the sample size selected.

4.11 DATA VALIDITY, RELIABILITY AND TRUSTWORTHINESS

The appropriateness of the research methods, soundness of the research applications and integrity of the research conclusions were ascertained by the validity of the research. Noble and Smith (2015) refer to validity as the precision and integrity of the application of the research methods and the accuracy of the findings in the reflected data. Trustworthiness ascertains the credibility of the research. The consistency within the analytical procedures used in the research infers the reliability of the research.

Strategies employed in this research to strengthen validity, reliability and trustworthiness included:

- Multiple data in the form of semi-structured interviews, questionnaires, an extensive literature review, and images from observations were collected; these increased the reliability of the research.
- The triangulation technique employed the use of a quantitative and qualitative data collection technique, which demonstrated the complementary fashion of data collection and fills in any gaps that may have been created.
- The use of questionnaires and interviews added credibility in the provision of trustworthy information.
- The researcher ensured there was a logical link between the research instruments (questionnaires and semi-structured interview) and the study objectives. This was done to promote the research validity.
- A multi-site survey added validity to the over-all output on the study area.
- Collection and analysis of relevant and sufficient data were a true reflection of the research problem.
- Transparency and consistency of data collection affirmed data validity.
- The perspectives of participants were presented accurately, thus adding credibility to the research.
- During analysis of data, the decisions of the researcher were clear and transparent.
- Data were analysed in such a way that independent researchers will reach similar or comparable conclusions, thus reducing bias. A reproducible result attests to the effectiveness and dependability of the methodology.

- The research findings can be applied to other settings and contexts. Transferability further validates research findings.
- Interview transcripts were made available to participants on request for their comments, and affirmation that the themes and concepts finally arrived at adequately addressed the problem being investigated. This gave the research credibility.

4.12 ANONYMITY AND CONFIDENTIALITY

The protection of a research subject/participant's identity is known as anonymity, whereas confidentiality is the protection of information obtained in confidence through the research period (Mills, Durepos and Wiebe 2013). In this research, extreme measures were taken to protect the identity of the participants and the information they gave.

This research ensured the anonymity and confidentiality of the participants and respondents in the following ways:

i. Data were kept secure through password-protected files and locked drawers; made available only to the supervisor of the research.
ii. Results to identifying information were coded by means of pseudonyms.
iii. Aggregate findings were reported to the public and not individual-level data.

4.13 ETHICAL CONSIDERATION

This study secured ethics clearance from the Research Ethics Committee (IREC) of the Durban University of Technology (DUT). Authorisation to collect data from the study area was obtained from the relevant authorities of the eThekwini metropolitan municipality. Ethics consideration taken in this research aimed to ensure voluntary participation and address participant anonymity and confidentiality, which included the following:

i. Participants signed consent forms during the data collection permitting the researcher to use the information they provided.

ii. All necessary information on the research was made known to the participants so they would understand the impact of the research and the usefulness of their participation.
iii. Participants were made aware that their participation was voluntary and they could opt-out whenever they desired.
iv. Participants were not subjected to any physical, psychological or moral abuse and were in no way exploited for any form of gain.

The reason for the research was clearly communicated and confidentiality of responses provided.

4.14 DELIMITATION OF THE STUDY

These are study limitations that originate from conscious choices made by the researcher in a quest to narrow the study scope (Connelly 2013). Designing the research for a particular age group, gender, occupation, or geographically selected area and so on, limits the generalisation of the research findings. Connelly (2013) infers such consciously made decisions by the researcher involving inclusionary or exclusionary criteria during the study plan development, may represent a systematic bias intentionally introduced into the study design or instrument.

Delimitations in this research included:

i) The EMA is composed of 37 cities covering a land area of 2 297km^2. The study focused on four flood-prone cities representing the North, South, East and West of the EMA, because it would have been near impossible in finances and time, to cover all the cities. However, information may be limited when compared to using all the cities in the study area.
ii) Participants for the interview were local government officials of the EMA responsible directly or indirectly for flood disaster management. Hence, in-depth information may not be very truthful, due to participant subjectiveness.

iii) Development of the framework was restricted to data collected from the selected flood prone areas.

4.15 LIMITATIONS OF THE STUDY

There were a few limitations in this study. Limitations to a study represents weaknesses within a research design that may impact the research outcomes and conclusions. Ross and Zaidi (2019) infer a study limitation provides the probable restrictions, offers clarifications regarding the implication of the limitations, making alternative approaches available that would counter the limitations, as well as describe procedures taken to mitigate the limitations. These are done in order to enrich the reader's understanding of the limitations inherent in the study and support further investigations.

The major limitation experienced during the research was the Corona Virus disease (Covid-19) pandemic caused by the SARS-CoV-2 virus, a highly infectious disease that spreads primarily through saliva droplets or nose discharge from the cough or sneeze of an infected person (WHO 2021). This pandemic, which started in Wuhan city, China, in December 2019, had its index cluster of imported cases confirmed in SA on 3 March 2020.

The South African Government introduced various measures to combat the spread of the virus. A risk-adjusted strategy that aligned five levels with the intensity of transmission, where level five signified the highest level when there is an intense community transmission and level one the lowest, was introduced. This resulted in the imposition of a countrywide lockdown, which started from midnight of 26 March 2020. The country went through various levels of lockdown and regulations until mid-June 2022, when eminent risk declined and all remaining regulations regarding Covid-19 were stopped (Department of Health 2022). These lockdowns brought about immense delay in the issuance of the ethics clearance by the institution and gatekeepers' permission to conduct research in the study area, as well as collection of data. To mitigate this delay, health regulations were used to collect data when the level of transmission permitted. However, this led to an increase in funds required to conduct the survey.

The following safety measures were taken during data collection, as advised by the World Health Organization (WHO 2021):

- Respiratory etiquette, which involved coughing into a flexed hand, was practiced.
- Facemasks were used by both the researcher and the respondents. The mask was worn in such a way that it covered both nose, mouth and chin.
- Short time periods were spent with each respondent.
- A physical distance of at least one meter was maintained between researcher and respondent.
- The survey was carried out in open air spaces.
- Alcohol-based hand sanitiser was used frequently to disinfect hands during the exchange of questionnaires.
- The researcher ensured large groups were not formed at any point of data collection, as respondents were attended to individually.
- The majority interviews for qualitative data were conducted telephonically.

Another limitation to the research was the availability and co-operation of stakeholders that further caused delays in data collection. Disaster management respondents for interview were very reluctant and uncooperative. The councillors were busy in various council meetings trying to get the municipality back to its vibrant nature after the terrible consequences of the Covid-19 pandemic, and were very slow in consenting to interviews. The disaster management practitioners/coordinators were working tirelessly on bringing back normalcy to the municipality, particularly after another flood disaster was again experienced in April 2022; a disaster recorded as one of the deadliest since the flood disaster of 1987. The researcher had to allow flexible hours for telephonic interviews as requested by respondents, with some conducted at very late hours.

4.16 CONCLUSION

This chapter described the research design, the study area and how the target population was sampled. The chapter additionally explained the data collection techniques employed using questionnaires and semi-structured interviews and how data analysis was performed. Also discussed is how a pilot study was performed to improve the methodological and social reliability of the research. The chapter, furthermore, extensively discussed the study limitations due to the Covid-19 pandemic and how they were overcome. The next chapter will present and discuss the analysed results of the questionnaire and interviews.

CHAPTER 5

DATA ANALYSIS AND INTERPRETATION OF FINDINGS

5.1 INTRODUCTION

This chapter is an output of the previous chapter that highlighted the quantitative and qualitative methods approach, where the triangulation technique for data collection was used to strengthen the research reliability and validity. In addition, the use of qualitative and quantitative data provided a more complete picture of the research, wherein the qualitative data provided rich detail and context, while the quantitative data provided a picture of the broader patterns and trends. The semi-structured interviews also served as a follow-up to further solicit clarification on some aspects not satisfactorily addressed by the questionnaire, while offering an explanation on the contrary views raised in the questionnaire concerning management of flood risk in the study area. This chapter, therefore, focuses on the analysis and interpretation of the results from the measurement instruments.

5.2 QUANTITATIVE DATA ANALYSIS

Quantitative data were analysed using SPSS v. 29. The sample was computed using descriptive statistics, with frequencies used, as well as the chi-square test for non-parametric findings.

5.2.1 Response rate

Response rates to questionnaires are very important in any research. A response rate of approximately 60 percent should be the goal for most researchers, otherwise the research will suffer from a non-response bias (Fincham 2008). This bias is explained by Fincham (2008) to mean lack of response to the questionnaires by respondents drawn from a population or a sample size. Non-response bias negatively impacts both the validity and reliability of findings in a survey. Thus, the response rate analysis of this research is Tabled below:

Table 5.1: Response Distribution of the study area

S/N	Study Area	Sample	Percent
1	uMlazi	155	40.4
2	Inanda	115	29.9
3	Clare Estate	76	19.8
4	Cato Manor	38	9.9
	Total	384	100

Table 5.1 shows the response distribution across the selected cities under coverage within the EMA where the sample comprised 40.4 percent (uMlazi), 29.9 percent (Inanda), 19.8 percent (Clare Estate) and 9.9 percent (Cato Manor) respectively. This distribution aligns with the sampling technique used and the probability proportion to size, considering the populations of the respective cities. The sample distribution expresses a representation of the populations of the study area affected by floods. Notably, the research was able to obtain a 100 percent response rate. Hence, the research lacks a non-response bias and results will be reliable and valid.

5.2.2 Demographic information

This section consists of basic information on the respondents, such as gender, age, marital status, and education, as well as occupation, household size, years of community residency, and ownership status, in addition to basic income. Root causes of flooding in the study area can be learnt from knowing the demographics. Vulnerability of the study area residents to flood risks can be captured through demographic information. This section of the questionnaire assisted in the vulnerability assessment of the study area to flood disasters. This addressed objective one, which examined flood risk in the study area.

5.2.2.1 Gender

The aim of this question was to determine the vulnerability of the study area to floods. Statistics have shown, when disaster strikes, women and children are 14 times more vulnerable than men (Okai 2022). This is because women disproportionately suffer the impact of flood-related disasters more than men, as a result of inequitable distribution of roles, powers, resources and cultural norms, particularly in developing countries (Yavinsky 2012; Fan and Huang 2023). A knowledge of the population's gender will help explain the degree of vulnerability in flood-related disasters in the study area.

Table 5.2: Gender Distribution across the Study Area

			Gender	
			Male	Female
Study Area	uMlazi	Count	47	108
		Percent	30.3%	69.7%
	Inanda	Count	47	68
		Percent	40.9%	59.1%
	Clare Estate	Count	44	32
		Percent	57.9%	42.1%
	Cato Manor	Count	22	16
		Percent	57.9%	42.1%
Total		**Count**	**160**	**224**
		Percent	**41.7%**	**58.3%**

Table 5.2 illustrates the respondent gender distribution across the cities. In general, 58.3 percent respondents are female, while 41.7 percent are male, which indicates there are relatively more females than males across the study area. This could also explain why the study area is highly impacted by flood disaster.

5.2.2.2 Age

The age of the respondents ranges from 18 to 24 years, 25 to 34 years, 35 to 50 years, and 51 to 70 years, and more than 70 years. Within each of these age categories, respondents were allowed to select the range in which their age falls. This was in a bid to gain added confidentiality, rather than collecting their actual age, which may have led to a poor response rate. The Figure below (Figure 5.1) depicts the distribution of the respondents' age range in years.

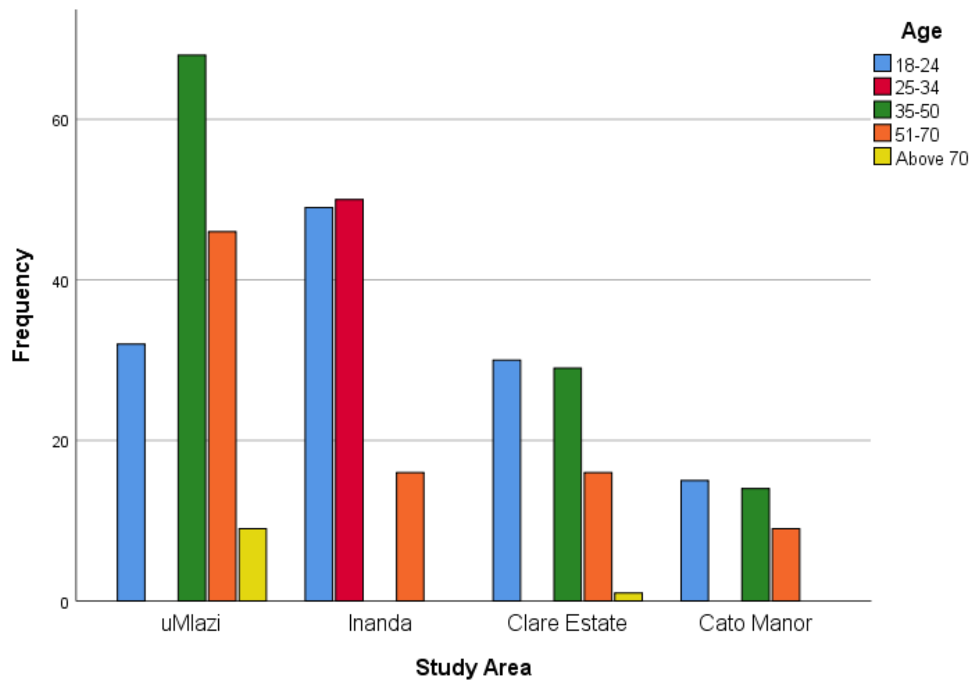

Figure 5.1: Distribution of Respondents' Age range by study area

Figure 5.1 illustrates in uMlazi, 43.9 percent respondents are aged between 35-50 years, 29.7 percent are between the age of 51-70 years, 20.6 percent between the age of 18-24 years and 5.8 percent were older than 70 years. In Inanda, 43.5 percent respondents are in the 25-34year age range, 42.6 percent are between 18-24 years and 13.9 percent fall in the 51-70year age range. In Clare estate, 39.5 percent are in the 18-24year age range, 36.8% are between 35-50 years, and 23.7% between 51-70 years of age. Cato Manor had 32.8 percent respondents between 18-24 years, 28.9 percent are 35-50 years of age and 23.7 percent are between 51-70 years. In summary, the highest age range in uMlazi Township with 43.9 percent respondents falls within 35-50 years, Inanda Township with 43.5 percent between 25-34 years, Clare Estate with 39.5 percent within the 18-24year age range, and Cato manor with 32.8 percent between 18-24 years.

Generally, the highest age range in the study area with 32.8 percent, falls within the 18-24year age group. According to the Organization for Economic Co-operation and Development (OECD 2023), the working age category is between 15-64 years. This implies the study area will suffer high economic vulnerability should a flood disaster occur, as approximately 97 percent residents are in the working age. In addition, disasters in the study area will result in social vulnerability. This is because the youth, who constitute the highest percentage of 32.8 percent of the population, is known to suffer from stress reactions, anxiety disorders, grief, and Post-Traumatic Stress Disorders (PTSD), as well as other comorbid conditions following disasters (Pfefferbaum *et al.* 2009). According to the UN (1985), youth are those persons between the ages of 15-24 years.

5.2.2.3 Marital status

The aim of this question in the questionnaire (appendix 1) was to ascertain the vulnerability of the community in correlation to marital status. Research findings by Cvetkovi (2019) suggest marital status plays a big role in disaster preparedness at community level. The research infers married people are better prepared for flood disaster. Frequent and long-lasting floods force them to consider preparedness, while they are also familiar with viruses and infections that occur during and after flood disasters and are very familiar with safety procedures.

These findings by Cvetkovi (2019) also infer divorced citizens mostly take preventive measures to reduce tangible consequences caused by flood disasters. Konttinen *et al.* (2021) showed in their research that marital status moderates the impact of disaster on mental health. Unmarried women may be at higher risk of distress after natural disasters (Howells *et al.* 2020). Moreover, Konttinen *et al.* (2021) also showed in their findings that the impact on mental health was not restricted to unmarried women and single or divorced marital status is associated with symptoms of depression at every age in men.

Table 5.3: Marital status across the Study area

			Marital status					Total
			Single	**Married**	**Divorced**	**Separated**	**Widowed**	
Study Area	uMlazi	Count	100	22	8	16	9	155
		Percent	64.5%	14.2%	5.2%	10.3%	5.8%	100.0%
	Inanda	Count	88	22	2	3	0	115
		Percent	76.5%	19.1%	1.7%	2.6%	0.0%	100.0%
	Clare Estate	Count	68	6	0	0	2	76
		Percent	89.5%	7.9%	0.0%	0.0%	2.6%	100.0%
	Cato Manor	Count	34	2	0	0	2	38
		Percent	89.5%	5.3%	0.0%	0.0%	5.3%	100.0%
Total		**Count**	**290**	**52**	**10**	**19**	**13**	**384**
		Percent	75.5%	13.5%	2.6%	4.9%	3.4%	100.0%

The study shows in uMlazi, 64.5 percent respondents are single, 14.2 percent are married, 10.3 percent are separated, and 5.8 percent and 5.2 percent are widowed and divorced, respectively. In Inanda, 76.5 percent respondents are single, 19.1 percent are married, and 2.6 percent and 1.7 percent are separated and divorced, respectively. In Clare Estate, 89.5 percent respondents are single, with 7.9 percent and 2.6 percent married and widowed, respectively. While in Cato Manor, 89.5 percent are single, 5.3 percent are married and widowed, respectively. In general, 75.5 percent respondents are single, 13.5 percent are married, 4.9 percent are separated, and 3.4 percent are widowed, while 2.6 percent are divorced.

The high percentage of unmarried or single residents in the study area explains the lack of preparedness against flood disasters in the community. Lack of preparedness will mean the community will be highly vulnerable to the disaster. In addition, after the disaster, unmarried/single citizens will have a very slow recovery, due to the lack of a strong emotional support system, which may lead to symptoms of depression.

5.2.2.4 Education

There is a link between education and vulnerability to flood disasters and effective DRR. This statement in the questionnaire (Appendix 1) aimed to analyse the association between educational attainment and vulnerability to flood disasters. The researcher hypothesised that educational attainment is positively associated with vulnerability and resilience and other natural disasters induced by natural hazards.

A study by Drzewiecki *et al.* (2020) showed adults with professional education were significantly more resilient than those with no more than primary school education and no significant changes were found between the primary and those with no more than secondary school education. Not only does education have a direct influence on risk perception, knowledge, and skills, it also indirectly promotes access to information, as well as strengthens human capacity such as poverty reduction and health improvement. Educated individuals are more adaptive and empowered in their preparedness, response and recovery from disasters (Drzewiecki *et al.* 2020).

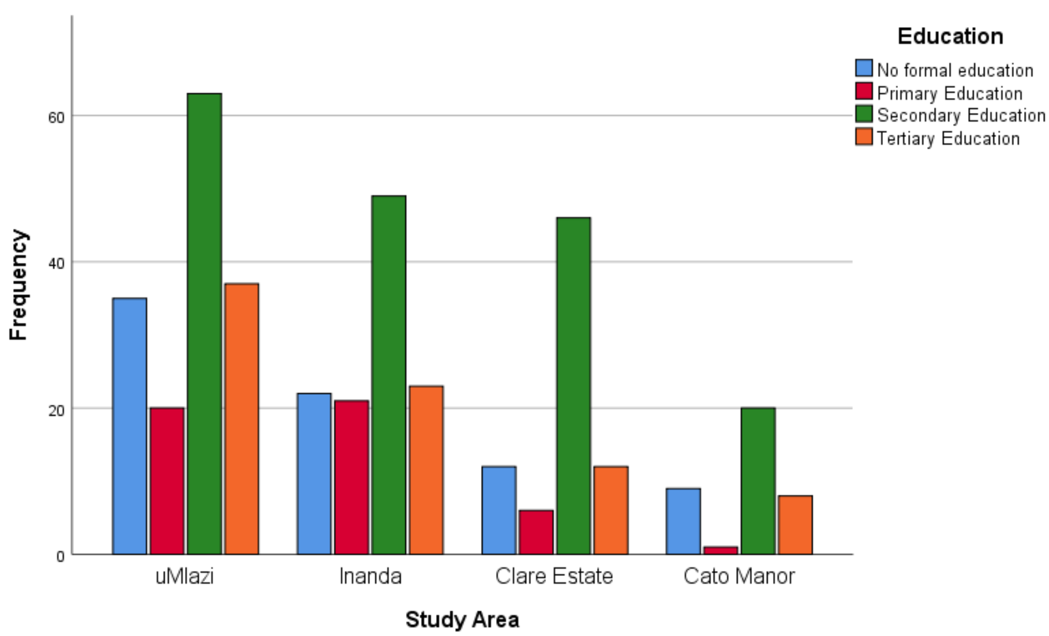

Figure 5.2: Distribution of Respondents' educational attainment

The study results, as shown in Figure 5.2, revealed in uMlazi, 40.6 percent have a secondary education, 23.9 percent a tertiary education, and 22.6 percent have no formal education, while 12.9 percent have a primary education. In Inanda, 42.6 percent have a secondary education, 20 percent a tertiary education, and 19.1 percent and 18.3 percent have no formal or primary education, respectively. In Clare estate, 60.5 percent have a secondary education, 15.8 percent have no formal education or tertiary education, respectively, while 7.9 percent have a primary education. While in Cato Manor, 52.6 percent have a secondary education, 23.7 percent have no formal education, 21.1 percent have a tertiary education, and 2.6 percent have a primary education. Generally, the study showed most respondents (46.6 percent) have a secondary education, 20.8 percent have a tertiary education, and 20.3 percent have no formal education, while 12.5 percent have a primary education.

This research shows only a minority people (20.3 percent) have a tertiary education. This may account for the lack of adequate preparedness for flood disasters and why there is increasing impact of flood in the study area on a yearly basis. This authenticates research by Muttarak and Lutz (2014) that highly educated individuals and societies have better preparedness, respond better to disasters, suffer less from negative impacts of floods and recover faster. Thus, education increases awareness and reduces the impacts of natural hazards such as floods. It has become relevant from this finding, to say the best strategy for flood DRR is education, starting from the primary and secondary school system.

5.2.2.5 Occupation

This is a fundamental component of demographic identity, which exerts a profound influence on individuals' lives, shaping not only their economic well-being but also their perspectives, aspirations, and daily experiences. This section aims to connect unemployment to poverty and invariably, the vulnerability to flood disaster. Being of low socio-economic status (SES) may affect the way disaster risk is understood, prepared for and responded to.

The Substance Abuse and Mental Health Services Administration (SAMHSA) (2017), in their review of several literature on how disasters affected people of lower SES, found people living in poverty with low income and less education prepared less for disasters, due to some preparedness actions being too costly; for example, flood insurance. Findings by Tasri, Karimi and Muslim (2022) show unemployment and poverty variables had a significant effect on the disaster loss variable. This analysis encompassed a diverse range of occupational categories, namely public sector worker, self-employed, retired, and unemployed.

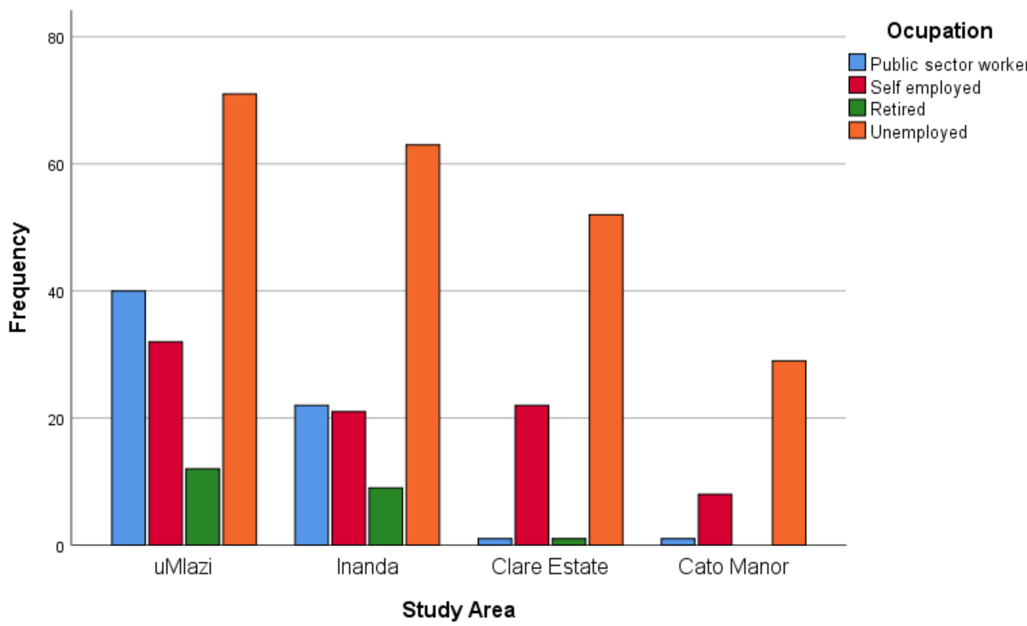

Figure 5.3: Distribution of Respondent Occupations

The result from the study (Figure 5.3) indicates in uMlazi, 45.8 percent respondents are unemployed, 54.8 percent are unemployed in Inanda, while 68.4 percent and 76.3 percent are unemployed in Clare Estate and Cator Manor, respectively. Generally, approximately

56 percent respondents are unemployed, 21.6 percent are self-employed, 16.7 percent are public sector workers, while 5.7 percent are retired. This indicates most residents in the EMA are unemployed. Their unemployed status will account for the lack of preparedness for flood disasters, where their low SES and poverty lead to very slow recovery from flood disasters, with poor housing resulting in informal settlements and high losses from flood disasters.

5.2.2.6 Household size

This is another important demographic factor in resource allocation, vulnerability, housing density, and understanding the household sizes, as these are crucial for evacuation planning during flooding. Notably, households of a smaller size might be more resilient during flooding, as they may be more mobile and able to relocate or evacuate quicker. However, the size of a household can largely contribute to the recovery process.

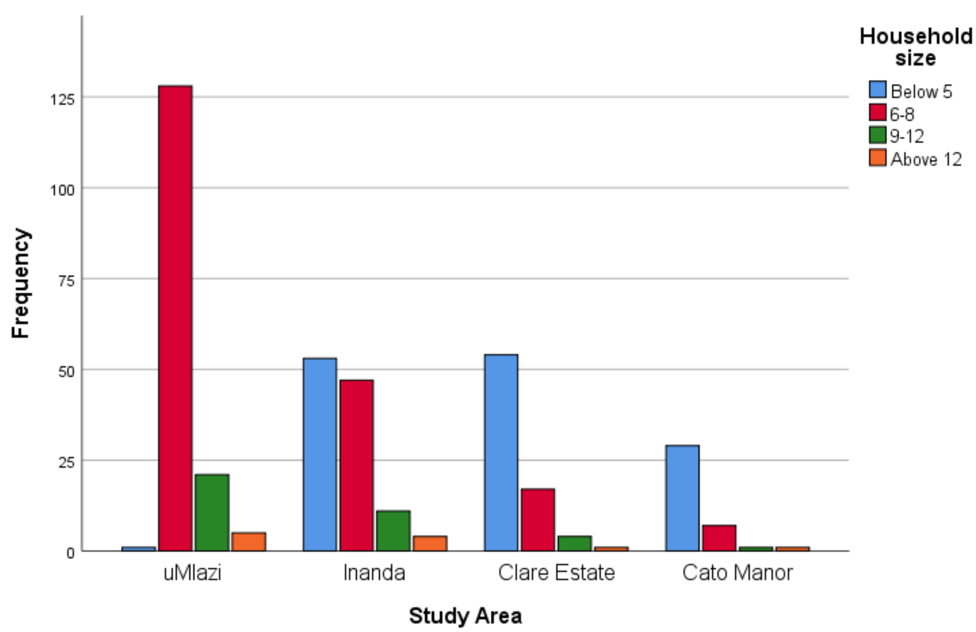

Figure 5.4: Distribution of Household Size

According to the study results (Figure 5.4), it was revealed in the eThekwini municipality, the majority households have a size of 6-8 members, accounting for 51.8 percent respondents, 35.7 percent have a household size below five, and 9.6 percent have a household size between nine and 12, while 2.9 percent have a household size above 12. A household size with 6-8 members, with the possibility of unemployment for the head of the family, low educational attainment and having aged people among them, will make disaster response and recovery very slow and ineffective due to economic and social limitations. This may explain why disaster response and recovery may not be as effective as the effort by disaster management practitioners.

5.2.2.7 Property type

Floods have a huge impact on the housing sector, which is deemed the most vulnerable, after the immediate threat to human life. The flood disaster in Durban in 2022 saw at least 13 000 homes damaged and houses located in low-income neighborhoods were reportedly the most affected (BBC 2022; CNN 2022). A majority of poor people in developing countries live in mud houses; this may mainly be due to local skills in construction and availability of raw materials. A mud house is a building made of soil dug from the earth. The soil may be naturally enhanced with paddy straws. Mud and straw/grasses for construction are locally available all over the world. The most affected houses during floods are the mud houses. Mud as a building material is seen as a fragile and short-lived material unable to adequately survive natural disasters (Chowdhooree and Das 2022). Although the environmental performance of the houses is very good, they are vulnerable to flood disasters, as mud bricks are very weak in shear, tension and compression.

Recent studies show most homes in SA are built with brick and concrete (Capeetc 2022). However, the encroachment of informal houses or backyard shacks as a by-product of formal houses, is responsible for making the area more vulnerable to floods. Backyard shacks are mainly built with wood and Corrugated Galvanised Iron (CGI) sheets. These shacks appear in different shapes, sizes and conditions. Other materials used to build backyard shacks include but are not restricted to cardboard, plywood, tires, and newspapers, as well as tarpaulins.

In this research, wooden houses refer to backyard shacks, which also encompass all materials used for their construction. Shacks are highly vulnerable to floods due to their construction materials and in most cases, being built in unsafe locations. The flood disaster of April 2022 in eThekwini and other municipalities in KZN resulted in hundreds of people dead and thousands displaced. Shack dwellers experienced the worst, as shacks were washed away (Potenza 2022).

Table 5.4: Property type in the Study Area

			Property Type			Total
			Brick house	Mud house	Wooden house	
Study Area	uMlazi	Count	71	47	37	155
		Percent	45.8%	30.3%	23.9%	100.0%
	Inanda	Count	60	38	17	115
		Percent	52.2%	33.0%	14.8%	100.0%
	Clare Estate	Count	16	0	60	76
		Percent	21.1%	0.0%	78.9%	100.0%
	Cato Manor	Count	13	0	25	38
		Percent	34.2%	0.0%	65.8%	100.0%
Total		**Count**	**160**	**85**	**139**	**384**
		Percentage	**41.7%**	**22.1%**	**36.2%**	**100.0%**

The study result shown in Table 5.4 indicates 41.7 percent respondents live in a house made of brick, 36.2 percent live in a wooden house, while 22.1 percent live in a mud house. However, in uMlazi and Inanda, 45.8 percent and 52.2 percent respectively, live in brick houses, while in Clare Estate and Cato Manor, 78.9 percent and 65.8 percent respectively live in wooden houses. This explains why eThekwini is highly impacted by flood disaster, since the majority houses (58.3 percent) are constructed with wood and mud.

5.2.2.8 Community residency (Years)

This variable refers to the length of time respondents have been living in the study area. It is an important piece of demographic information in understanding the trend of flood disasters in the study area, as well as the vulnerability and coping capacity of community members.

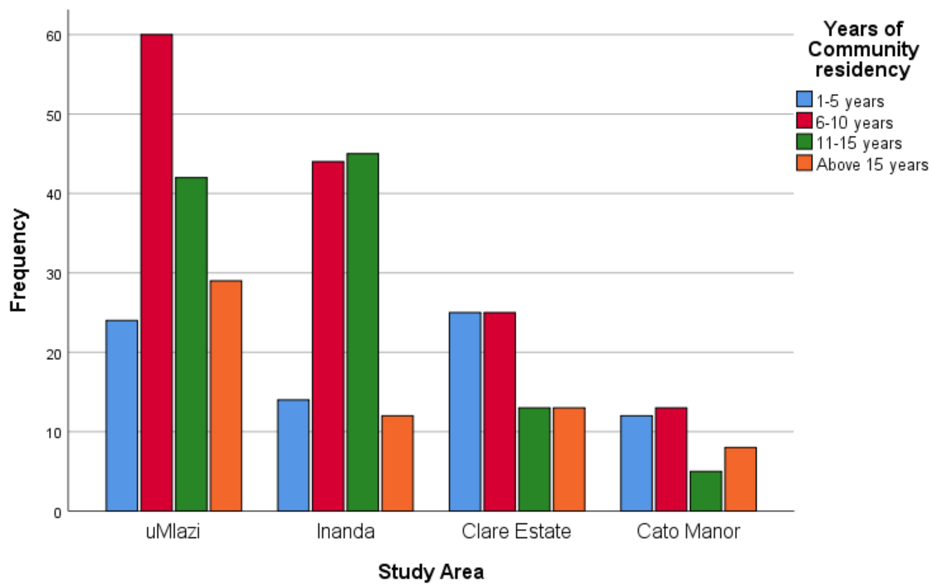

Figure 5.5: Community residency (Years)

A general review of the number of years the respondents have lived in the study area showed 16.1 percent respondents have lived there more than 15 years, 27.3 percent between 11-15 years, 37 percent between 6 -10 years and 19.1% between 1-5 years (Figure 5.5). It is safe to conclude the majority residents have very good knowledge of their community and the happenings in it, specifically where flood disasters and its management are concerned.

5.2.2.9 Ownership status

This is a demographic variable that examined whether respondents own or rent the property they live in. Understanding their ownership status was essential in ascertaining the SES of the respondents and their preparedness status in the event of natural disasters such as floods. Having a safe and secure place to live helps the occupants be better prepared for natural disasters. Home owners are more inclined to protect their property against damage and prepare for any eventualities, whereas tenants (single or sharing) may decide to leave the property for another more secure place, leaving the house with its problems to other non-suspecting tenants (Dube, Nhamo and Chikodzi 2022).

Table 5.5: Ownership Status

			Ownership Status			Total
			Owner	Renting	Sharing	
Study Area	uMlazi	Count	107	14	34	155
		Percent	69.0%	9.0%	21.9%	100.0%
	Inanda	Count	48	25	42	115
		Percent	41.7%	21.7%	36.5%	100.0%
	Clare Estate	Count	51	21	4	76
		Percent	67.1%	27.6%	5.3%	100.0%
	Cato Manor	Count	24	12	2	38
		Percent	63.2%	31.6%	5.3%	100.0%
Total		**Count**	**230**	**72**	**82**	**384**
		Percent	**59.9%**	**18.8%**	**21.4%**	**100.0%**

The result from the study shows 59.9 percent property in the study area is owned by residents, 21.4 percent share the property, while 18.7 percent are renting (Table 5.5). This means the majority residents are home owners. However, the home type factor comes into play. Owning a home, whether constructed from brick, mud or wood, it is still at risk of flood disasters. In addition, 40.1 percent homes are rented by single or sharing occupants, which indicates a possible lack of or very low level of prevention and preparedness against flood disasters (Dube, Nhamo and Chikodzi 2022).

5.2.2.10 Basic income

This variable provides valuable insight into the socio-economic aspects of the study area. Thus, assessing the socio-economic vulnerability of residents, their access to resources, ability to recover and rebuild after a disaster, is very important. Studies conducted on the relationship between natural disasters and income at the household level suggest poor households are more vulnerable to disasters and suffer significant income losses (Wang and Zhao 2023). Dube *et al.* (2022) contend that floods pose an urgent concern to the socio-economically vulnerable. This was demonstrated in the April 2022 flood disaster in KZN that was catastrophic in the study area, as the majority deceased were from informal settlements in the study area (Magidimisha-Chipungu 2022)

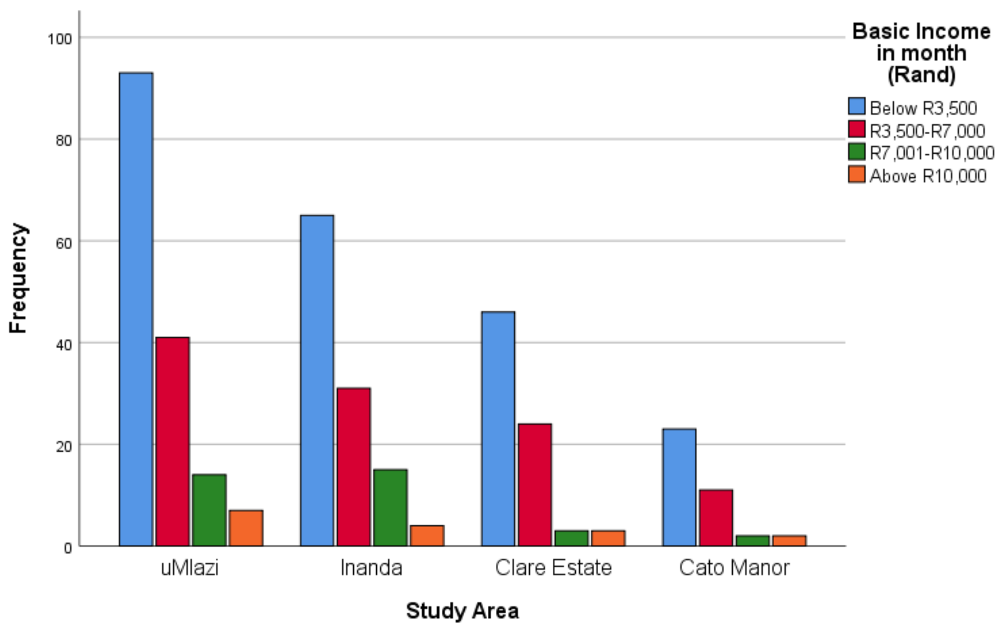

Figure 5.6: Basic Income

The outcome of the study revealed 59.1 percent respondents have a basic income below R3 500; 27.9 percent have a basic income between R3 500 and R7 000 and 8.9 percent respondents have a basic income between R7 001 and R10 000. However, only 4.2 percent have a basic income above R10,000 (Figure 5.6). The analysis shows a very high proportion of the study area residents earned less than R3 500 per month, making them socio-economically vulnerable. Only 14.1 percent of the population in the study area earned more than R7 000. This explains the lack of adequate preparedness, high level of destruction and death and very slow recovery rate in the study area.

5.2.3 Impacts of flood

The impacts of flood were viewed through two scenarios vis-à-vis impacts on property and impacts on individuals.

5.2.3.1 Impacts of flood on property

This section of the questionnaire comprised questions assessing the impacts of flood on the property of the residents in the study area. The questions include knowledge on the type and age of property, frequency of floods in the community, as well as its impact on the residential/business property, the duration of floods and estimated damages (if any) that may have occurred. Also assessed was the source of the flood (land overflow/fluvial or surface water/pluvial) and whether residents were provided any assistance from disaster and risk management stakeholders.

These questions were used in analysing the exposure of the individual property and community to flood disasters. It also highlights the physical vulnerability of the study area, assessing the general characteristics of the flood hazard, such as its frequency and duration. These questions addressed objective one and two, bearing in mind to examine flood risk in the study area (objective 1) it was imperative to assess the hazard, vulnerability and exposure. Furthermore, to identify factors that increase vulnerability (objective 2), assessment of the exposure of the study area to the flood hazard and the characteristic of the flood was also very important.

Table 5.6: Statistics on impacts of flood on property

	Age of property	Flood frequency on property	Duration of flood inside property	Estimated cost of damage to property
Number of valid responses	384	384	384	384
Mean	2.38	1.47	4.02	3.45
Median	2.00	1.00	4.00	3.00
Mode	3	1	6	4
Std. Deviation	.929	.500	1.621	1.428

In this study, there were 384 properties, Table 5.6 illustrates the average age of the properties is 2.38 years, and the standard deviation of 0.929 indicates some variability in property ages around the mean value. This suggests the ages of the properties are somewhat spread out from the mean, but the spread is not extremely large, thus indicating some degree of vulnerability.

5.2.3.1.1 Age of property

Vulnerability to components of the built environment, including physical structures, is very important in assessing the impact of floods on a community. This is because physical vulnerability may influence other vulnerability aspects such as economic, social and the environment. The World Bank refers to physical vulnerability as encompassing non-structural and structural damages to buildings, building components and other infrastructure (Fatemi *et al*. 2020). These damages could be the gradual and consistent deterioration of buildings and other infrastructure (World Bank 2014).

Vulnerability of buildings has been shown to be directly related to the age of the building and its construction materials. Buildings older than 20 years and built with natural materials are likely to experience high flood damage, compared to those that are less than 10 years and built with updated and flood fortified building materials (Fatemi *et al*. 2020).

Table 5.7: Age of property

Age of Property	Frequency	Percent	Cumulative Percent
Below 5 years	76	19.8	19.8
6-10 years	129	33.6	53.4
11-20 years	135	35.2	88.5
Above 20 years	44	11.5	100.0
Total	384	100.0	

Table 5.7 shows 35.2 percent property occupation of between 11 to 20 years, 33.6 percent is within six to 10 years, 19.8 percent is less than five years, while 11.5 percent occupation is more than 20 years. Therefore, 46.7 percent buildings are more than 10 years old, making them vulnerable to flood disasters. This may be the reason for the high impact on individuals and property after a disaster has occurred, as seen in the large number of displaced people and destroyed property.

5.2.3.1.2 Flood frequency on property

The impact of floods on property can also be ascertained through flood frequency in the community. Flood frequency is said to mean the number of times flood occurred within a specified time interval (World Bank 2014). During flood disasters, houses bear the lateral impact of flood water crashing into and around these structures. With an active current, the flood water could still be moving around the house. These movements cause hydrodynamic loads that continually push against the building, weakening the structure, as well as depositing sediments and soil against the house (World Bank 2014). The build-up of the sediments produces a weight that puts pressure on the building, contributing to the damage. Frequent flooding additionally causes groundwater pressure to increase, pushing on the foundation of the house, also leading to damage (World Bank 2014). Damage to the homes of community members exposes them to several other vulnerabilities, including PTSD, anxiety and suicidal tendencies.

Table 5.8: Flood frequency on property

Flood frequency on property	Frequency	Percent	Cumulative Percent
Once in a while	202	52.6	52.6
All the time	I82	47.4	100.0
Total	384	100.0	

It was claimed by 52.6 percent residents in the study area that the flood frequency impact on their property occurs 'once in a while', 47.4 percent residents affirmed it happens 'all the time' (Table 5.8). These frequent impacts of floods on their property exposes residents to physical, social, economic, as well as environmental vulnerability.

5.2.3.1.3 Duration of flood inside property

Floodwater inside a property or home compromises the building material, as long as the water remains inside the property, which remains waterlogged long after the water has receded outside the property and continues to cause damage (World Bank 2014). Floodwater inside the property also causes damage to internal finishes, disrupting services such as electricity and the internet. The degree of damage increases with the depth and duration of the water remaining inside the property (World Bank 2014). These could lead to damages that would require evacuation for a certain time, which could potentially disrupt the social fabric and livelihood of the property occupants, causing vulnerability.

Table 5.9: Duration of flood inside property

Duration of flood inside property	Frequency	Percent	Cumulative Percent
0-1hour	19	4.9	4.9
2-4hours	69	18.0	22.9
5-7hours	70	18.2	41.1
8-10hours	60	15.6	56.8
Above 10hours	58	15.1	71.9

N/A	108	28.1	100.0
Total	384	100.0	

It was reported by 28.1 percent respondents that flood does not enter their property at all, 18.2 percent affirmed the flood stays inside their property for 5-7 hours, 18 percent reported flood is experienced on their property for approximately 2-4 hours, and 15.6 percent reported it dissipated within 8-10 hours, whereas 15.1 percent mentioned that lasts for more than 10 hours, and 4.9 percent respondents reported they experience flood inside their property within one hour. In summary, roughly 50 percent study area residents affirmed floodwater enters and stays inside their property for more than five hours (Table 5.9). Aside from damaging the foundation and infrastructure of the property, it also causes damage to their personal belongings, may disrupt essential services and, most likely, cause some to leave their homes, while the flood water resides. This leaves them extremely vulnerable.

5.2.3.1.4 Estimated cost of damage to property

Floods can cause extensive damage to property that could be immediate or long-term damage. Flash floods cause immediate damage to property when heavy debris is carried that can lead to damage to houses in their path, rendering them uninhabitable (Hill 2016). Such floods can carry and deposit variously sized objects into the home and onto the property. In the long-term, property affected by floodwater may be irrecoverably damaged, with the homes potentially developing mould through rot, leading to health challenges. Other damages may include loose floors, collapsed roofs, cracked foundation and submerged vehicles. These damages caused by floods could run into thousands of Rands that potentially constitute a setback and create increased vulnerability of the affected people (Hill 2016). Those with mud and wooden houses stand a chance of incurring more damage.

Table 5.10: Estimated cost of damage to property

Estimated cost of damage to property	Frequency	Percent	Cumulative Percent
Up to R1000	36	9.4	9.4
R1001-R2000	74	19.3	28.6
R2001-R4000	85	22.1	50.8
R4001-R6000	94	24.5	75.3
Above R6000	62	16.1	91.4
N/A	33	8.6	100.0
Total	384	100.0	

It was reported by 24.5 percent respondents that the estimated cost of damage to their property was within R4 001 to R6 000, 22.1 percent respondents stated it amounted to between R2 001 to R4 000 worth of damage, 19.3 percent put their estimated cost of damage within R1 001 to R2 000, while 16.1 percent and 9.4 percent respondents estimated the damage on their property to be above R6 000 and up to R1 000 respectively. In addition, 8.6 percent respondents did not have to spend on property damage (Table 5.10). This result shows 91.4 percent residents of the study area experience losses whenever flooding occurs, ultimately impacting their livelihood.

5.2.3.1.5 Frequency of flood on property using the chi-square test of independence

The Chi-square test of independence is used to check whether two categorical or nominal variables are likely to be related to each other (Agresti 1996). Thus, it is used to determine whether the data is significantly different from the researchers' expectation. Here, the researcher seeks to find out if there is a significant relationship between the study area and the frequency of flooding. As with all hypothesis tests, the Chi-Square test of independence evaluates using the null and alternative hypotheses, which are two competing answers to the question whether the two variables are related. This is illustrated below.

5.2.3.1.6 Hypothesis Testing

Null hypothesis (H_0): There is a significant association or relationship between the study area and flood frequency on the property.

Alternative hypothesis (H_1): There is no significant association or relationship between the study area and flood frequency on the property.

Data obtained were organised into a frequency distribution Table or contingency Table, also known as cross tabulation (Table 5.11). This Table shows the number of observations in each combination of groups. It can also be visualised in bar charts, as illustrated (Figure 5.7) below.

Table 5.11: Cross tabulation of study area vs. flood frequency on property

Study Area	Flood frequency on property		Total
	Once in a while	All the time	
uMlazi	79	76	155
Inanda	80	35	115
Clare Estate	27	49	76
Cato Manor	16	22	38
Total	202	182	384

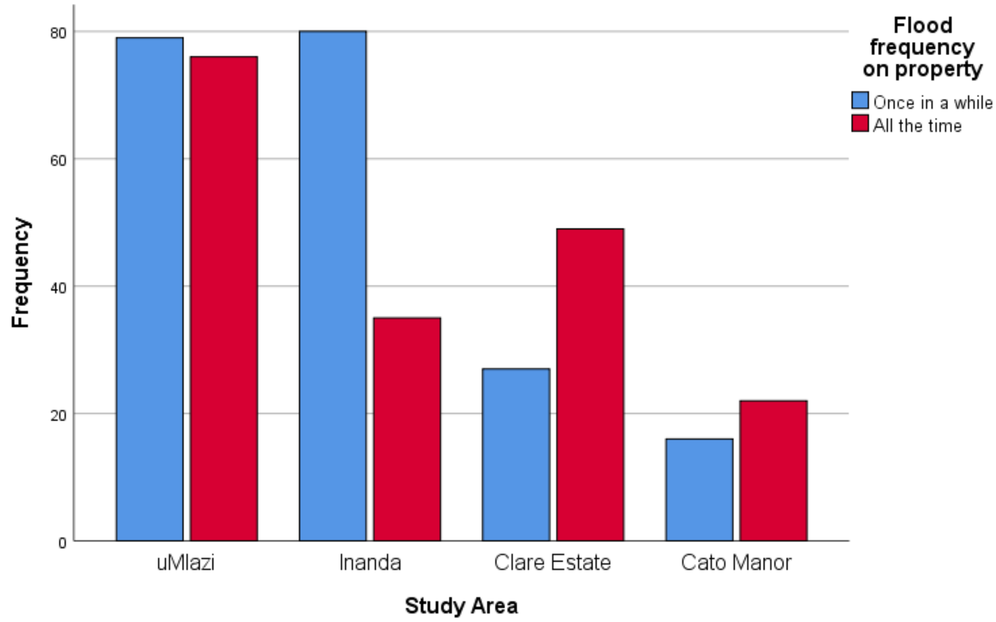

Figure 5.7: Study Area vs. flood frequency on property

Next, the significance level was calculated. The significance level is used to decide whether there is sufficient evidence against the null hypothesis to reject it in favour of the alternative hypothesis. A five percent significance level is a common choice in statistics. The test statistics and its corresponding p-value are used to determine the probability of obtaining a sample statistic equal to or more extreme than the observed test statistics. The Pearson chi-square test is the test statistics for the chi-square test of independence (Agresti 1996).

Confidence intervals are used to represent how good an estimate is. By convention, 0.05 percent or 95 percent is used as confidence interval (Levin 1999). This means there is a five percent chance of being wrong. The Likelihood Ratio test is used to compare the goodness of fit of two variables, based on the ratio of their likelihoods (Patrone 2022). Linear-by-Linear Association, also known as the Mantel-Haenszel test for linear association, is an ordinal measure of significance, used to test the significance of linear relationships between two ordinal variables. When found significant, it interprets that increases in one variable are associated with increases in the other (Agresti 1996).

Table 5.12: Chi-square test for study area vs. flood frequency on property

	Value	Degree of freedom (df) (n-1)	Asymptotic Significance (2-sided)
Pearson Chi-Square	24.006[a]	3	.000
Likelihood Ratio	24.516	3	.000
Linear-by-Linear Association	3.545	1	.060
Number of Valid Cases	384		

Where:

a = 0 cells (0.0%) have expected count less than 5. The minimum expected count is 18.01.

n = 4 and 2

Decision rule: If P-value < 0.05, reject H_0, else, fail to reject H_0.

The Pearson chi-square and likelihood ratio chi-square tests both yielded very low p-values (essentially zero), indicating a highly significant association between the study area and the flood frequency on property. The linear-by-linear association test, while slightly less significant, also showed a p-value below the conventional threshold of 0.05, which suggests some evidence of a linear trend in the association between the study area and flood frequency on the property (Table 5.12).

The result from the chi-square test suggests a statistically significant relationship between the study area and the flood frequency on property, which means the variables are not independent of each other, and their association is unlikely to have occurred by chance.

5.2.3.2 Estimated cost of damage caused by flood disasters

Floods can cause immediate and long-term damage to property and critical infrastructure. Flash floods can carry heavy debris that can cause damage to houses, rendering them uninhabitable. Such floods can deposit small and large pieces of property within the home. Some examples include electronics, vehicles, utensils and furniture. In the long-term, properties in contact with floodwater may be so damaged they can no longer be used. The houses may also develop mould, causing health challenges. This damage could run into thousands of Rands, constituting a setback to the affected people and increasing their vulnerability, with the poor usually the most vulnerable.

5.2.3.2.1 Hypothesis Testing

Null hypothesis (H_0): There is a significant association or relationship between the study area and the cost of damage to property.

Alternative hypothesis (H_1): There is no significant association or relationship between the study area and the cost of damage to property.

Table 5.13: Cross tabulation of study area vs. Estimated cost of damage to property

Study Area	Estimated cost of damage to property						Total
	Up to R1000	R1001-R2000	R2001-R4000	R4001-R6000	Above R6000	N/A	
uMlazi	36	64	37	10	8	0	155
Inanda	0	2	28	55	30	0	115
Clare Estate	0	7	14	20	16	19	76
Cato Manor	0	1	6	9	8	14	38
Total	36	74	85	94	62	33	384

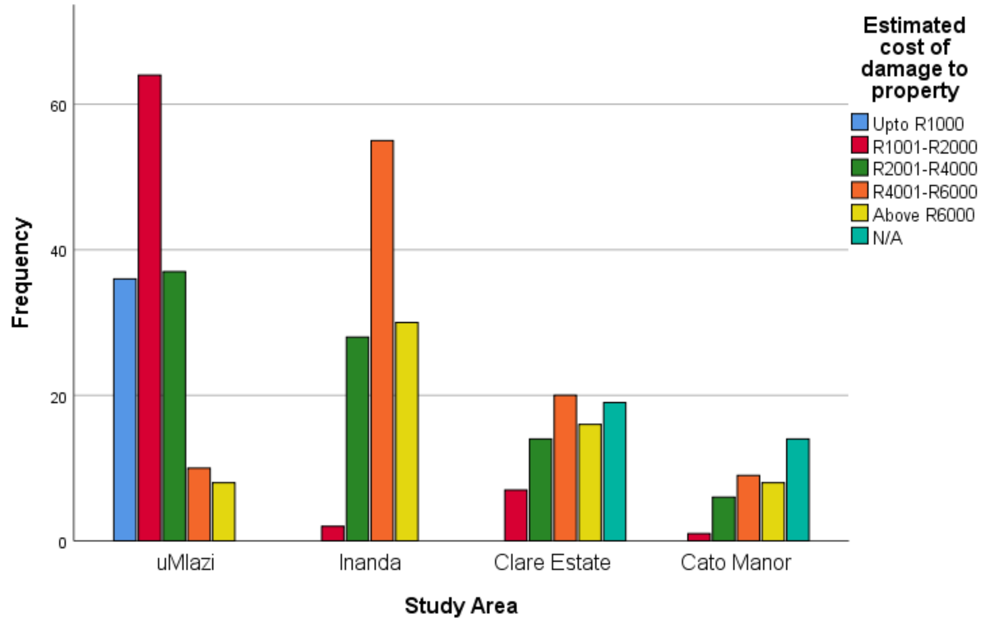

Figure 5.8: Study Area vs. Estimated cost of damage to property

Table 5.14: Chi-square Test for Study Area vs. Estimated cost of damage to property

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	270.523[a]	15	.000
Likelihood Ratio	294.559	15	.000
Linear-by-Linear Association	152.736	1	.000
Number of Valid Cases	384		
a = 2 cells (8.3%) have expected count less than 5. The minimum expected count is 3.27.			

The results from the chi-square test are highly significant, indicating a strong association between the variables analysed (Table 5.14). The very low p-values from both the Pearson and likelihood ratio chi-square tests provide strong evidence against the null hypothesis of independence. Additionally, the linear-by-linear association test suggests a significant linear trend in the relationship between the variables. These findings suggest the variables are not independent and there is a substantial and meaningful association among them (Figure 5.8).

5.2.3.3 Help received during flood disaster

Receiving help immediately after or before flood disasters determines how effective disaster response and relief will be. This could be termed as disaster relief or humanitarian response. It encompasses immediate response and early recovery. The provision of basic needs is the first and most important form of relief in the period immediately following a disaster. These needs include water, food, shelter, and clothes, as well as cash support, and should be provided to those most impacted by the flood disaster. Damage and needs assessment are crucial at this point, with accurate and reliable information very important.

Table 5.15: Confirmation of any help received during flood disaster

Response	Frequency	Percent	Cumulative Percent
No	326	84.9	84.9
Yes	58	15.1	100.0
Total	384	100.0	

Table 5.15 revealed 84.9 percent respondents did not receive any help, while 15.1 percent affirmed they have received help at one time or the other.

5.2.3.4 Impact of floods on individual

Floods have far-reaching effect on the individual and the community at large. This section of the questionnaire also addressed objective two, which sought to identify the factors that increase vulnerability of the community members to floods in the study area. Here, the focus was on the individuals and their perception of flood risk. Also assessed were the impact of floods on physical (infrastructure), social (healthcare, education and population density), economic (livelihood), and environmental (waste management and drainage system), as well as technical (access to media and internet) factors that may increase vulnerability as a result of floods. In this section, respondents had to answer the questions using a 6-point response scale (agree, disagree, strongly agree, strongly disagree, neither agree nor disagree (neutral) and an option was provided for those who were unsure). The sub-section that follows analyses the responses to the questions.

5.2.4 Flooding occurs only as a result of nearby rivers and creeks

As discussed, the EMA has several rivers and creeks in the study area, in addition to the Indian ocean. Settlements and infrastructure located close to water bodies and valleys are most vulnerable to flood disasters (Sinthumule and Mudau 2019).

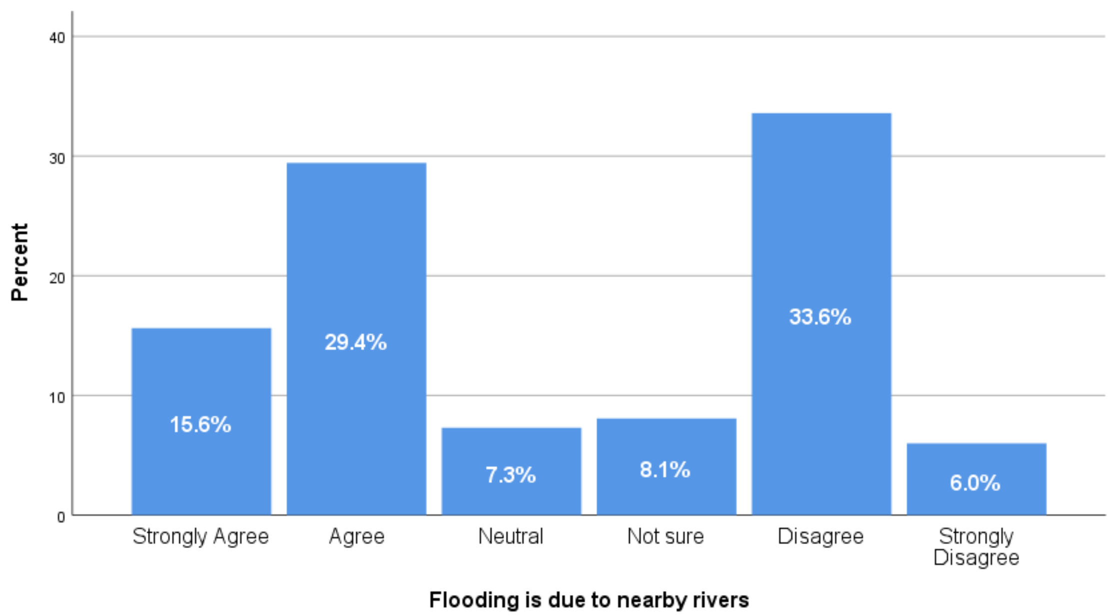

Figure 5.9: Percentage distribution of response on flooding is due to nearby rivers

The result from Figure 5.9 shows the respondents (29.4 percent and 15.6 percent) agreed and strongly agreed, respectively. This amounts to 45 percent majority respondents, as opposed to 33.6 percent and six percent who disagreed and strongly disagreed, respectively, amounting to 39.9 percent respondents. U further 8.1 percent were unsure, while 7.3 percent remained neutral, neither agreeing or disagreeing. This authenticated the study by Sinthumule and Mudau (2019). The study area having several rivers and creeks, as well as the Indian ocean, means it is vulnerable to storm surges, among many other contributing factors. However, through the course of responding to the questionnaires, respondents strongly affirmed other causes of vulnerability to flood disasters in the study area.

5.2.5 Other causes and factors contributing to flooding in the study area

There are other factors that could contribute to flooding in the study area. Numerous studies have shown over-population, poor infrastructure and vulnerability of community members could be factors that contribute to flooding in the study area (Solín, Sládeková Madajová and Michaleje, 2018; Williams *et al.*, 2019; Seemuangngam and Lin, 2024).

5.2.5.1 Over-population as contributing factor

Urban growth, particularly the coastal population, raises concern on exposure of community members to flood hazards. The increasing flood disasters in urban areas are highly correlated with increase in exposed population and flooding is greatest where population growth is more (Gil-Guirado 2019). This is as a result of the socio-economic growth process occurring without planned strategies to reduce the impact of floods.

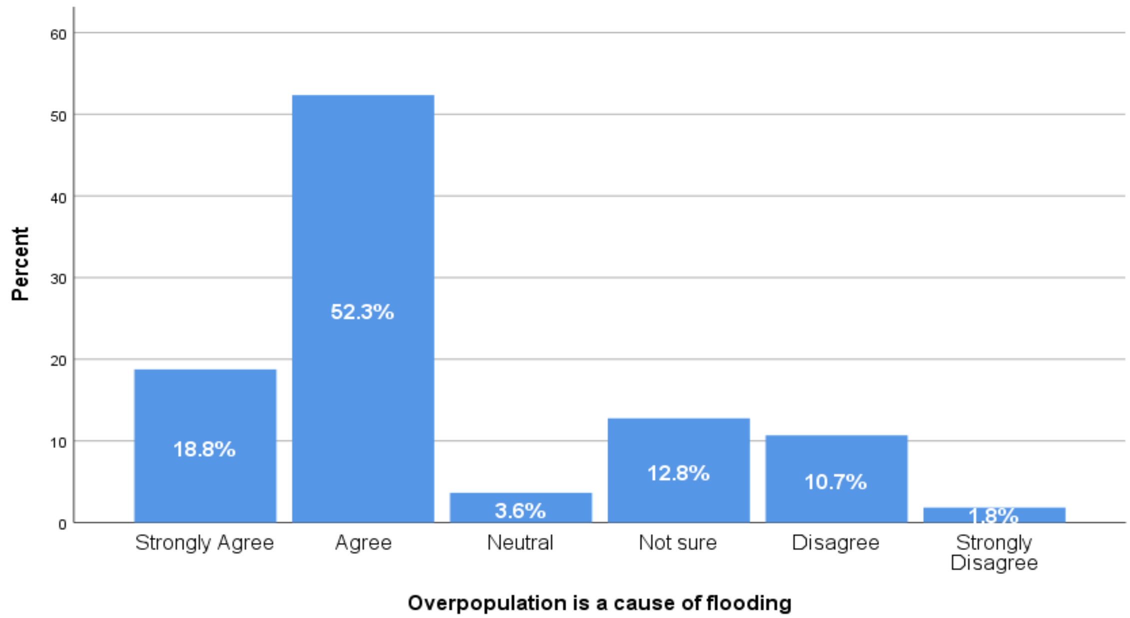

Figure 5.10: Percentage distribution of response on overpopulation as a cause of flooding

The majority respondents (71.1 percent) agreed overpopulation is one of the causes of flooding in the study area, while 12.5 percent disagreed. A further 12.8 percent and 3.6 percent were unsure and neutral, respectively (Figure 5.10). This authenticates the findings by other researchers that over-population plays a significant role in flood disasters (Seemuangngam and Lin, 2024).

5.2.5.2 Poor infrastructure

Infrastructure such as drainage channels, roads, waste management, and more, are crucial factors in contributing to flood disasters. Hence, respondents were asked regarding the state of their infrastructure.

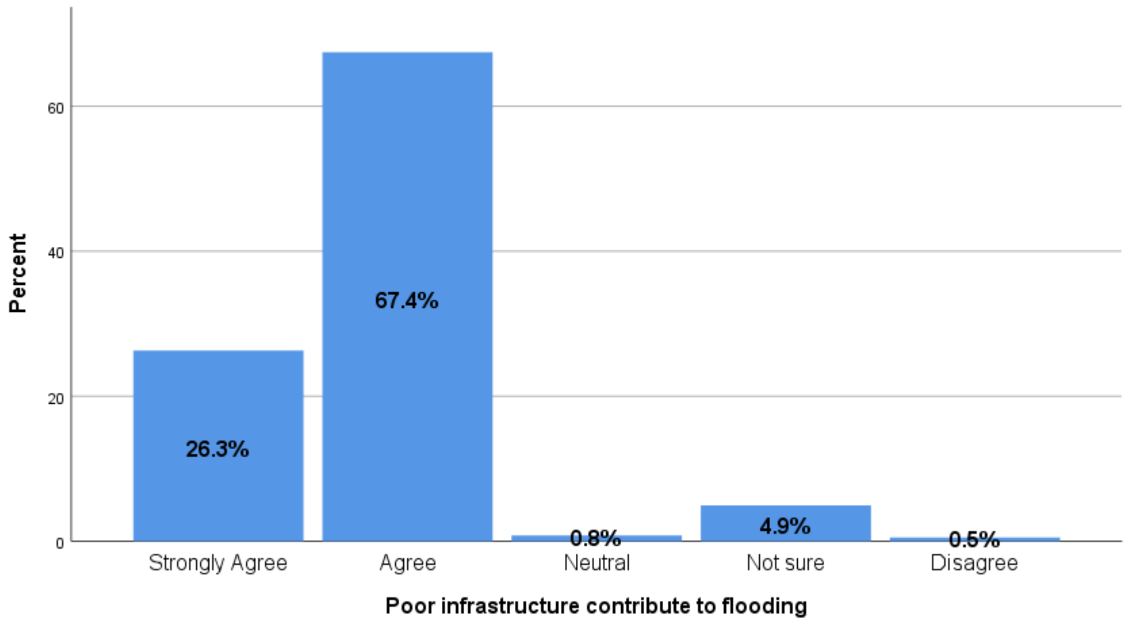

Figure 5.11: Percentage distribution of response on infrastructure as a cause of flooding

The study revealed 93.7 percent respondents agreed poor infrastructure such as bad roads, poor waste management removal, and old drainage channels, among many other factors, contributed to flooding within the study area. Furthermore, less than one percent disagreed, while 4.9 percent and 0.9 percent were unsure and neutral, respectively (Figure 5.11).

5.2.5.3 Vulnerability of community members

The risk of flooding in SA is found to have 83.3 percent chance of occurrence in every given year. This is due to its exposure to flood hazards (Munyai *et al.* 2021). The EMA is highly vulnerable to flood disasters due to geographical and socio-economic factors. Furthermore, areas located in valleys and wetlands are more vulnerable to flood disasters (Sinthumule and Mudau 2019).

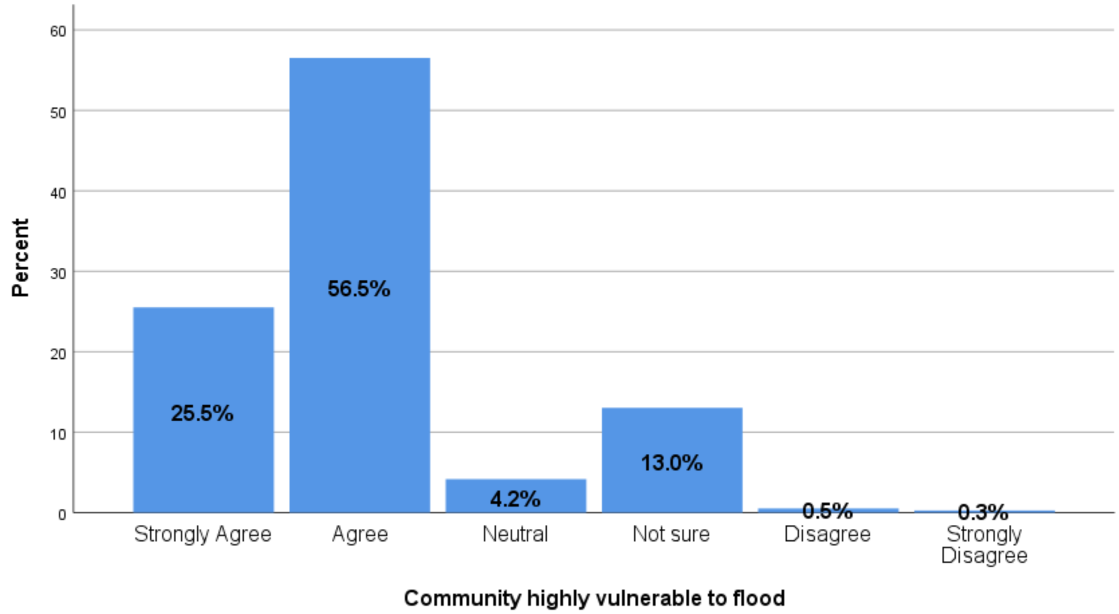

Figure 5.12: Percentage distribution of response on vulnerability of community members to flooding

82 percent respondents agreed the community is highly vulnerable to flood, 0.8 percent disagreed, while 4.2 percent and 13 percent were respectively neutral and uncertain (Figure 5.12). This authenticates the findings of Sinthumule and Mudau (2019).

5.2.5.4 Poor access to clean drinking water during floods

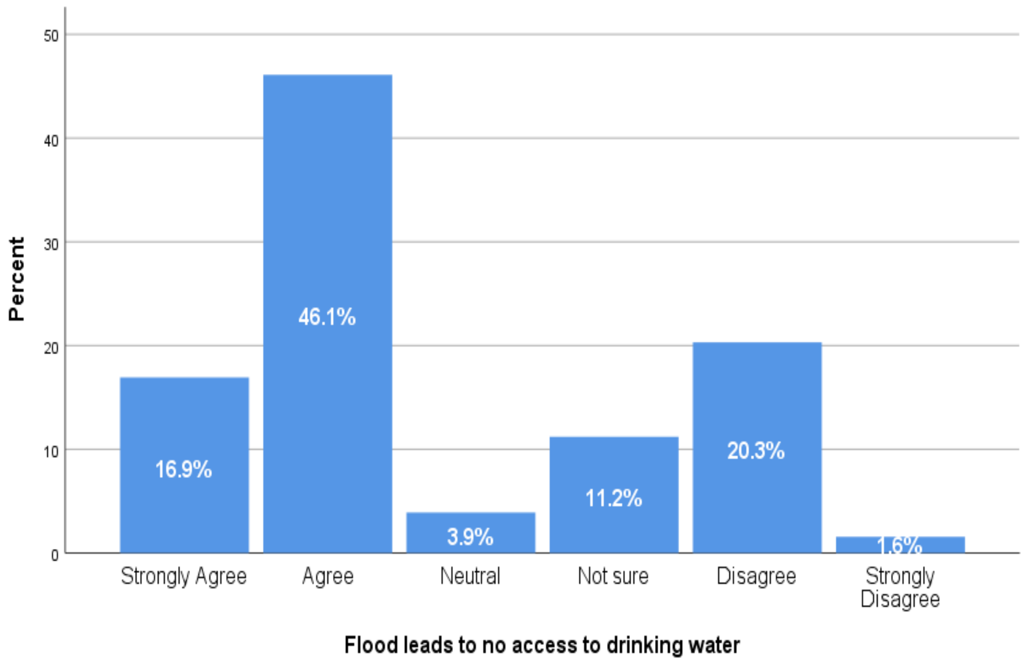

Figure 5.13: Distribution of access to clean drinking water during flood disaster

The analysis above (Figure 5.13) shows 46.1 percent and 16.9 percent respondents respectively agreed and strongly agreed there is poor access to clean drinking water during flood disaster in the study area, as compared to 20.3 percent and 1.6 percent who disagreed and strongly disagreed that flood disaster does not affect access to clean drinking water. A further 11.2 percent were unsure, while 3.9 percent respondents were neutral. Thus, the majority respondents (63 percent) agreed with the statement.

It is, in addition, worth noting that floodwater carries contaminants such as livestock waste, agricultural chemicals, human sewage, and so on, into lakes, well water, rivers and streams. According to a CNN (2022) report on the April 2022 flood disaster in KZN, flooding caused damage to the water network, resulting in 80 percent of the drinking water network being out of order, putting thousands of homes in the study area at risk of various water-borne diseases in their quest to obtain drinking water from alternative sources.

5.2.5.5 Infrastructure is affected due to flood disasters

Infrastructure is the basic facility serving a country. This includes telecommunication, energy and power, bridges, and waste management, as well as highways, roads, schools, and railways, in addition to government buildings and water, to mention a few.

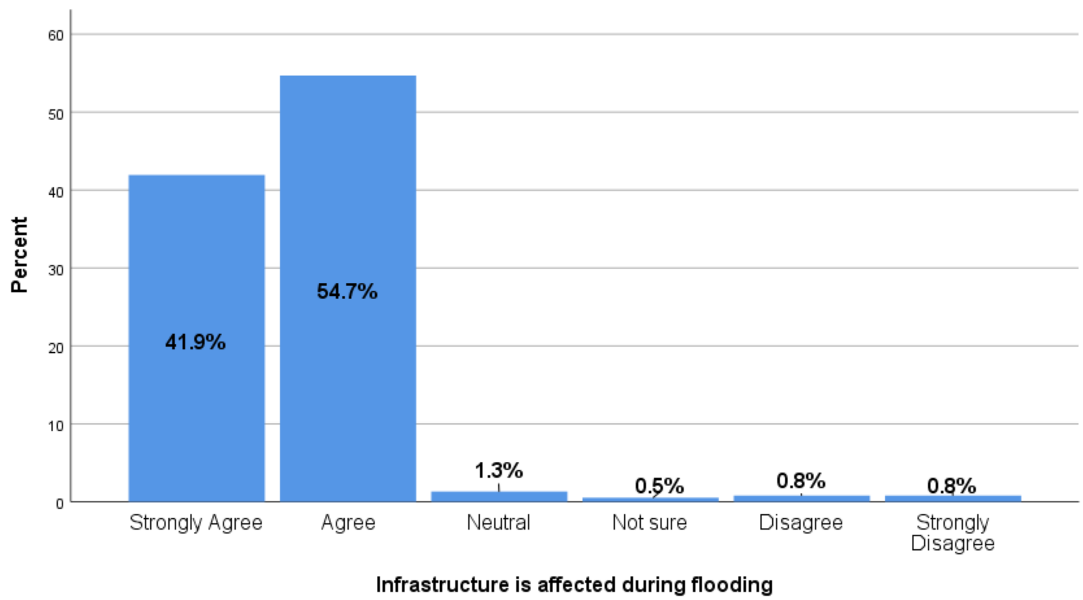

Figure 5.14: Impact of flood disaster on infrastructure

The analysis illustrated in Figure 5.14 shows the majority respondents (96.6 percent) agreed and strongly agreed (54.7 percent and 41.9 percent) respectively that infrastructure is affected as a result of flood disasters. This was experienced in the April 2022 flood disaster that affected eThekwini metropolitan area and other parts of KZN, which caused temporary closure of more than 600 schools, with several roads destroyed and bridges swept away (CNN 2022).

Based on the above result, a further analysis was conducted on the nexus between inadequate infrastructure and flooding and assessing the vulnerability of infrastructure during flooding. The analysis examined the intricate relations between inadequate infrastructure and flooding, in a bid to understand how the deficiencies in infrastructure can contribute to the occurrence and severity of flooding events in the study area.

Table 5.16: Descriptive statistics

	Mean	**Std. Deviation**	**Number of respondents**
Poor infrastructure contributes to flood	1.86	.705	384
Infrastructure is affected during flooding	1.66	.730	384

Table 5.17: Correlations between poor infrastructure contributing to floods and the impact of infrastructure during flooding

Correlations			
		Poor infrastructure contributes to flood	Infrastructure is affected during flooding
Poor infrastructure contributes to flood	Pearson Correlation	1	.201**
	Sig. (2-tailed)		.000
	N	384	384
Infrastructure is affected during flooding	Pearson Correlation	.201**	1
	Sig. (2-tailed)	.000	
	N	384	384

**. Correlation is significant at the 0.01 level (2-tailed)

N = Number of respondents

Table 5.17 revealed a statistically significant positive correlation between poor infrastructure contributing to flooding and infrastructure being affected during flooding.

The Pearson correlation coefficient for both relationships is approximately 0.201. Since this coefficient measures the strength and direction of the linear relationship between the two variables, in this case, the positive sign (0.201) indicates a positive correlation, which means as one variable increases, the other tends to increase as well. The p-value associated with these correlations is less than 0.01 (**), which suggests the observed correlations are statistically significant at 0.01 significance level. That is, the relationships are unlikely to have occurred by random chance.

Results from the study showed poor infrastructure contributes to flood, as well as a positive correlation with the infrastructure being affected during flooding. This implies, on the one hand, communities in the study area with poor infrastructure tend to experience more severe flooding disasters where infrastructure is more likely to be affected. On the other hand, infrastructure being affected during flooding also poses a positive correlation with poor infrastructure contributing to flood, which indicates when flooding occurs and infrastructure is affected, it may also be a result of pre-existing poor infrastructure conditions in the areas. Therefore, this significant positive relationship between poor infrastructure and flooding, and the vulnerability of infrastructure during flooding events, suggest improving infrastructure can play a crucial role in reducing the impact of flooding and enhancing resilience in flood-prone areas in the study area.

5.2.5.6 Access to healthcare facilities is disrupted

A healthcare facility can be said to be any building or location where healthcare can be provided for those in need of health services. Healthcare facilities range from small clinics to large hospitals offering emergency services. Healthcare facilities in SA include but are not restricted to the following: clinics, community health centres, district hospitals, and primary healthcare centres, as well as specialised hospitals and referral or regional hospitals.

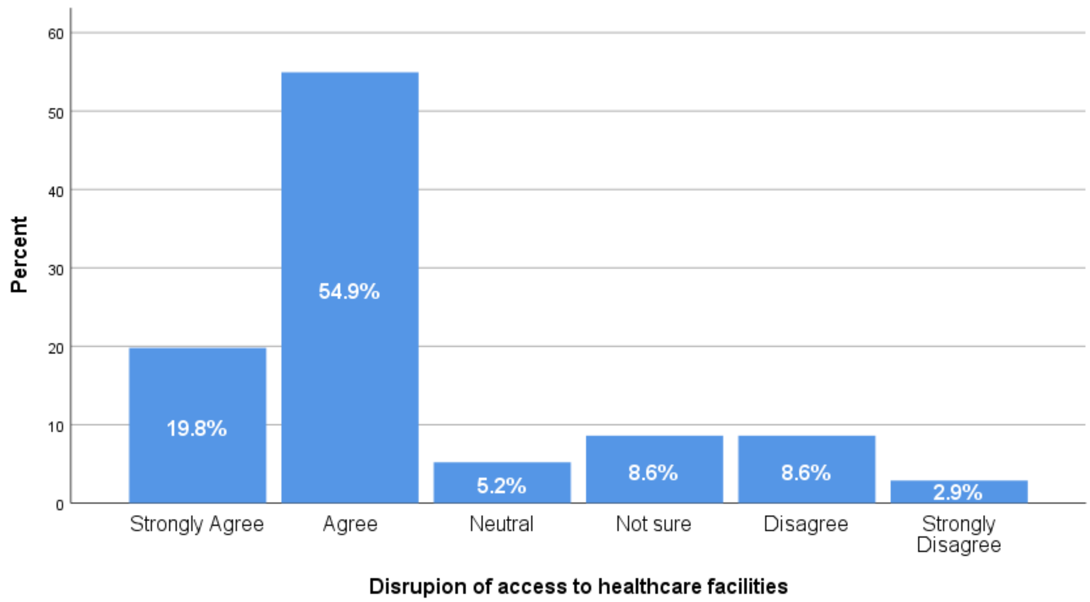

Figure 5.15: Impact of flood disaster on access to healthcare facilities

The analysis showed 74.7 percent respondents reported flooding disrupts access to healthcare facilities, while 11.5 percent opined the flood does not disrupt their access to healthcare facilities in the municipality (Figure 5.15). Infrastructure such as hospitals, roads, transportation and power are likely to hinder access to healthcare facilities and services, thus increasing the impact of flood disaster to the affected community.

5.2.5.7 Healthcare provision is interrupted during floods

Healthcare or health services are provided by medical professionals, auxiliary healthcare workers and organisations providing medical care to communities and the population at large. They are focused on ensuring healthcare is accessible to those who need it. Health services cover several categories of medical issues, ranging from emergency care, to long-term management of chronic sicknesses. In the aftermath of a disaster, a substantial number of people will need proper medical care, as disasters decrease the physical health of survivors that have sustained injuries, as well as increased intensity in chronic diseases.

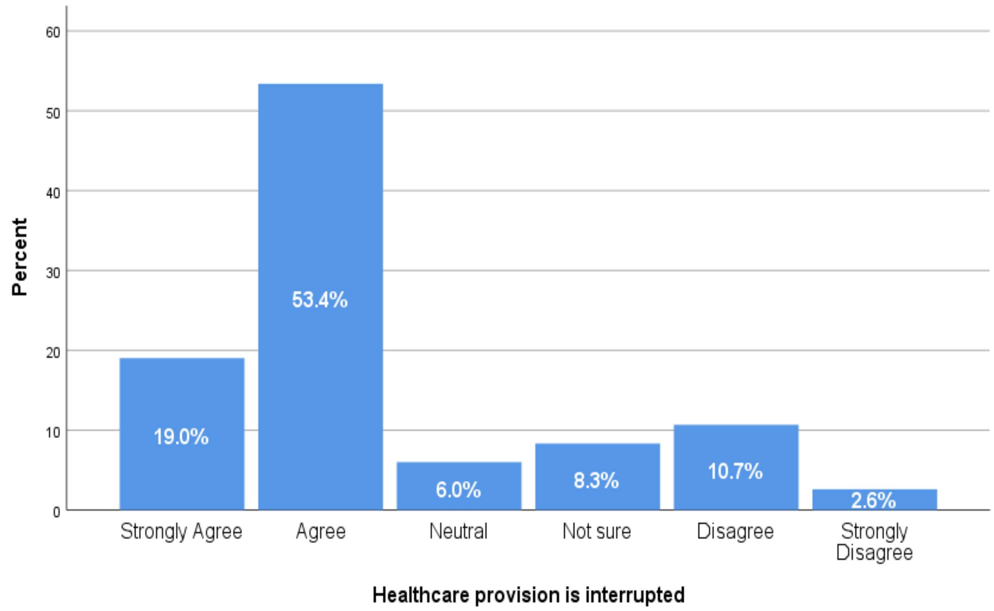

Figure 5.16: Impact of flood disaster on healthcare provision

The study revealed 72.4 percent respondents reported healthcare provision in the municipality is interrupted by flooding, while 13.3 percent opined flooding has no effect on provision of healthcare in the area. In addition, 6.3 percent and 8.3 percent were neutral and unsure, respectively (Figure 5.16). Interruption of healthcare provision implies people affected by flood disaster in the study area are unable to have their health needs met; this could lead to people not obtaining immediate service, even once the flood disaster is over.

5.2.5.8 Increase in disease outbreak during flood disaster

In the aftermath of flood disaster there is poor hygiene, coupled with an increased risk of disease outbreak, notably among displaced people. Assessment documented by the WHO on their flooding and communicable disease fact sheet, postulates there may be contamination of potable water during flood disasters, by pollutants from burst or overflowing sanitation facilities. This results in risk of waterborne diseases such as cholera, hepatitis A, leptospirosis and typhoid fever (WHO 2016). Diarrheal outbreak (cholera and dysentery) are reported to be the most common waterborne infection isolated after flood disasters (Olanrewaju *et al.* 2019). This high prevalence is attributed to contamination of drinking water from destroyed sewage systems and sanitary infrastructure.

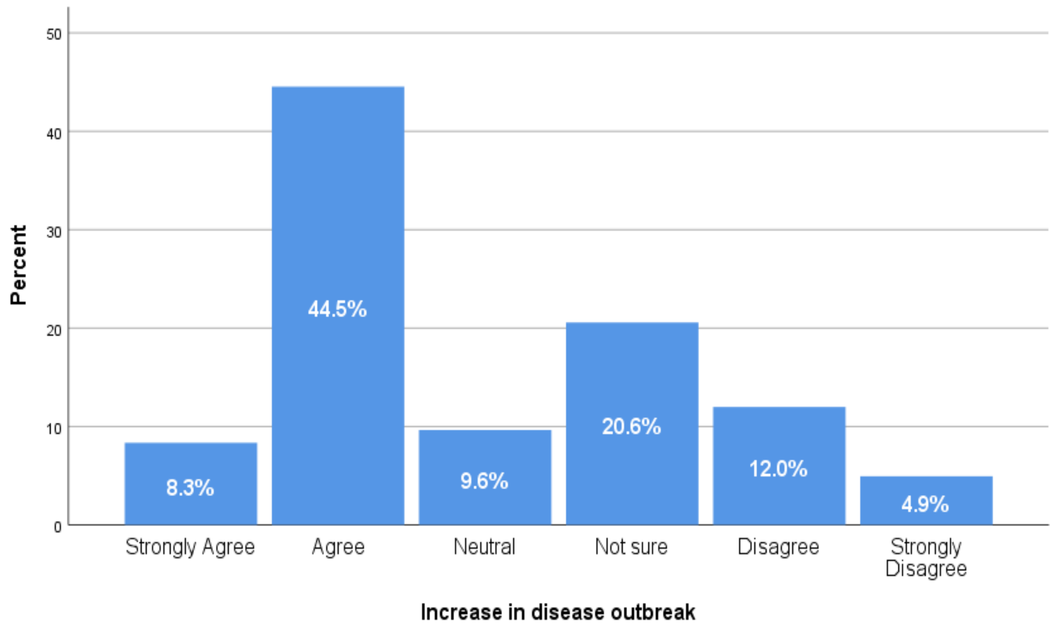

Figure 5.17: Increase in disease outbreak during flood disaster

The analysis shows 52.8 percent respondents affirmed an increase in disease outbreak in the municipality due to flooding, while 16.9 percent disagreed flooding increased disease outbreak in the area (Figure 5.17).

In view of the above result and the majority agreement that flooding was a yearly occurrence in the study area, a further analysis was undertaken to ascertain the relationship between flood frequency and its potential impact on disease outbreak in the study area, as shown below (Table 5.18).

Table 5.18: Cross-tabulation on relationship between flooding frequency and its potential disease outbreak impact

Yearly occurrence of flood disaster	Increase in disease outbreak						Total
	Strongly Agree	Agree	Neutral	Not sure	Disagree	Strongly Disagree	
Strongly Agree	11	39	8	27	5	3	93
Agree	12	86	22	32	19	7	178
Neutral	2	14	1	2	0	3	22
Not sure	0	2	0	6	5	1	14
Disagree	7	27	5	12	17	5	73
Strongly Disagree	0	3	1	0	0	0	4
Total	32	171	37	79	46	19	384

Null Hypothesis: There is no association between the two categorical variables in the population.

Alternative Hypothesis: There is a significant association or relationship between the two categorical variables in the population.

Table 5.19: Chi-Square Tests for yearly flooding frequency vs. Increase in disease outbreak

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	52.017[a]	25	.001
Likelihood Ratio	54.495	25	.001
Linear-by-Linear Association	5.740	1	.017
N of Valid Cases	384		
a = 18 cells (50.0%) have expected count less than 5. The minimum expected count is .20			

In Table 5.19, the Pearson Chi-Square and Likelihood Ratio provide similar results, where the p-value is very small (0.001) in both cases, which indicates evidence to reject the null hypothesis. This suggests a statistically significant association between the two categorical variables. The statistical tests for a linear association between the two variables show a low p-value (0.017), reflecting a significant linear association between the two variables. There is thus strong evidence to conclude a significant association between the frequency of flooding events and its impact on disease outbreak. However, the study results revealed the outbreak of disease does not necessarily occur at every flooding event in the eThekwini municipality; nonetheless, the flooding frequency is a contributing factor to increased disease outbreak in the municipality.

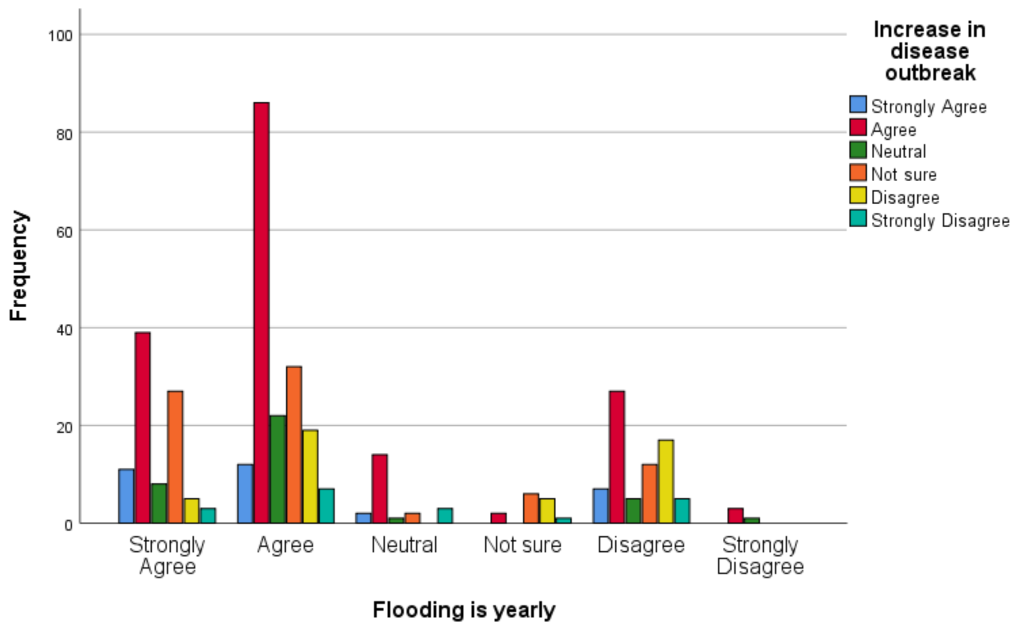

Figure 5.18: Frequency of interaction between flooding occurrence yearly and its impact on disease outbreak

5.2.5.9 Water sources in the community are affected

Water sources refer to bodies of water that could be surface water (lakes, reservoirs, rivers and streams) and ground water (aquifers). Debris and sewage from broken pipes may be washed into water bodies after flood disasters. The flood disaster of April 2023 in the EMA damaged sewage and water systems, causing a large volume of untreated sewage to spill onto beaches, and into harbours, rivers and the ocean in and around eThekwini, leading to high and critical levels of *E. coli* in the water (Khan 2023). *E. coli* is the bacteria that causes diarrhoea, fever and vomiting. According to Khan (2023), nine months after the flood disaster, high levels of *E. coli* can still be found in the water, indicating community members continue to suffer water-borne diseases, even when the flood waters have dried up.

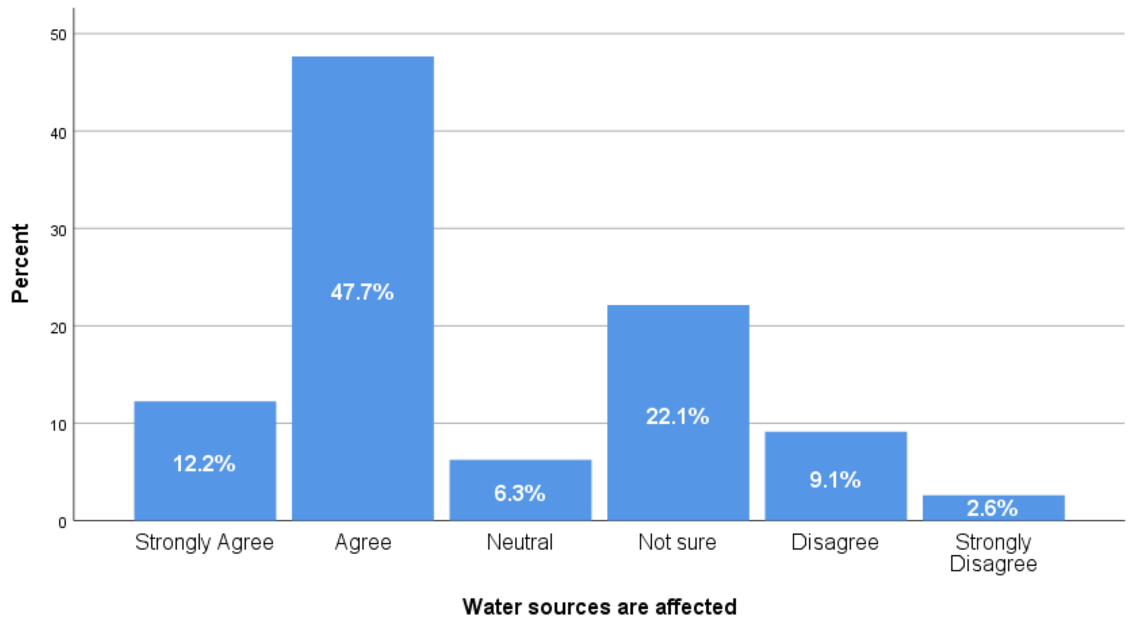

Figure 5.19: Response on effect of water sources in the community during flood disaster

The analysis showed 59.9 percent respondents agreed water sources are affected due to flooding, while 11.7 percent disagreed. A further 22.1 percent were unsure and 6.3 percent remained neutral (Figure 5.19).

5.2.5.10 Floods impact livelihood negatively

Flooding presents a multifaceted challenge to communities, involving intricate interactions among social, economic, environmental, and infrastructural factors. Communities particularly vulnerable to these flood-related complexities often endure the most severe consequences. These consequences can manifest as property damage, interruptions to essential services, threats to public health, and economic setbacks. Recognising and actively addressing this vulnerability is not only crucial but also fundamental to successful FRM, fostering resilience, and safeguarding community well-being.

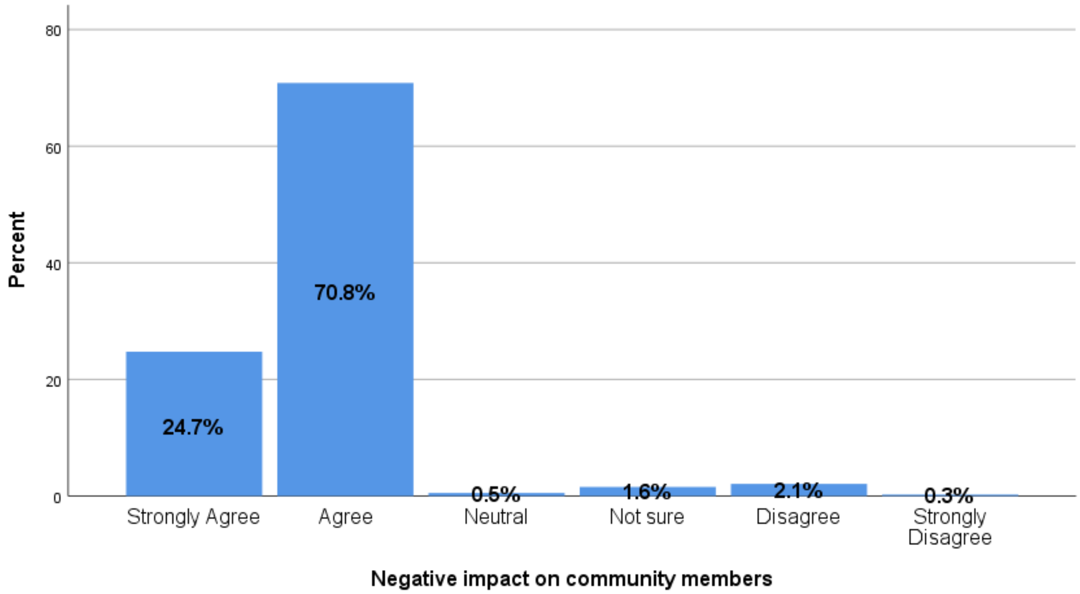

Figure 5.20: Response on effect of negative impact of flood on livelihood

Most respondents (95.5 percent) reported flooding in the study area negatively impacts community members, 2.4 percent reported otherwise, while 2.1 percent were uncertain and neutral regarding the negative impact of flooding on community members (Figure 5.20).

5.2.5.11 Security of community against flood disaster

In areas identified as flood prone areas, putting measures in place to ascertain the safeguarding of humans and property before, during and after a disaster is crucial. Respondents were asked whether any measures are put in place to secure the safety of life and property, with their responses shown below (Figure 5.21).

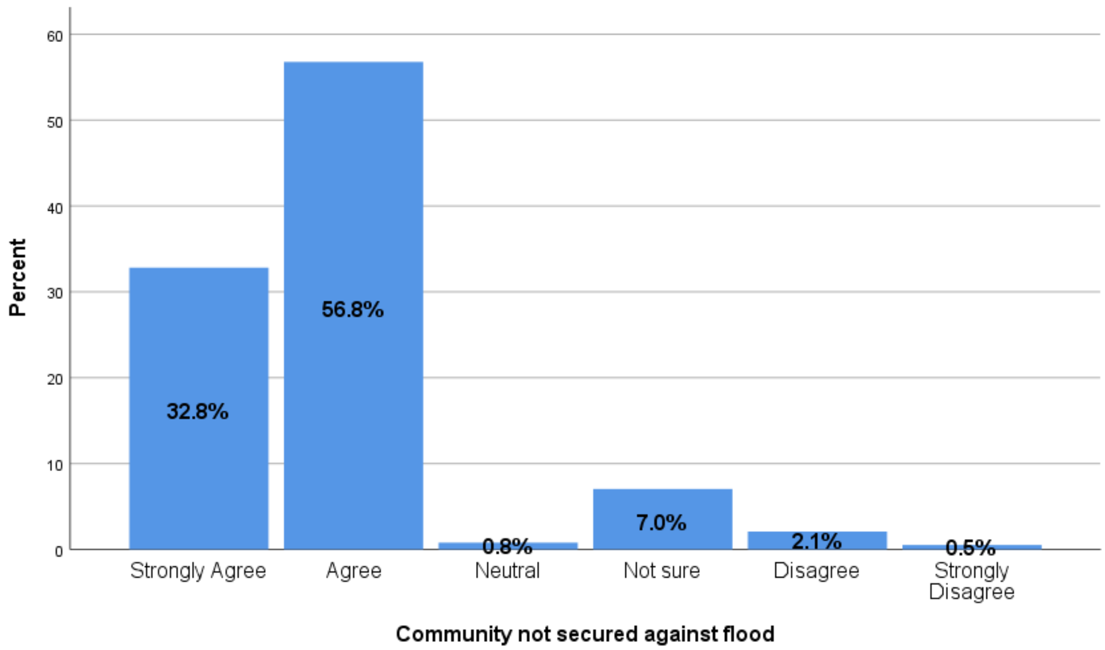

Figure 5.21: Response on security of community against flood disasters

The study showed 89.6 percent respondents confirmed communities within the municipality are not secured against flood, 2.6 percent mentioned the community is secured against flood, while seven percent were uncertain and 0.9 percent neither agreed nor disagreed on security of the community against flood (Figure 5.21).

5.2.5.12 Response to flood disasters by the government

The Department of Cooperative Governance and Traditional Affairs (COGTA) is the government arm responsible for disaster management in SA. Disaster management in the country comprises policy and implementation measures, requiring stakeholders from a host of sectors and disciplines, involving government and NGOs. All these stakeholder activities are coordinated in the national Disaster Management Center (DMC) and its subsidiaries (Provincial DMC and Municipal DMC).

The DMC in eThekwini municipality is responsible for coordinating disaster management activities in the study area for prompt and effective risk reduction. Based on this knowledge, respondents were asked whether the disaster management officials in the eThekwini DMC are prompt in responding to flood disasters and its consequences. Their response is shown (Figure 5.22) below.

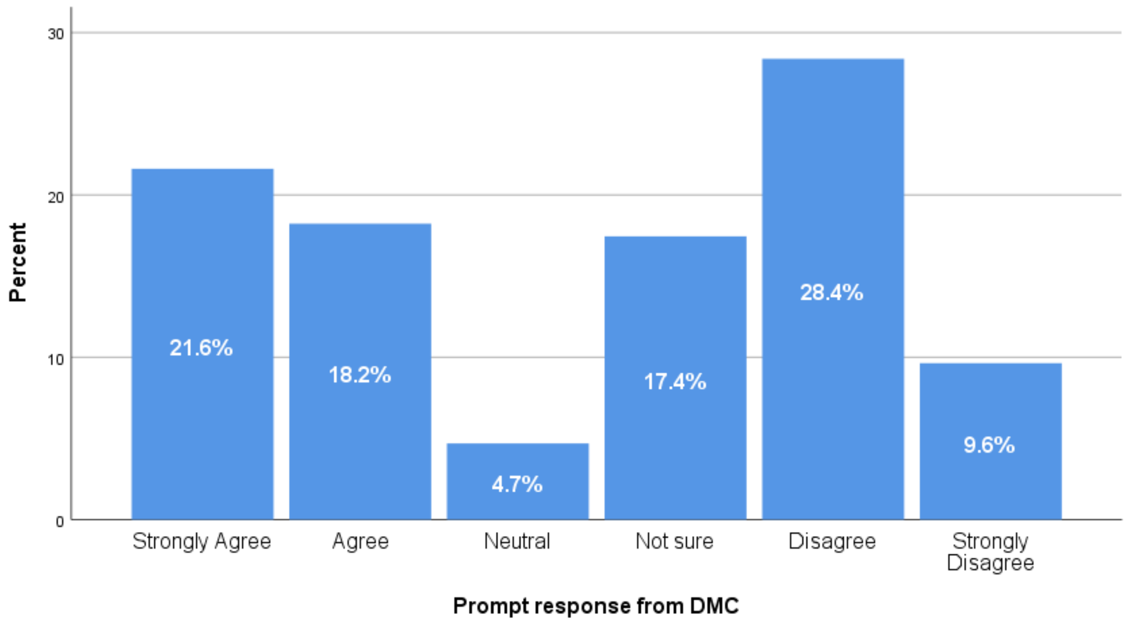

Figure 5.22: Response on prompt response by Disaster Management officials during flood disasters

It was indicated by 39.8 percent respondents that there is a prompt response from the DMC, 38 percent complained there is no prompt response from DMC, while 17.4 percent could not ascertain the promptness of the DMC and 4.7 percent chose to remain neutral.

5.2.6 Exposure to floods

Emerging research has shown at least one in five people around the world live in areas directly exposed to 1 in 100-year flood risk and approximately 89 percent of this population is from lower and middle income families all over the world (McDermott 2022). This section of the questionnaire sought to determine the vulnerability of community members to floods vis-a-vis the proximity of their homes to waterbodies, and losses they may have experienced to life, property and livelihood. Analysis from this section addresses objectives one and two.

Table 5.20: Statistics on responses to exposure of community members to flood disasters

	Individual vulnerability	Is your home close to waterbodies	Have you lost family members to	Have you lost property to flood	Community drainage system	Have you fallen ill after flooding
Mean	2.93	.53	.28	.65	.33	.40
Median	3.00	1.00	.00	1.00	.00	.00
Mode	4	1	0	1	0	0
Std. Deviation	1.194	.500	.449	.477	.469	.490

(Number of valid responses = 384)

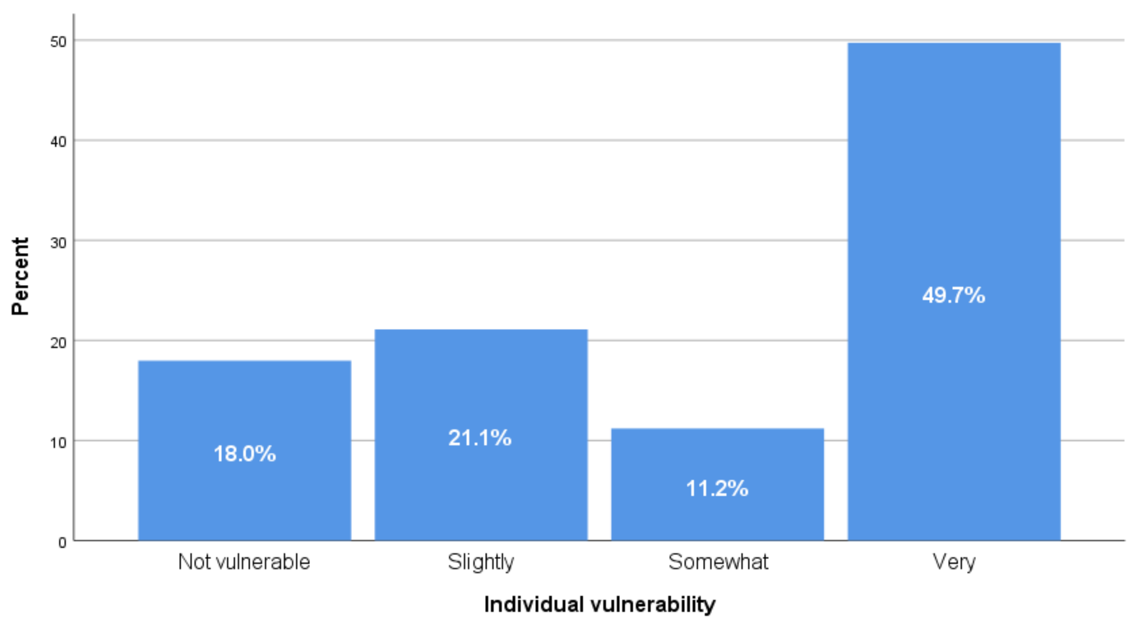

Figure 5.23: Percentage distribution of individual vulnerability

The study revealed 49.7 percent respondents are very vulnerable to flood, 21.1 percent are slightly vulnerable, 18 percent are not vulnerable, while 11.2 percent are somewhat vulnerable (Figure 5.23). This indicates that 82 percent respondents have some level of vulnerability.

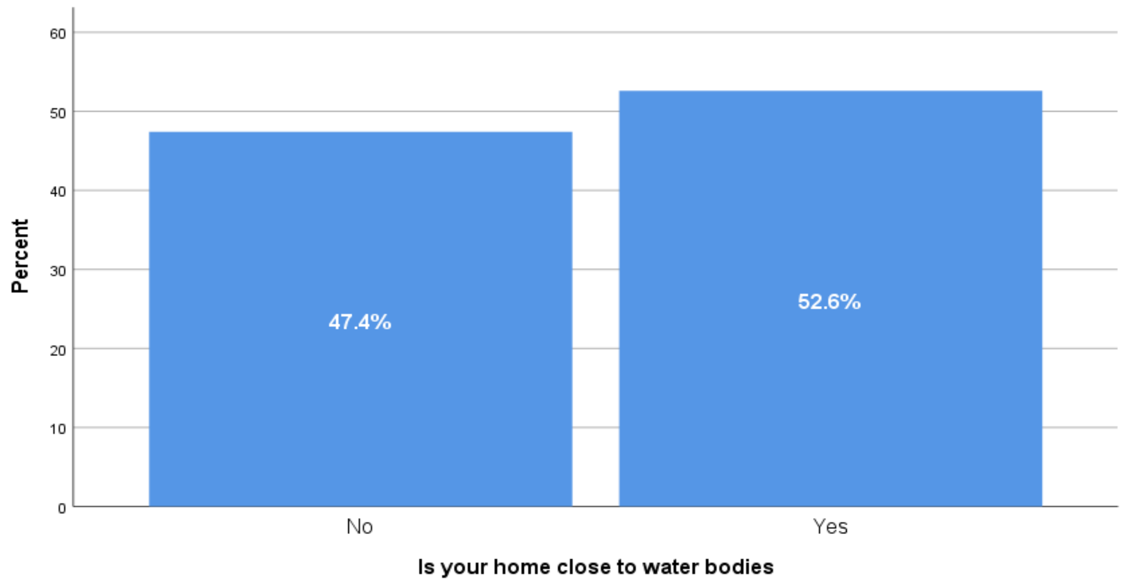

Figure 5.24: Percentage distribution of respondents' home closeness to water bodies

The analysis above showed 52.6 percent respondents have their home close to water bodies, while 47.4 percent do not (Figure 5.24).

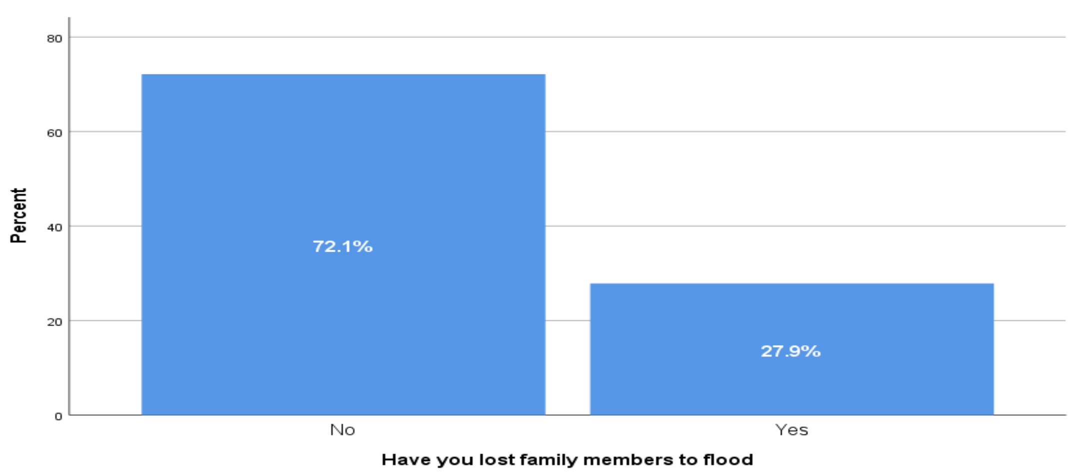

Figure 5.25: Percentage distribution of respondents who lost family members to flood

Figure 5.25 revealed, although 72.1 percent respondents have not lost family members to flood, 27.9 percent have lost family members to flood.

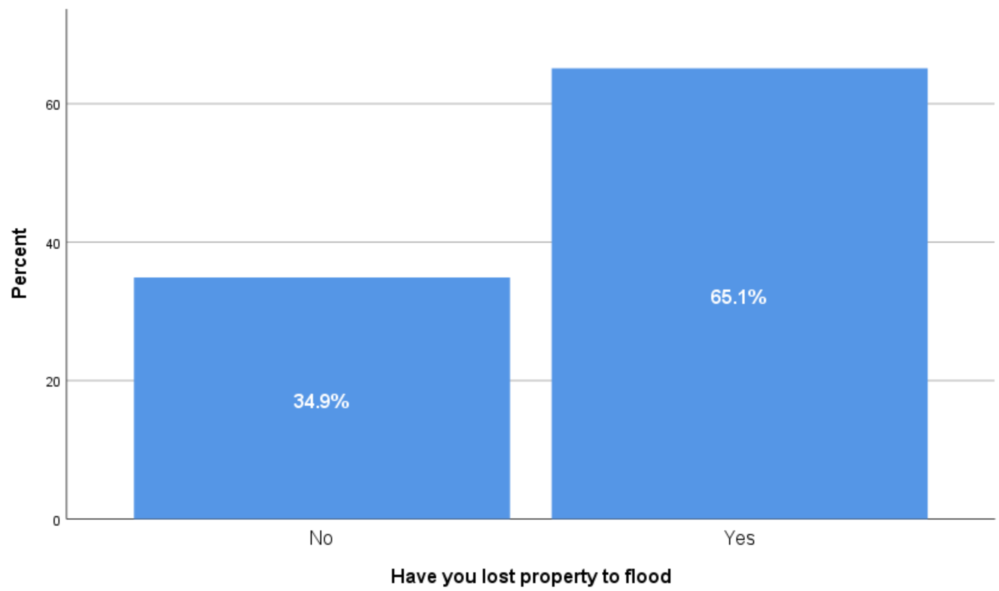

Figure 5.26: Percentage of respondents who have lost property to flood

The study showed, within the eThekwini municipality, 65.1 percent respondents have lost their property to flood, while 34.9 percent have not (Figure 5.26).

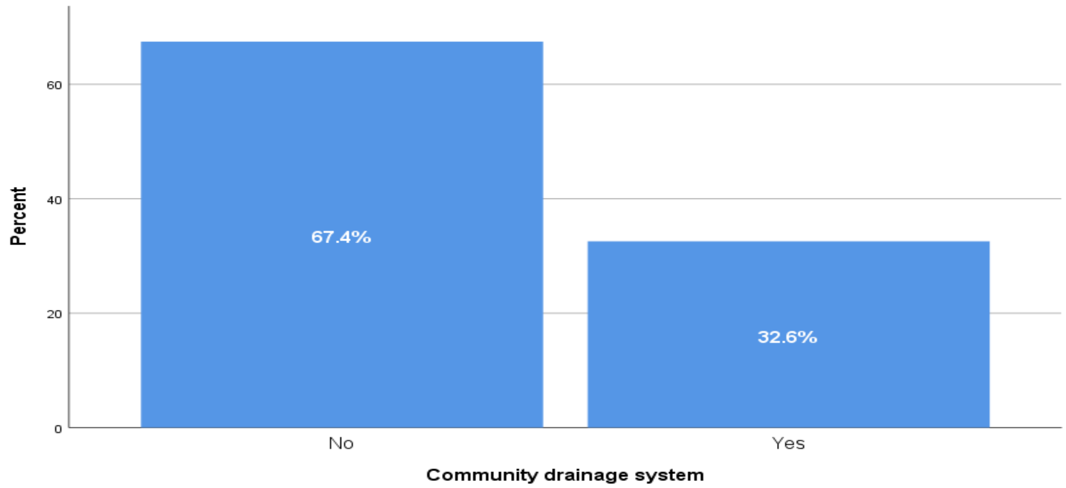

Figure 5.27: Percentage of response on functional drainage system

Figure 5.27 depicts that 67.4 percent respondents complained there is no functional drainage system in their community, while 32.6 percent affirmed there is a functional drainage system in their community.

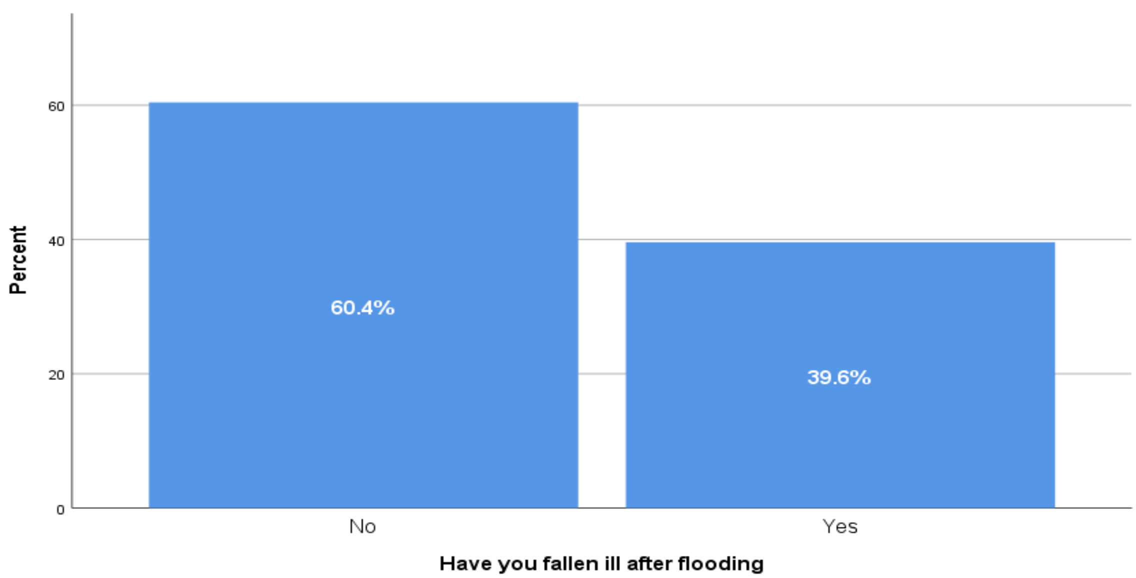

Figure 5.28: Percentage of respondents who have fallen ill after flooding

Figure 5.28 showed 60.4 percent respondents have not fallen ill after flooding, while 39.6 percent expressed they fall ill after flooding.

5.2.6.1 Relationship between respondents' home closeness to water bodies and likelihood of falling ill after flooding.

Null hypothesis: There is no association between respondents' home closeness to water bodies and falling ill after flooding.

Alternative hypothesis: there is an association between respondents' home closeness to water bodies and falling ill after flooding.

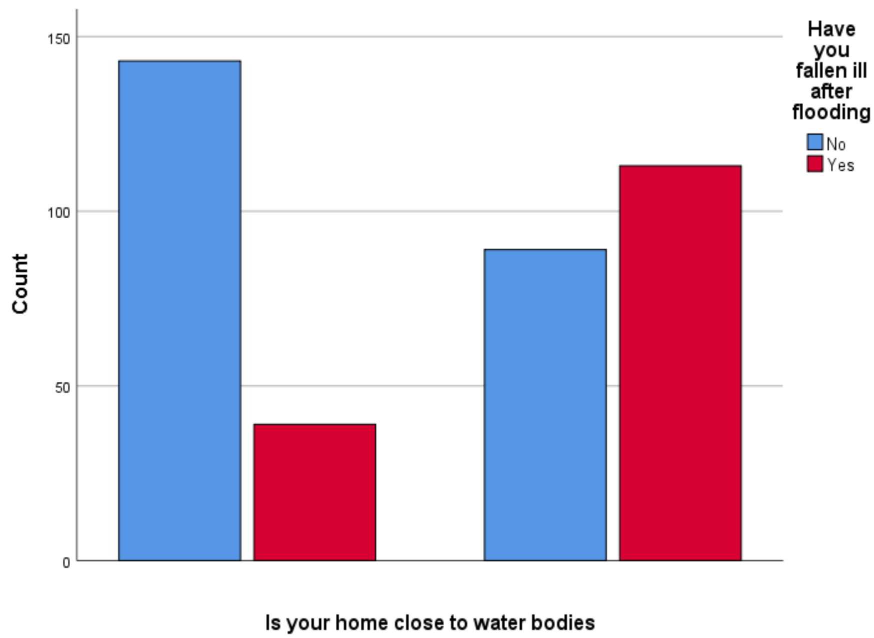

Figure 5.29: Frequency of interaction between home closeness to water bodies and likelihood of falling ill after flooding

Table 5.21: Chi-square tests of relationship between respondents' home closeness to water bodies and likelihood of falling ill after flooding

	Value	df	Asymptotic Significance (2-sided)	Exact Significance (2-sided)	Exact Significance (1-sided)
Pearson Chi-Square	47.683[a]	1	.000		
Continuity Correction[b]	46.251	1	.000		
Likelihood Ratio	49.247	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	47.559	1	.000		
N of Valid Cases	384				

a = 0 cells (0.0%) have expected count less than 5. The minimum expected count is 72.04.

b = Computed only for a 2x2 Table

The result from Table 5.21 showed the Pearson Chi-square statistics is 47.683, with one degree of freedom. The p-value (0.000) is associated with the Pearson Chi-square statistic testing the null hypothesis. In this case, the p-value is less than the typical significance level of 0.05, which indicates a high statistically significant association between the variables. The Fisher's Exact test, an alternative to the chi-square test, assists with small sample size, particularly when expected cell counts are very low. In this result, it shows a highly statistically significant result with a p-value of 0.000. To understand the linear trend in the data, a linear-by-linear association was conducted, which equally shows a highly statistically significant result, with a p-value of 0.000.

From the study, a strong and highly statistically significant association is observed between the two categorical variables analysed. Since all tests conducted are all very close to zero (0.000), it indicates the association is not due to random chance. This suggests a significant relationship between respondents' home closeness to water bodies and that they become ill after flooding.

5.2.6.2 Relationship between the adequacy/functionality of the community drainage system and the loss of property to floods

Null hypothesis: There is no association between the adequacy/functionality of the community drainage system and the loss of property to floods.

Alternative hypothesis: There is an association between the adequacy/functionality of the community drainage system and the loss of property to floods.

Table 5.22: Crosstabulation of Community drainage system and loss of property to flood

		Have you lost property to flood		Total
		No	Yes	
Community drainage system	No	77	182	259
	Yes	57	68	125
Total		134	250	384

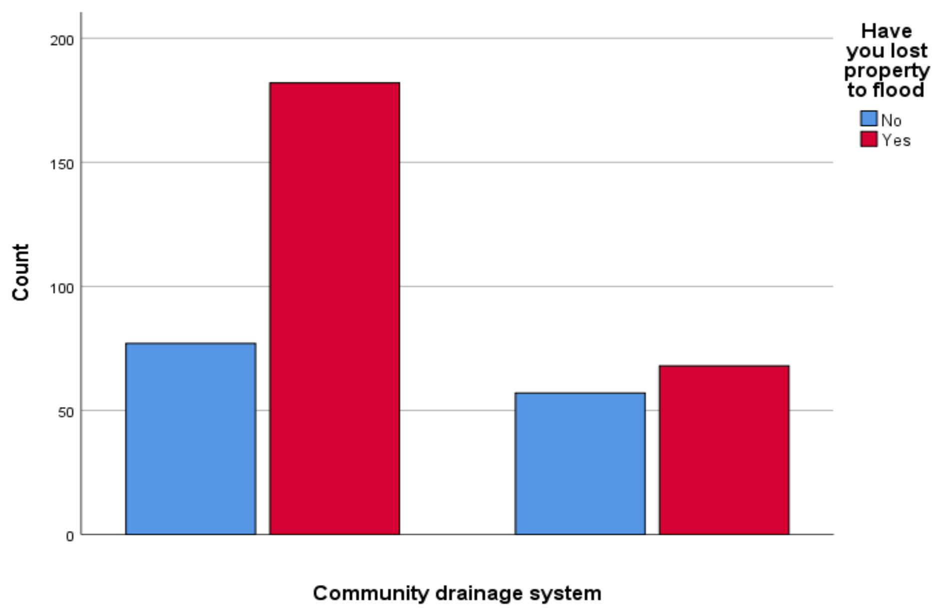

Figure 5.30: Frequency of interaction between adequacy/functionality of community drainage system and loss of property to floods

Table 5.23: Chi-square tests of relationship between adequacy of community drainage system and loss of property to floods

	Value	df	Asymptotic Significance (2-sided)	Exact Significance (2-sided)	Exact Significance (1-sided)
Pearson Chi-Square	9.347[a]	1	.002		
Continuity Correction[b]	8.661	1	.003		
Likelihood Ratio	9.192	1	.002		
Fisher's Exact Test				.003	.002
Linear-by-Linear Association	9.322	1	.002		
N of Valid Cases	384				

a = 0 cells (0.0%) have expected count less than 5. The minimum expected count is 43.62

b = Computed only for a 2x2 Table

The Pearson Chi-Square statistic is 9.347, with one degree of freedom. For the asymptotic significance (2-sided), the p-value is o.002, which tested the null hypothesis that there is no association between the variables in the analysis. With a p-value of 0.002 less than the typical significance level of 0.05, this indicates a statistically significant association between the variables. Furthermore, the exact significance (2-sided) showing a p-value of 0.003, suggests a statistically significant association between the variables. For the Fisher's Exact Test with a p-value of 0.003, a statistically significant association is indicated (Table 5.23). The result also assesses the linear trend in the data and shows a p-value of 0.002, reflecting that this is a statistically significant association.

With all tests conducted, and showing the same outcome, it is evident to conclude a significant association between the adequacy/functionality of the community drainage system and the loss of property to floods.

5.2.7 Flood management

The adverse impact of floods can be prevented or reduced by adopting efficient planning and preparation measures. Effective flood management strategies can significantly reduce the impact of flooding events on both individuals and their communities. Various approaches are used to mitigate and manage floods and its subsequent aftermath. This section explores several key variables related to flood management and preparedness, to gain a comprehensive understanding of existing strategies and approaches in the study area.

5.2.7.1 Flood prevention and mitigation measures

These processes and procedures include structural and non-structural measures used to prevent or reduce damage to life and property. They may include evacuation of people and property from flood prone areas, erecting flood preventive structures, use of building codes, and zoning, as well as having an effective flood management plan in place. Respondents in the study area were asked whether there were any flood preventive measures in place to prevent damage to property and safeguard life, their response is shown (Figure 5.31) below.

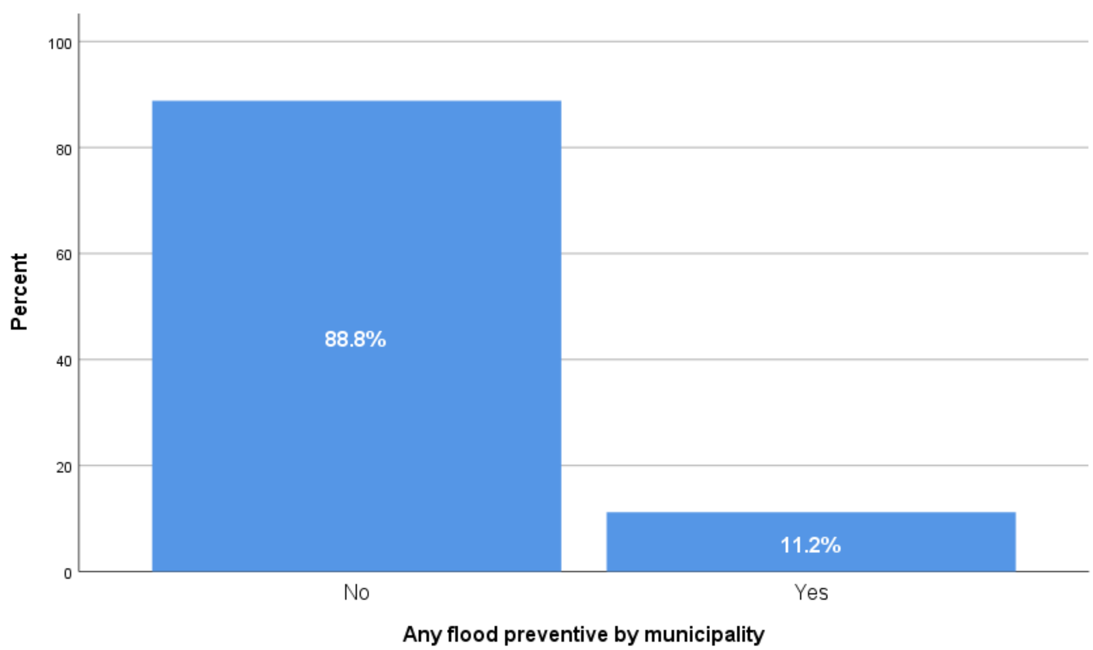

Figure 5.31: Percentages of response on flood disaster risk preventive and mitigation measures

A majority 88.8 percent respondents complained there are no flood preventive measures by the municipal authority put in place, while 11.2 percent reported there are flood preventive measures taken by the municipality in the study area (Figure 5.31).

On flood mitigation, they were asked whether there were any mitigation activities put in place in their community, their response is shown (Figure 5.34) below.

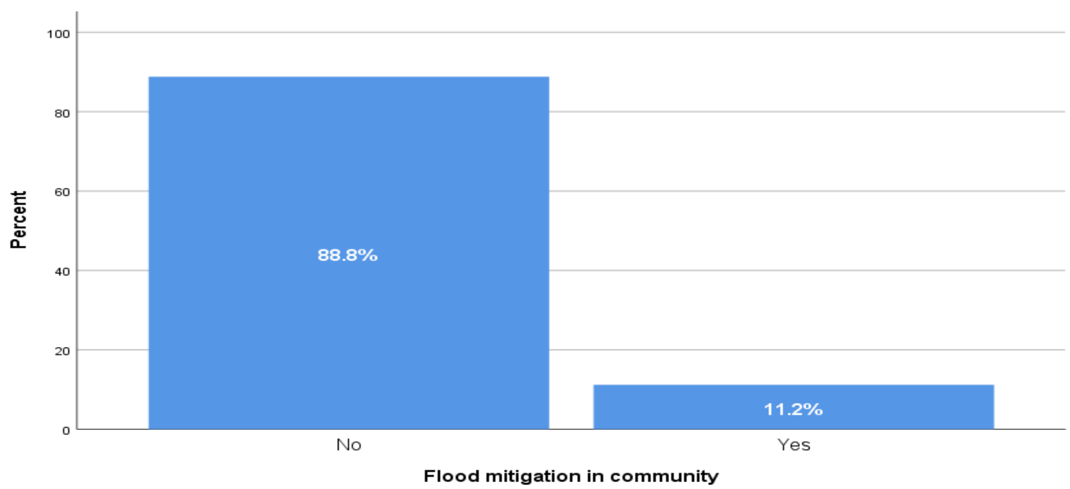

Figure 5.32: Percentage response on flood mitigation activities in study area

The study showed (Figure 5.32) that 88.8 percent respondents affirmed there is no flood mitigation in the community, while 11.2 percent reported there is flood mitigation in their community.

Respondents aware of flood mitigation activities in the study area (11.2 percent) were asked whether they participated in these activities. Their response is shown (Figure 5.33) below.

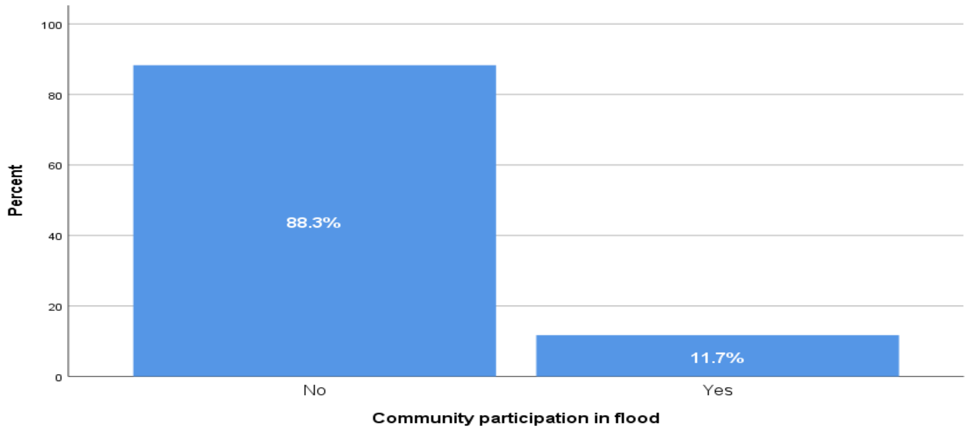

Figure 5.33: Percentage response on community participation in flood mitigation activities

A majority 88.3 percent respondents reported there is no community participation in flood mitigation in their community, while 11.7 percent opined there is community participation in flood mitigation.

5.2.7.2 Respondents' flood preparedness

Flood preparedness is a set of activities used as precautionary measures in the face of a potential flood disaster. Such activities may include early warnings on a potential flood event, having an evacuation plan in place, stock piling emergency flood kits, as well as training and exercises of community members, along with disaster management practitioners and insurance. Respondents were asked whether they received any forecast of possible flood disasters, their response is shown (Figure 5.34) below.

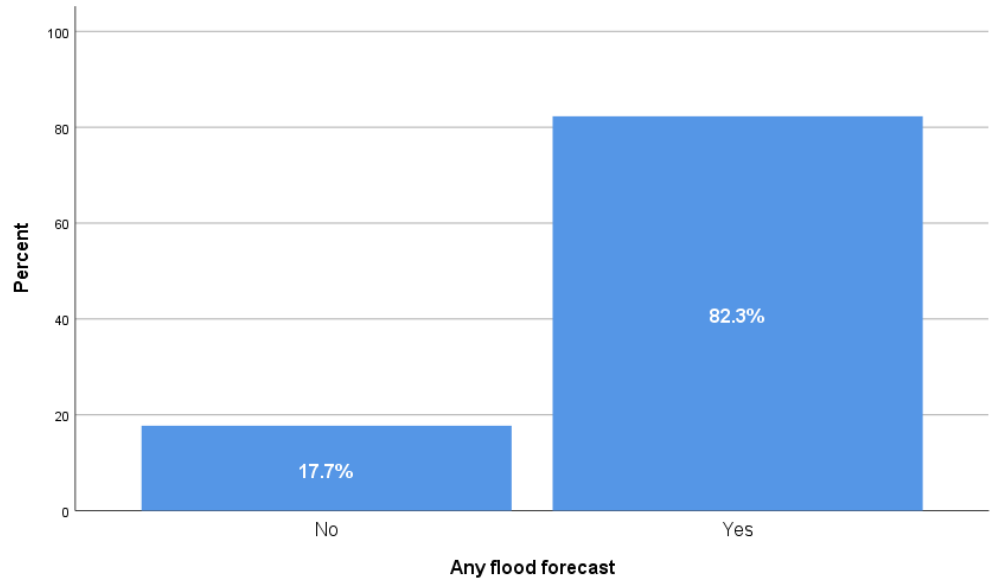

Figure 5.34: Percentages of response on early warnings through flood forecast

The study showed 82.3 percent respondents reported they receive flood forecasts in the study area, while 17.7 percent opined there is no flood forecast in the study area.

Respondents that received the flood forecast were further probed on the medium they received the forecast. Their response is shown (Figure 5.35) below.

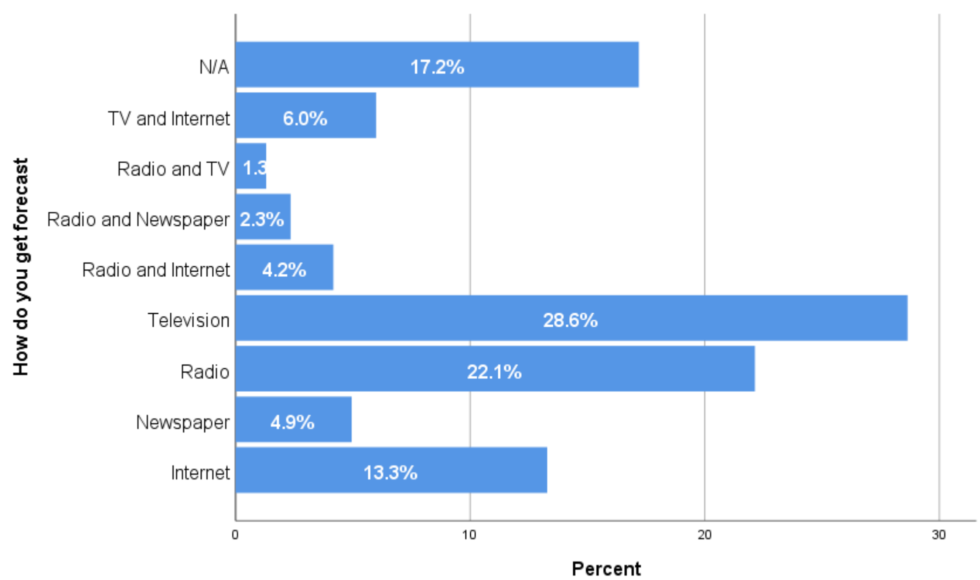

Figure 5.35: Percentages distribution of medium of flood forecast in the study area

The chart above shows the majority respondents (28.6 percent) receive flood forecasts through television, 22.1 percent through radio broadcast, while 13.3 percent acquire the forecasts through the internet. Various distribution of multiple other sources included six percent via the television and internet, 4.9 percent through reading newspapers, 4.2 percent from radio broadcast and the internet, and 2.3 percent via radio broadcast and reading newspapers, in addition to 1.3 percent that accessed forecasts through radio broadcast and television.

When asked whether they were prepared for flood disaster, they responded as shown (Figure 5.36) below.

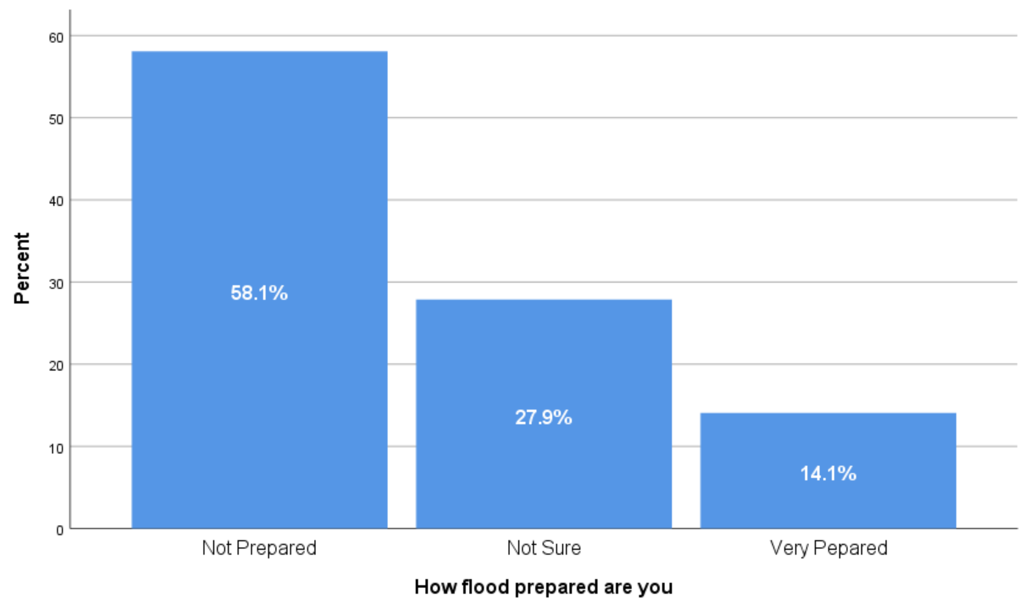

Figure 5.36: Percentages of response on flood preparedness

Figure 5.36 depicts that 58.1 percent respondents were not prepared for flood events, 27.9 percent were uncertain regarding their preparedness, while 14.1 percent indicated they were very prepared for occurrence of flood in the study area.

Respondents were further asked whether they had any concerns regarding flood disasters in their community, with their response shown (Figure 5.37) below.

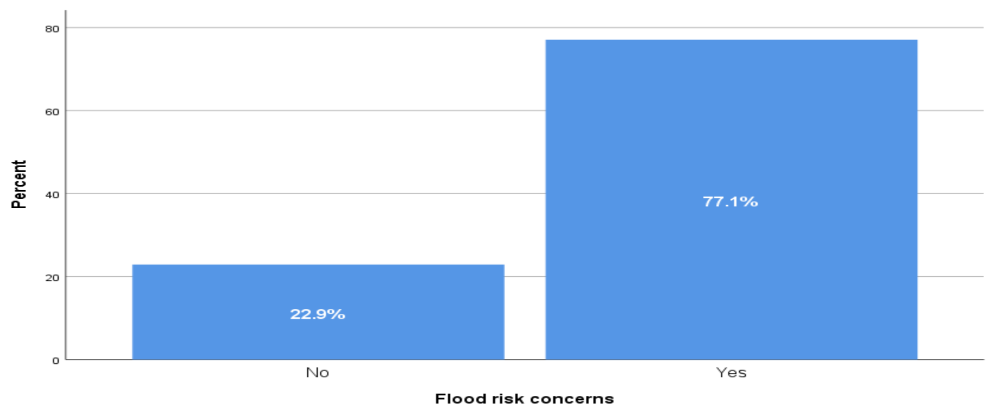

Figure 5.37: Percentages of response on flood disaster risk concerns

Most respondents (77.1 percent) affirmed they are concerned regarding flood disasters in their community, while 22.9 percent indicated they are not concerned.

5.2.7.3 Flood response plan by eThekwini disaster management centre

The flood response plan is an important tool that helps reduce the impact of floods on life and property. It is the provision of emergency services during and immediately after a flood disaster, aimed at preventing and/or reducing mortality and morbidity, damage to property, as well as meeting all basic needs of the affected people (Wang *et al.* 2022). Respondents were asked to rate the flood response plan put in place by the eThekwini municipality, which ensures they are safe before and taken care of after a flood disaster. Their response is shown (Figure 5.38) below.

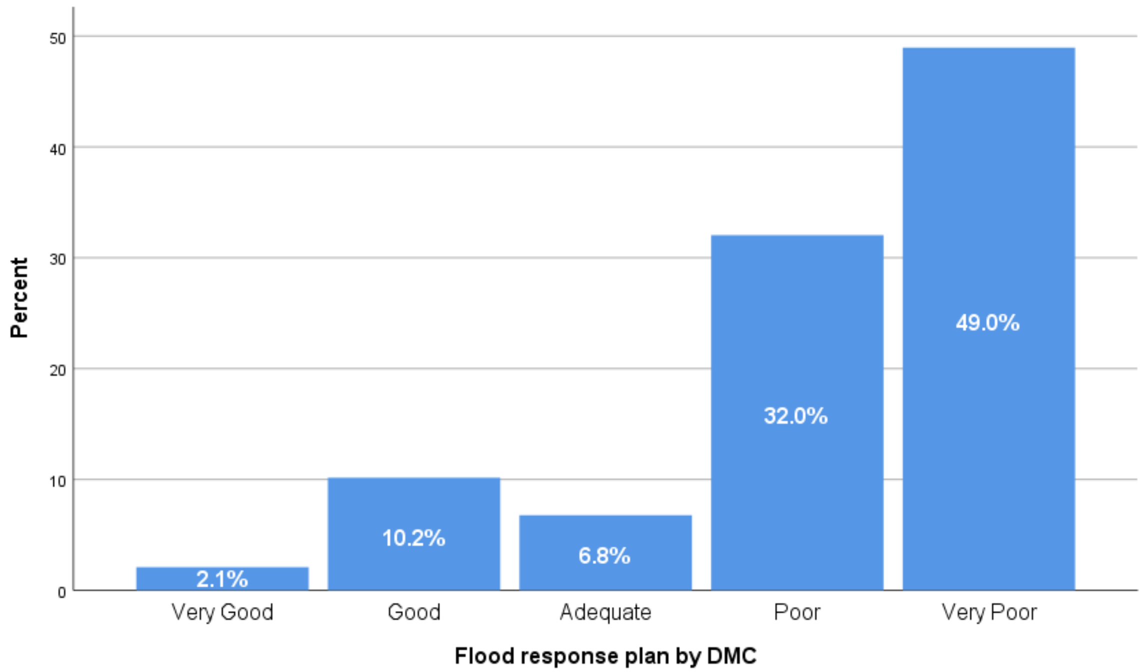

Figure 5.38: Percentage of response on flood response plan by the DMC

It is illustrated (Figure 5.38) that 49 percent respondents were of the opinion the flood response plan by the DMC in the study area is very poor, 32 percent said it is poor, while 10.2 percent and 6.8 percent respectively stated it is good and adequate. However, 2.1 percent were of the opinion it is very good.

5.2.7.4 Relief measures by the eThekwini DMC

Floods are one of the frequent and most costly disasters around the world, with donations and support helping those highly impacted. This section of the research determined whether the community received any form of incentive to help them prepare for flood disasters, as well as recover quickly from the disaster in the study area. Their response is shown (Figure 5.39) below.

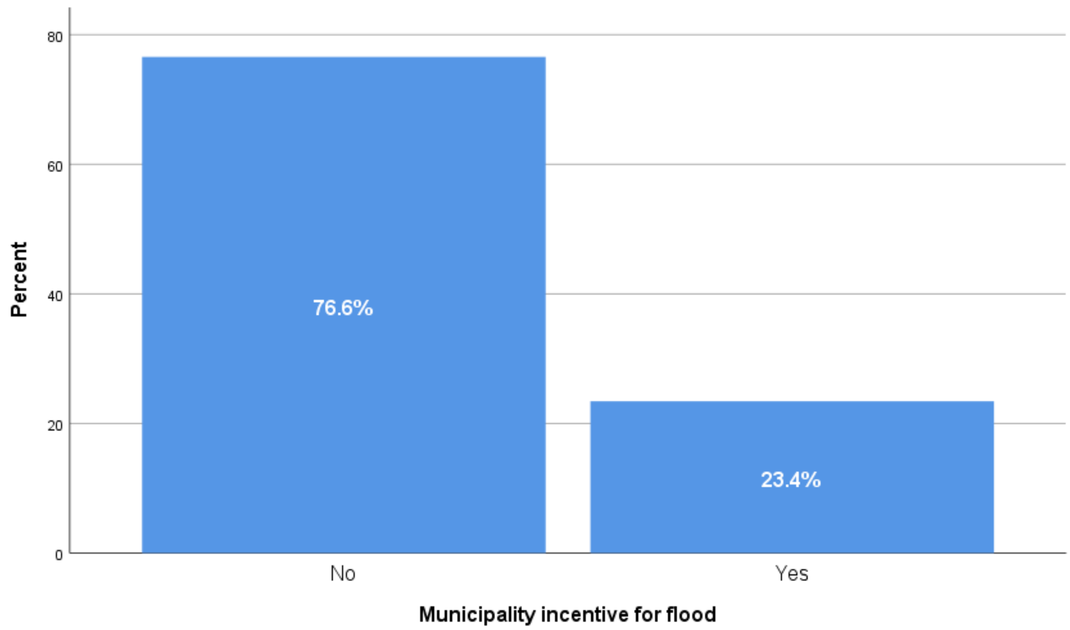

Figure 5.39: Percentage of response on municipal incentive for flood preparedness

It was reported by 76.6 percent respondents that there is no municipality incentive for flood disaster risk, while 23.4 percent confirmed there is incentive from the municipality.

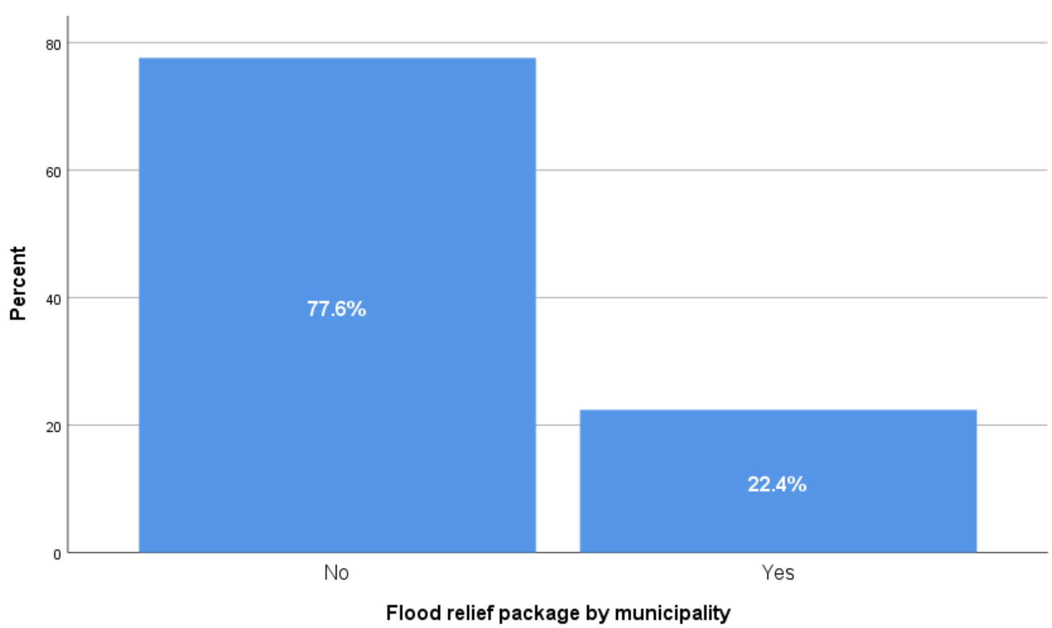

Figure 5.40: Percentage of response on flood relief package after the flood disaster

Figure 5.40 depicts that 77.6 percent respondents expressed there is no flood relief package by the municipality after the flood disaster, while 22.4 percent confirmed there is flood relief package by the municipality.

Based on the responses on incentive for floods and flood risk concerns, the researcher determined the possible relationship between these variables, as shown (Table 5.24) below.

Null hypothesis: Municipality incentive for flood and Flood risk concerns are related.
Alternative hypothesis: Municipality incentive for flood and Flood risk concerns are not related.

Table 5.24: Crosstabulation of Municipality incentive for flood versus Flood risk concerns

		Flood risk concerns		Total
		No	Yes	
Municipality incentive for flood	No	42	252	294
	Yes	46	44	90
Total		88	296	384

Table 5.25: Chi-square tests on Municipality incentive for flood versus Flood risk concerns

	Value	df	Asymptotic Significance (2-sided)	Exact Significance (2-sided)	Exact Significance (1-sided)
Pearson Chi-Square	52.898[a]	1	.000		
Continuity Correction[b]	50.834	1	.000		
Likelihood Ratio	47.519	1	.000		
Fisher's Exact Test				.000	.000

Linear-by-Linear Association	52.761	1	.000		
N of Valid Cases	384				

a = 0 cells (0.0%) have expected count less than 5. The minimum expected count is 20.63.

b = Computed only for a 2x2 Table

The output in Table 5.25 showed the Pearson chi-square test statistic (52.898), which measures the overall association between the two variables, testing for a significant relationship between municipality incentive for flood and flood risk concerns. The chi-square statistic was compared to a chi-square distribution to determine statistical significance. The p-value associated with this statistic is very low ($p < 0.001$), indicating a highly significant relationship between the two variables. The continuity correction (50.834) shows a highly significant relationship ($p<0.01$), as does the likelihood ratio, with a statistic (47.519) equally indicating a highly significant relationship ($p<0.001$).

Fisher’s Exact Test was used to assume the chi-square test is not met, in this case, it shows a very low p-value ($p<0.001$), which suggests a significant association between the variables. To understand the linear relationship between the two variables, the statistic (52.761) indicates a highly significant relationship.

The study results showed strong evidence to conclude the municipality incentive for flood and flood risk concerns are significantly associated. That is, the presence or absence of municipality incentives for flood management in eThekwini is related to the level of flood risk concerns expressed by residents. The low p-values across all test statistics shows this association is highly unlikely to be due to random chance. Thus, this information is valuable for policymakers and researchers interested in understanding how municipal incentives may impact residents’ perceptions of flood risk.

5.3 QUALITATIVE DATA ANALYSIS

This section presents the study findings resulting from data obtained through in-depth interviews with respondents from the eThekwini municipality. These respondents included six disaster management practitioners also known as disaster management coordinators, four officials of disaster management with one each from the engineering department, water and sanitation department, development planning and environmental management unit and the academia. Also interviewed were three councillors and two ward committee members of the eThekwini municipality. Although the research had proposed five disaster management practitioners, allowance was made for referrals from participants through snowball sampling, hence the one extra respondent. Interviews were conducted face-to-face or telephonically, as convenient for respondents.

The analysis elucidated recurring themes, providing valuable insights into the complexities of disaster management within the municipality. Qualitative data were analysed using Nvivo 14, a computer-assisted qualitative data analysis software (CAQDA) that allows qualitative inquiry beyond coding, sorting and data retrieval. It integrates coding with qualitative linking, shaping, as well as modelling.

5.3.1 Thematic analysis

The researcher employed a thematic approach in analysing the data. Thematic analysis is used in qualitative data analysis to systematically organise and analyse data sets. Themes are identified through careful reading and re-reading of the transcribed data from in-depth interviews, with patterns identified across the data to derive themes (topics, ideas and patterns of meaning that are repeated) (Dawadi 2020; Caulfield 2023). A thorough thematic analysis approach produces insightful findings that are trustworthy (White and Moules 2017).

Braun and Clarke (2006) infer that thematic analysis is theoretically flexible for identifying, describing and interpreting themes (patterns) in detail within a data set. They surmise the thematic approach of analysing qualitative data makes the analyses more valid, because of its transparency, accessibility and flexibility. Cavendish (2011) describes thematic analysis as a constant comparative method that involves reading and re-reading the transcripts in a systematic way, to enable the final product to be of good quality.

There are different approaches used in conducting thematic analysis. This research adopted an inductive approach, which involves allowing the data to determine the themes. The six step process of familiarisation, coding, generating themes, and reviewing themes, as well as defining and naming themes and producing the report, originally developed by Braun and Clarke (2006), was followed to analyse the data. This process assisted in confirmation bias avoidance when formulating the analysis. The steps are discussed below.

Step 1 – Familiarisation with the data

The researcher was able to gain insight and figure out theme types contained in the data. First, the interviews collected through audio recordings were transcribed into written text. Transcription familiarises the researcher with the data, providing a more thorough understanding of the data (Braun and Clarke 2006). The researcher ensured each transcript was checked against the initial recordings for accuracy. All transcripts were transferred into Nvivo 14 software for analysis. Following this, the text (data) was read repeatedly and thoroughly, searching for meanings, patterns and themes and ensuring the researcher's influence was not included. According to Braun and Clarke (2006), re-reading the data shapes possible patterns. At this point, the researcher took down notes and marked ideas for coding. All interesting information was highlighted, and the points of interest detected and cross referenced against the research questions.

Step 2 – Generating initial codes

This involved producing initial codes from the data, where the codes are the most basic part of the raw data that can be assessed meaningfully regarding the phenomenon (Braun and Clarke 2006). These codes identify the data features of interest to the researcher; codes organise the data into groups of interest. The coding in this research was done to identify recurring themes, patterns and concepts within the data. The Nvivo coding future enabled the application of multiple codes by selecting phrases of interest. Each segment of the texts was systematically coded based on its relevance to the research question.

Step 3 – Searching for themes

This step involved sorting the different codes into potential themes and the collation of all relevant coded data extracts within the identified themes. This step began after all data were initially coded and collated, with a list of different codes identified across the data set. The codes identified were grouped based on their similarities and relationship to form broader themes. The researcher followed suggestions by Braun and Clarke (2006) geared toward easing this process by preparing a list of codes separately and then organising them into theme-piles that show the relationship between the themes and codes.

A theme captures important information on the data patterning to the research question and represents patterned responses and meaning within the data set (Braun and Clarke 2006). Thus, conceptualisation of the codes is very important as building blocks, as well as the combination of similar or multiple codes to generate potential themes as they relate to the research question.

Step 4 – Reviewing themes

At this stage, all the themes were brought together. This was aimed at refining the initial grouped themes and presenting them in a more systematic way. Following suggestions by Braun and Clarke (2006), the themes were checked for coherence and consistency, as well differences between themes. This stage ran at two levels, where the first level involved reviewing the coded data extract. Here the researcher read all collated extracts for each theme thoroughly and considered whether they appeared to form a coherent pattern. having determined that they formed a coherent pattern and adequately capture the contours of the data, level two was initiated.

Level two involved a similar process but in relation to the entire data set. Here the researcher considered the validity of individual themes in relation to the data set and whether the thematic map accurately reflects the meanings evident in the data set as a whole. to achieve this, the transcript was reread and a few additional data within theme, missed earlier in the coding stages, were coded. Recoding of a data set is needful and expected, as coding is an on-going organic process (Braun and Clarke 2006). At the point where a satisfactory thematic map was reached, and further refinement was not adding anything substantial, recoding and refinement were stopped. The thematic map generated for this research is shown below (Figure 5.41).

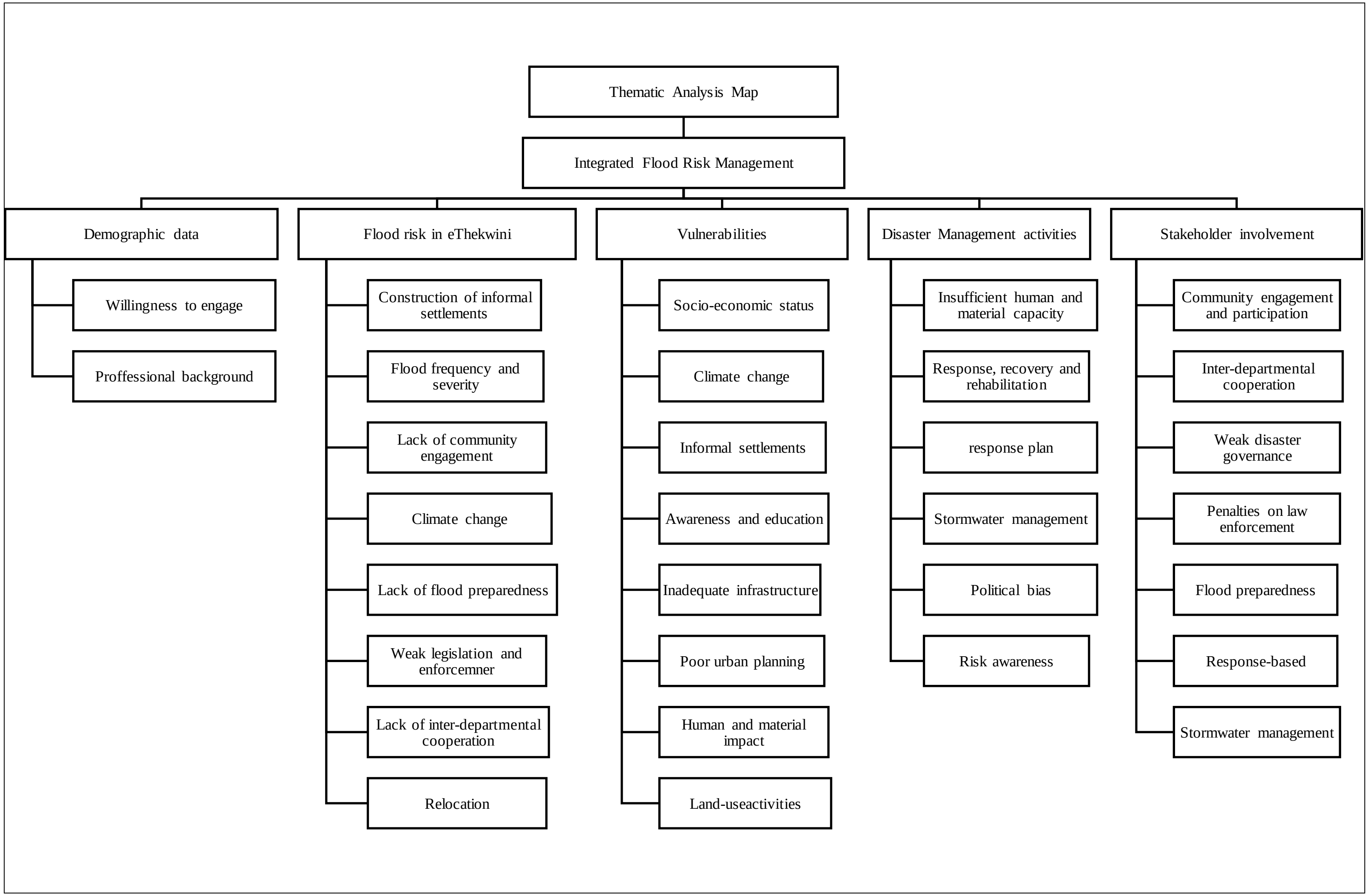

Figure 5.41: Thematic analysis map

Source: Author's own mapped analysis (2024)

At the end of stage 4, the different themes were known and their relationship described, thereby highlighting the overall story the themes tell of the obtained data.

Stage 5 – Defining and naming themes

The researcher started this stage by further refining and defining the themes. This involved identifying the essential meaning of each theme and determining the data set that captures each theme. To avoid diversity and complexity, data extracted for each theme were collated and organised into an internally consistent account with accompanying narratives. Care was taken to ensure the data content extracts presented are not paraphrased, rather, what was interesting about them and why it is interesting were captured. A detailed analysis was conducted and written on each individual theme and the story they tell was identified to ensured its fit into the broader overall story on the data, in relation to the research questions. This was to ensure themes did not overlap; hence, the researcher considered each theme in relation to other themes, with sub-themes also identified. At the end of this stage, the themes were clearly identified and named.

Stage 6 – Producing the report

This stage involved the final analysis and writing of the report. Following advice from Braun and Clarke (2006), the analysis must tell the story of the data in a convincing way and not lack merit and validity. The researcher ensured the coding and thematic analysis processes were verified through frequent and thorough reviews to ensure the reliability and validity of the findings; thus, discrepancies were resolved through each phase of the review. Efforts were made to ensure the story the data presented within and across themes was coherent, logical, concise, and non-repetitive, as well as interesting, providing sufficient examples and extracts that captured the essence being demonstrated. The analytical narratives were embedded in examples and extracts in a way that made an argument in respect of the research objective, while illustrating the story being told. The findings are discussed in the next section.

The findings from the qualitative interview were thoroughly analysed without any researcher bias. This can be seen from the sections following.

5.3.2 Response rate

Response rate is defined as a measure of people who complete a survey, relative to the total number of people invited (Masson 2023). The response rate can be calculated, as Masson (2023) explained, by dividing the total number of representatives that completed the survey by the total number of proposed or invited participants. The result is multiplied by 100 to express in percentage. Survey response rate is used to assess survey data representativeness. Thus, a high response rate indicates a good representation of the target population; this enhances the validity of the survey result and reliability of the research findings.

Fincham (2008) postulates a response rate of approximately 60 percent for most research is considered a good response rate. In this research, a total of 20 key-informants were proposed as interviewees in the study. They fell into three categories namely: disaster management practitioners, senior disaster management officials, ward councillors and ward committee members from uMlazi Township, Clare estate, Inanda Township and Cato Manor, who were all key stakeholders of disaster management in the EMA at the time of study. From this number, 14 respondents and one snowballed gave consent and participated in the study. The response rate and response percentage are shown in the Table 5.26 below

Table 5.26: Response rate

Category	Total Sample	Return	Return Percent (%)
Head of Disaster Management Center (eThekwini Municipality)	1	**0**	(15/20) x100 = 75%
eThekwini Disaster Management Practitioner	5	5 + 1 (snowball)	
eThekwini Disaster Management Officials	5	4	
eThekwini ward councillors	5	3	
eThekwini ward committee members	4	2	
Overall Total	20	15	

A 75 percent response rate was obtained (Table 5.26), which indicates an acceptable response rate that will enhance the validity and reliability of the research findings.

5.3.3 Respondent consent and demographic data

This section examines the consent by respondents and their demographic data. Respondent consent underscores their desire to take part in the study and assist in their own way to bring about a lasting solution to the flood disasters occurring in the study area. Demographic data assisted in categorising the respondents and the different perspective they bring to the study. Based on the above, the following themes were generated.

i) **Theme 1: Willingness to engage**

Respondents were willing to engage in the interview once they understood the nature of the research, which was aimed at preventing and reducing flood disasters and their impacts. The disaster management practitioners were enthusiastic in their responses and wanted to share their opinions on how the yearly disasters impacting the municipality and causing so much havoc can be mitigated and their risk reduced. The councillors were not forthcoming as they were busy dealing with other engagements. Only 50 percent ward councillors and ward committee members made themselves available after consenting to participate in the survey. This explains the consensus that the people directly in charge of policy-making are engaged in other activities and afford very little time to disaster and risk management, highlighting the reactive nature of the government to flood risk, instead of being proactive.

ii) Theme 2: Professional background

A knowledge of the professional background of respondents is crucial for this research, as it will show the researcher captured all relevant stakeholders that will bring a wealth of knowledge to the study findings. The disaster management practitioners interviewed had grown in the ranks over the years, from being volunteers to the emergency control room, before they were absorbed into the disaster management unit as disaster management coordinators. They had disaster management experience ranging from five to 20 years. The disaster management officials are in the supporting fields of engineering, water and sanitation, development planning and environmental management.

Although disaster management technocrats from the academia were not proposed, inclusion was not required, as there was a wealth of knowledge to be shared. The councillors had political appointments with a tenure of four years that commenced in November 2021. However, some had completed tenure previously and were being retained. The ward councillors have direct contact with the community members and were able to fully express the flood challenges experienced in their respective wards.

5.3.4 Analysis and interpretation of results collected from disaster managers and practitioners

Data were collected from six disaster management practitioners, with their responses to the questions analysed and interpreted according to the themes generated, to answer the research questions and align with the research objectives. Extracts that emphasised arguments and painted a clearer picture were also added to the findings in italics. The researcher did not alter or paraphrase the extracts included but has reported them verbatim.

1) Objective 1 – Examine flood risk in the selected study area

The following themes were generated, analysed and interpreted when the disaster management practitioners were asked:

- Their opinion on the cause of floods in the eThekwini municipality.

i) Theme 1: Construction of informal settlements

All respondents indicated the illegal construction of houses, also known as shacks, on land not suitable for building houses, are a major cause of disasters from floods in the study area as people are exposed to flood hazard and become highly vulnerable. Some explained the people are aware but due to the cost and unavailability of land for building, they are driven to construct houses on flood prone areas, near rivers, on flood lines and land with silt soil not meant for construction.

A respondent stated: *"[...] they are aware of the risk, that if you build your house next to a flood plain is the risk".* They emphasised they have no permission from the government to build and construct without building codes but because of urbanisation and their desperate need for housing, they construct make-shift houses. One respondent clearly stated: *"People who are building shacks or informal settlements in flood prone areas on steep hills, they build around a long floodplain. They build without building codes".*

Informal settlements in eThekwini municipality are reportedly built anywhere anyone can find land space. GIS information has shown vacant land being encroached on were situated below the 50 to 100-year flood lines (Magidimisha-chipungu 2022). Living within areas demarcated as flood lines is very dangerous and leaves occupants prone to flood disasters. eThekwini is recorded to have the highest number of informal settlements among all the municipalities in SA, with housing in 580 urban informal settlements currently containing a quarter of its population (UN 2022). These informal settlements lack basic amenities, have poor road networks and stormwater management predisposing them to flood disasters.

According to Magidimisha-chipungu (2022), poor progress in urban land reform has made it difficult for the local government to provide adequate housing for its communities, making people desperate and willing to take the risk to construct their houses anywhere there is available land. This would explain the lack of risk perception noticed in the behaviour of study area residents.

ii) Theme 2 - Weak legislation and enforcement

Approximately 65 percent respondents blame the government for its very weak legislation and non-enforcement of flood risk reduction plans in the study area. They are of the opinion that land already marked as non-residential and not suitable for building is forcefully occupied by people. These occupiers construct their homes and businesses and the government does not forcefully remove them or punish them in some way as a detriment for others; instead, it provides materials to reconstruct homes on the same land, after the disaster has occurred.

One respondent stated:

> *"[...] most of the areas they build on are the places the government abandoned as not being suitable for living. They do not want people to live there and did not want to build houses for people on the land. So now because of urbanization, shortage of land and high prices of houses people occupy these spaces, build houses using materials that get easily washed away when there are heavy rains like cardboard sheets. Instead of the government to use this opportunity to move them, they give them cardboard sheets to rebuild their shacks where they were before".*

This behaviour is said to encourage others to do the same, even when aware of the risk involved. It is also alleged the government builds RDP houses on land they know is not suitable for building, which they then give to the people and subsequent heavy rains wash away roads and collapse these houses. The RDP affords a beneficiary an opportunity to acquire a house built and provided by the government through a government subsidy.

It is obvious the governments' lack of enforcement and penalties of people who occupy areas marked by government as uninhabitable, could be because they are unable to provide proper housing and service delivery to citizens. The rapid urbanisation in the eThekwini municipality, at the rate of 4 000 informal settlement households per year, would take close on 80 years to overcome the informal settlement backlog through conventional housing projects such as the construction of RDP houses (UN 2022). Hence the government is lenient regarding penalties, enforcement and policy formulation but would rather assist in rebuilding the damaged houses, bearing in mind it is only a temporary measure until the next flood disaster.

iii) Theme 3 - Poor service delivery

All respondents are of the opinion that poor service delivery is a major reason for flood risk in the study area. They say in the townships and the informal settlements adopted by the government, they lack basic service delivery, for example, waste collection, tap borne water, proper sanitation such as toilets and so on. Most agreed because of this, the people find anywhere to drop their waste and defecate into rivers. These behaviours and the lack in maintenance of drainage systems cause blockages, leading to water overflowing into the area when there are heavy rains. This respondent says in his own words,

> *"[...] lack of good drainage system and especially waste collection is a major problem people are facing. People throw their waste into drainage systems blocking them and causing flooding. The main problem is waste collection.* Another respondent puts it this way *"I think the blockage of drainage network as well as not taking care of sewage system, if I may say, so, there are high level of sampling that are taking place in the stream. So, even the water doesn't flow in the right place. So, it is all about dumping and blockage of drainage network"* [the respondent explained sampling when asked by the researcher to mean defecation].

Several reviews have shown that poor waste management contributes greatly to urban flooding by increasing debris, blocking drainage and causing health hazards (Okwesili, Ndukwe and Nwuzor 2016; Ojo and Adejugbagbe 2017; Echendu 2023). Blockage of drainage automatically prevents the water from flowing when it rains. African cities are cited as offenders in indiscriminate waste disposal into stormwater drains, streams, rivers and on the streets. These practices could be linked to institutional failure leading to poor service delivery.

iv) Climate change

Approximately 80 percent respondents pointed out that climate change was a major contributing factor to flood risk in the study area. According to them, the rainfall has become heavier and more frequent and, considering that eThekwini has a hilly topography, the rains cause flash floods that leave havoc in its wake. One respondent put it like this: *"It is the change in weather conditions like rain for an hour, but the amount of rain that falls within that period of time is too much or it ends up flooding and then people get affected because now most people are living in informal settlements, on top of hills or in the valleys or near rivers".* Some respondents inferred a lack of adequate knowledge of climate change and its consequences makes people take risk. They claim the majority people in the study area have no risk avoidance, because of their lack of climate change knowledge.

Climate change has been implicated as one of the causes of heavier rainfall and extreme floods. The United Nations Environmental Program (UNEP) infers it is a cause of worldwide flooding events. Furthermore, the climate change impact will be felt in urban cities along coastal zones (Andimuthu *et al*. 2019). Williams *et al.* (2019) assessed the vulnerability of communities in the context of rapid urbanisation and climate change and found urban resilience was weakened as a result of flood disasters. Were the community members to understand the impact of climate change, they would be better prepared and hence, the losses from yearly flood disasters would be prevented or reduced.

- What is the trend of flood disaster in the study area in the past 20 years (2000–2020)?

The following theme was generated from the above question.

More frequent flood disasters

The consensus of all respondents was that flood disasters have increased in frequency as the years progressed. Some respondents said in earlier years it used to be roughly one flood disaster every two years, citing the 1987, 1989 and 1991 flood disasters but in recent years, they have witnessed flood disasters three to four times in a year in the study area. One respondent stated: *"[...] the flood disaster used to be once in about two years. October 2017 and then it jumped to 2019 but now every year we get flooding for like roughly every four to six months"*

Olanrewaju and Reddy (2022), in their "Assessment and prediction of flood hazards using standardized precipitation index – A case study of eThekwini metropolitan area", traced all the flood disasters from 1985 to 2016, indicating the frequency and increase over the decade.

- How would you describe the impact of floods on the affected community on livelihood, access to clean drinking water, health, sanitation, infrastructure and housing (on a scale of 1-10 where 1 is very low and 10 is very high) in the past 20 years (2000-2020)?

Theme 1 – Varying degrees of high to very high

High to very high impact of flood disaster on livelihood, clean drinking water, health, sanitation, infrastructure and housing

There was consensus by all respondents of the very high impact flood disasters have on the people in the study area. The majority respondents graded between 7-10 on all factors. During floods, livelihoods are shattered as homes and businesses are washed away by floods. Sanitation is a major problem immediately after the floods, because sewage and waste carried by the rain water are deposited all over. Some said sewage is washed into rivers and sources of drinking water. Furthermore, infrastructure and houses are destroyed.

One respondent described the experience to be overwhelming and leaving people unable to cope: *"[...] the 2022 flood disaster was the most devastating. Apart from people dying, the infrastructure collapsing, a lot of people were going through trauma".* The impact on infrastructure, housing and sanitation scored very high ratings of 10, livelihood eight, while health and access to clean drinking water scored seven each.

The impact of flood in the EMA has been very grievous. The 2022 flood disaster is recorded as one of the most devastating since the 1987 flood disaster to impact the study area. There was a high mortality rate, with infrastructure such as roads, communication, power and sources of clean drinking water destroyed. Thousands were displaced from their homes and livelihoods were greatly impacted by the loss of jobs. The question remains, with all the research and advancement in technology, why do flood disasters in the study area continue to up-score in its impact.

- Indicate an estimate of people affected by flood disaster and cost of damage as a result of flood disasters in the study area

Theme 1 – Very high number of people are impacted, and very high cost of damages incurred.

Respondents answered to this question by quoting various Figures that were very high and went beyond the researcher's findings from StatsSA (2016), which was the most current statistics on the number of people living in the study area, as at the time of this research. This is because many informal settlements exist in the study area and those are mostly not included. It is estimated that approximately 90 percent residents are affected by the flood disaster and damages run into billions of Rands.

Flood disasters cause havoc in the study area. Infrastructure such as roads, bridges, schools, health facilities and so on are destroyed. Livelihoods are negatively impacted as bread winners are unable to earn a living and children do not attend school, remaining at home. The department of trade, industry and competition (DTIC) revealed that at least 826 companies were affected in the April 2022 flood disasters that occurred in KZN and damages incurred were estimated at R7 billion, with eThekwini accounting for 50.6 percent of the damages. The flood disaster affected 31 220 jobs, where eThekwini accounted for 68 percent% of the affected jobs. In addition, electricity and water were cut off for several days (Govt. SA 2022). This was the incident report in just one flood disaster. Continuous flood disasters will, however, have a lasting impact on community members.

2) Objective 2 - Identify the factors that increase vulnerability of community members to floods in the study areas

Disaster management practitioners were asked regarding the causes of vulnerability of community members to flood disasters in the study area and whether there were any coping strategies in place. Their response generated the following themes.

Theme 1 – Human behaviour

The majority respondents attest to the major cause of vulnerability in the study area being residents' lack of risk perception, particularly those living in informal settlements. These settlements are erected anywhere there is a piece of land, such as under a bridge and along river beds. Heavy rainfall floods the area and even though they are heavily impacted negatively, they refuse to move. One respondent explained: *"[...] even when the government gives them RDP houses, they sell the houses and move back to where they were staying because the place they work is just a few minutes from there. They knowingly take the risk".*

One respondent noted that those informal settlements are fully occupied from January to November but by December, the houses are empty, as the residents have returned to their homes in the rural areas. They stressed that most residents in the urban areas are simply there to make a living, and do not mind the houses being washed away by floods, because they are non-committal to these houses, with most kept unfurnished. Another respondent said that even some rich residents of the study area do not take responsibility for themselves and construct houses without assessing whether the area is suitable for building or constructing the type of houses they build.

The behaviour of individuals before, during and after a flood is a critical factor that can influence the impact of flood disasters. The degree of flood damage depends on the preparedness of people towards flood disasters (Raas and Jaroslav 2018). The migration of people from rural to urban areas in search of jobs causes crowding of cities, as migrants rent houses or build their homes on flood plains, because it is seen as merely a temporary measure. Home owners however, have better preparedness measures towards protecting their homes from the impact of floods.

Theme 2 – Socio-economic factors

Socio-economic factors raised by respondents while answering this question included lack of education, unemployment, poor or no income, and housing and food insecurities. The majority respondents believe the high rate of vulnerability was as a result of lack of knowledge. Some said if they knew what to do to minimise the risk of the flood disaster, maybe they would do it.

Concerning unemployment, respondents were unanimous in their argument that the majority residents of informal settlements are unemployed. They have no income to rent houses in better places, because they first have to worry about what to eat before they think of houses. Those with homes in townships do not have sufficient money to insure their homes. Some respondents believe corruption by governmental officials is aiding vulnerability in the study area, as residents of informal settlements and townships do not receive good service delivery. These hamper their health, availability of drinking water, hospitals and so on that they need.

Concerning coping strategies that could be used to combat these socio-economic vulnerabilities, respondents offered various views. The opinions gathered by the researcher was that in some communities, they do not have any coping strategies while in others, the community members come together to help themselves. They construct trenches, have public houses, food gardens, and day-care and skills empowerment centres.

One respondent said this about a community in eThekwini: *"[...] there is a gentleman or grandfather who built a bridge, a walking bridge for the community. Anytime it gets washed away by floods, he builds another one for the kids and everyone to use. So, we have places where people try to come up with coping strategies".* They are however, unaware of the government providing long-term recovery loans to the most affected low-income community members. However, one respondent mentioned NGOs are quick to assist once flood disasters occur. The respondent said, […] *"it is just that when things happen, NGOs such as Red Cross Society will pitch in and try to help".* It is obvious from the responses that DRM is mainly deemed as reactive, instead of proactive.

Theme 3 – Inadequate infrastructure

One theme that kept reoccurring throughout the interview sessions with the respondents, is the inadequacy of infrastructure such as good roads, solid waste disposal and sewage treatment, as well as electricity, drinking water, and primary/emergency health services, along with schools and telecommunications. The majority respondents said poor road networks was one of the hindering factors that prevented them from reaching flood victims on time, causing a high volume of casualties. They claim the townships and informal settlements had bad roads that were either not being renovated or non-existent. They also alleged very poor solid waste disposal and sewage treatment caused waste and debris to block drainage system and cause floods. Concerning electricity and drinking water, some respondents pointed to the lack of electricity in many informal settlements and extended load shedding in townships that prevent residents from being informed on disaster warnings posted regularly by the SAWs. Some claim certain residents of eThekwini have not had pipe-borne water for upwards of six months, making them use untreated water from streams and rivers.

eThekwini has a population of approximately 3.9 million people, making it the third largest metropolitan area in SA (eThekwini Municipality 2020). The government is unable to meet the demands of housing in the study area, leading to the construction of informal settlements to meet the housing needs of the people. Informal settlements spring up at a rate of 4 000 households per year. The metropolitan area is so overwhelmed with the speed, projects would take them mor than 80 years to meet the housing needs of the people (UN 2022). This also accounts for why service delivery is so poor.

Theme 4 – Poor urban planning

The majority respondents believe poor land use planning by the municipality is among the primary causes of vulnerability to floods. Residents do not build proper houses, and government has no plan for expanding the city. They say this is the reason government has seemingly ignored the erection of informal settlements, because they do not know how to properly manage the city.

3) Objective 3 - Examine the disaster management practices employed by disaster managers in urban FRM in the study area

The disaster management practitioners were asked several questions to address this objective. Several sub-themes were generated, grouped together to form themes that adequately explained all the responses. These questions include:

- Does the EMA have a flood disaster management plan in place?
- Is there a budget for flood disaster related activities? If yes, is the budget adequate?
- Is there a budget in other departments of the EMA for flood disaster management?
- What approach do you believe the EMA uses to manage flood disasters? Proactive or reactive approach?
- If proactive (i.e., focused more on prevention, mitigation and reduction), what measures are used to manage flood disaster in the EMA?
- If reactive (i.e., focused on emergency response, disaster recovery and rehabilitation), explain why such an approach is adopted?
- Do you have effective stormwater management in place in the EMA? If no, what are the challenges faced. If YES, what types/models do you have in place?
- Do you have sufficient capacity in the Municipality for FRM?
- How can the damage to flood disaster in the study area be reduced?
- What are your developmental options to address the flood patterns in the study area?
- What do you believe, in your opinion, is the biggest barrier to FRM in the study area?
- What are the lasting measures that can be put in place to mitigate against flood disasters in the study area?

Theme 1 – Insufficient human and material capacity

All the disaster management practitioners pointed out that they lacked sufficient human and material resources such as staff, vehicles and other response activities. They highlighted scenarios where they had emergencies but had no vehicles to attend to these situations. They also said there were very few of them, covering a very large area. One respondent put it as follow: "[…] *there are no staff and equipment for disaster management"* noting that the EMA is sprawled over 2 297km^2 of land. Therefore, the lack of adequate human and material resources will hinder effective FRM in the study area.

Theme 2 – Emergency response, disaster recovery and rehabilitation activities

All respondents cited the fact that they are reactive rather than being proactive. On the reason they chose to be reactive, knowing being proactive was a better option, they had varying responses. While some said the disasters are so overwhelming they are unable to implement the plans they had drawn up from previous disasters, some said they have no plan drawn up.

In addition, should they be unable to utilise any pre-plans and involve the people, they have no choice but to merely respond when disasters happen. Others hinted they try their best to engage with community members to tell them of the flood risk they face and even carry out web-based assessment but could not really explain why they remain reactive.

One respondent answered all these grey areas very clearly and said,

> *"[...] we are reactive because we do not have many coordinators (disaster management practitioners) and so are unable to deal with everything because basically, in eThekwini municipality, we have got how many of us? Seventeen or 20 coordinators for 111 wards so we end up centralizing our activities in the middle of eThekwini and have nobody to go out to the south and west. We try to distribute ourselves even though we do not have enough resources to go out there and be proactive and mitigate and try our best to prevent flood disasters. So, for now, until we get more staff and more resources, we are just going to keep being reactive.*

Theme 3 – Lack of clear response plan and budget for FDRM

While 50 percent respondents agreed there is a disaster plan, they are unclear regarding its contents. Concerning the budget for FRM, there were mixed responses. One respondent said: "*I do not know of any budget for flood related activities, but I know we have a level two disaster management plan and contingency management plan for floods but about the budget, we have not really been informed".* Another one stated: *"Yes, there is a budget. I can only say about human settlement because I know they build houses for the people whose homes collapse and we give short-term relief packages like blankets, food parcels etc."* The rest of the respondents stated there is no budget. These variances in answers could be because there is no information and clear allocations of budget for FRM. They all agreed these matters are discussed at the top level in the municipality and they were not informed.

Theme 4 – Inadequate stormwater management

Stormwater management is a crucial part of FRM and was proposed by the researcher as a component needed in the FDRM framework development for the EMA, hence the question was asked. Stormwater management is drawn towards the reduction of rainwater into the environment, as well as to improve water quality. Effective storm water management has several advantages, the main being the reduction of flood disasters, minimisation of damage to infrastructure and diminished risk for spreading contaminants that cause water-borne diseases.

When respondents were asked whether there was effective stormwater management in place in the study area, they all said no. The researcher enquired what challenges were responsible for that, with some tactically avoiding an answer, with responses such as from this respondent: *"[...] well am not sure, that fall within another department. You know, the stormwater department"*. Some responded by saying it was due to lack of maintenance as and when due.

One respondent stated: *"I think, it is because of the population. It has grown very fast over the years and the stormwater infrastructure is unable to cope. They need to extend the infrastructure so it can cope with the pressure of the people"*. The responses received simply show the lack of linkage between stormwater and the impact of flood risk in the study area. The researcher deduced a lack of cooperation and coordination between the disaster management department and the stormwater department.

4) Objective 4 - Examine the role of key stakeholders to urban flood management in the study area.

To examine the role of key stakeholders, which include community members, disaster management practitioners and other governmental and non-governmental agencies in the management of flood disasters in the study area, the disaster management practitioners were asked about stakeholder involvement in disaster management activities. Various sub-themes were generated that were combined to form major themes.

The questions include the following:

- Is there any community participation in flood disaster management in EMA? If no, why? If yes, to what extent?
- Is there any cooperation between the Provincial Disaster Management Centre and the EMA disaster management centre on flood disaster management? If yes, what is the degree of cooperation?
- What additional role do you suggest stakeholders can play in mitigating flood disaster in the study area?

- If you were to anticipate future changes to mitigation of flood risks, what changes will you make?

Theme 1 – Weak community engagement and participation

When respondents were asked regarding community member involvement in DRM in the study area, responses were varied, however, all culminated in the fact that community members felt entitled to some type of motivation, before they make disaster risk prevention a priority. Respondents indicated there is a volunteer training programme.

One respondent explained how they involve the community:

> *"Yes, we have this program 'risk management' lately when we go out into the communities, for people who have been living there for a long time they tell us about their community, what has been going on over the years, kind of what we're doing now, then they give us solutions to the problem like, what do they think can help make the situation better? That's what we do. We also have a volunteer training program for disaster management".*

It is not clear how impactful a few volunteers will be among millions of residents. The respondents, however, hinted that with challenges in capacity, they are unable to practically implement their findings, which is a discouragement to the community members.

Theme 2 – Inadequate inter-departmental cooperation in FDRM

Respondents were asked regarding cooperation with other stakeholders directly involved with disaster management in the study area, with the majority that agreed there was cooperation between the eThekwini disaster management centre and the Provincial disaster management centre. They also alleged that the government provides regular training for the practitioners and officials alike. However, all respondents agreed there is little or no cooperation between them and other departments mandated with DRR. According to them, they do not work together, so they are unaware of what other departments plan to do.

The respondents further intimated that these collaborations occur at high levels among executives, in forums they are not privileged to attend, and are only instructed on the section they are to deal with. The researcher was unable to obtain an interview with the executive in the centre to authenticate the statement. Respondents believe that should there be proper coordination between departments, flood mitigation and prevention will be achieved.

Theme 3 – Transparency in disaster governance

Respondents were finally asked to anticipate future changes in mitigation of flood risks and as stakeholders, to lasting solutions. The majority respondents anticipated transparency in governance, alleging corruption is an obstacle to successful flood mitigation, as this constitutes a major barrier. Examples were cited of resource allocation not accounted for or properly utilised. One respondent explained further, *"I think it is poor or lack of communication between the bodies that have the mandate to allocate the resources. I think they can do that better. Because recently, they were arguing that the money, the grant, had to go back because I think they do not agree on something and do it".*

Another respondent explained clearly and advised on the best route to take:

> *"Okay, firstly, encourage all the stakeholders to work together and using the budget effectively. So, the stakeholders will get together and all agree and talk to each other on improving the infrastructure and also in alerting the community by doing community awareness. Working collaboratively and maybe if the aim is communicated the division of management is communicated to other departments as well. I think that can help rather than what is happening now, I think what is happening right now is everyone wants to achieve there is a standard operating procedure but they do not work together hand in hand".*

Theme 4 – Enforcement of laws and penalties

Respondents are of the opinion that should governmental stakeholders strictly enforce laws, in addition to issuing punishments to violators, residents of the study area would be more careful regarding their attitudes concerning flood risk. One respondent said the enforcement of laws should be across the board and from top to bottom. In their words: *"I would emphasize on the local compliance of the laws, for instances departmental disaster, if you don't bring it on board, you can be disciplined. There're no penalties that's why people* *don't care".* Another respondent stated: *"I'll say we need to enforce laws, especially on land use building codes as well as the development of the infrastructure.*

According to the UN (2005a), good governance for DRR should elevate reducing disaster risk and make it a priority, allocate all necessary resources for DRR measures, while also assigning accountability for failures, in addition to facilitating participation from the general public. The researcher noted this has been ineffective in the study area.

Theme 5 – Effective flood preparedness activities

Respondents are of the opinion that should flood risk be properly mitigated through efficient and effective cooperation between all stakeholders, losses accrued from flood disasters can be reduced.

The opinion of one respondent is quoted:

> "[…] *they can work together and also have the goal of mitigating disaster. I'm thinking like for example DSW maybe even redo their plan into accommodating the population and may be coming twice in a week to collect the waste other than once a week that causes the illegal dumping which also is affecting the flood".*

The respondents' opinions, when put into practice, are essential in mitigating flood disaster in the study area. This is because the Durban Solid Waste (DSW) unit is overwhelmed with the waste generated, because of the high population (Rall 2022). Research by Rall (2022) showed that the rate at which waste is generated is far greater than its collection and the resources to manage this function such as vehicles and personnel.

5.3.5 Analysis and interpretation of result collected from ward councillors and ward committee members

Responses received from two ward councillors and two ward committee members were analysed and interpreted using the same format of documentation as the disaster management practitioners above. Ward committee members are those that represent various interest within the ward. They are a channel of communication and interaction between the municipality and members of the community. Ward committee members are chaired by ward councillors.

1) **Objective 1 – Examine flood risk in the selected study area**

To examine risk factors in the community, respondents were asked regarding the following:

- The causes of floods in their communities.
- The trend of flood disasters in the past two decades.
- To describe flood experience in their ward in the past 20 years.
- To describe the impact of floods on their ward on livelihood, access to clean drinking water, health, and sanitation, along with infrastructure and housing, on a scale of 1-10 (where 1 is very low and 10 is very high) in the past 20 years.
- To indicate an estimate of people affected by the flood disaster on a yearly basis in their ward in the past 20 years.

These questions generated several sub-themes, matched to obtain major themes as follow:

Theme 1 – Construction of informal settlements

This is a reoccurring theme representing a major cause of flood disaster in the study area. It has been established the eThekwini municipality has the highest number of informal settlements in SA. One councillor explained there are more than 21 informal settlements situated in her ward and whenever there is heavy rainfall, houses are destroyed. The councillors believe the construction of informal settlements is a major cause of flooding.

One respondent further explained: *"Basically what happened is these settlements are built on either side of the banks of a river, and it's on a sort of hill when the heavy rains fell, the water came through both sides of the river and the houses collapsed. About more than 60 houses with the people in them.*

In addition, the settlements constructed along river beds prevent the free flow of water, as garbage is dumped in the rivers, not allowing a free flow, thus when the water becomes too high, it overflows into the city. It was also reiterated that poor infrastructure is unable to withstand the heavy rains and when washed down, debris causes blockages in the area and results in floods.

Theme 2 – Lack of education and flood preparedness

Respondents believe that lack of education on flood risk is a cause of flooding. They believe when residents are aware of the consequences of flood disasters, they will behave differently towards preventing and mitigating flood disasters. Further to this, they believe the constant yearly flood disasters the study area experiences are due to a lack of preparedness for flood disasters. Community members do not know what to do and the volunteers trained to train them do not get to them. One councillor admitted none had been seen for several months prior to this interview. According to Torani *et al.* (2019), in their review of the importance of education on disaster and emergencies, highlighted that trained people are in a better position to protect themselves and others from disasters and recover faster from disaster impacts.

Theme 3 – lack of inter-departmental cooperation

The respondents agreed the lack of inter-departmental cooperation is a big problem and contributes to flood disaster in the study area. One respondent said the disaster management team, along with human settlement and housing, are not effective in their ward. The disaster management team is not seen around for awareness campaigns on flood risk, with human settlement and housing also not effective. The respondent put it this way: *"Our largest problem lies in the fact that housing and human settlements do not work as a team. Because working means the number of houses constructed. We need control of houses".*

This respondent explained residents displaced from their homes as a result of floods are not being quickly resettled and the flooded areas are not secured and prevented from being used. In the words of the respondent:

> *"[...] and I can tell you now, we have gone a year, April last year was the flood disaster, so it is a year and a half down the road. And speed has not hit the ground. Alright, so now the problem that we have in the community right now is, if you want to walk into there, you will see that all 60 houses or 40 houses destroyed by the floods have been built again, in the same place, despite me saying to housing that we have to control it. We cannot allow this to happen again. We are the murderers because if you allow people to build on your land and you know your land is not safe, then you have to take responsibility for what happens on that land".*

DRM cannot be effective when it works in a silo. There is a need for all relevant stakeholders to work together for effectiveness. Housing, human settlement, environmental management and all others need to understand their role in DRR.

Theme 4 – Flood experience has been terrible

The councillors unanimously agreed the flood experience in the study area has been terrible. One councillor admitted, *"It's so terrible. So terrible because each and every time even when I was not a ward councillor and I keep on experiencing the same thing each and every year".* They admitted that help comes in very slowly from other stakeholders, even those paid to do their job are not found at their jobs.

Another councillor explained further:

> *"[...] they are sitting at home and they are not doing anything, and getting paid monthly. I can think of a whole lot of emails, the coordinator of the Presidential Employment Program (PEP) in eThekwini municipality, the head of department for disaster management, every single top person in charge of this simply ignored me. I may have sent eights message, eight emails in the last. I don't know, five, three months. Nothing. You just get radio silence".*

Their voices when they explained the experience of frustration to mitigate the occurrences of flood disasters were heartfelt.

Theme 5 – very high impact of flood disaster on community members

The respondents all agreed that the impact of flood disasters on community members has been very high. One respondent had this to say about livelihood, when asked to rate from 1-10 where 1 was very low and 10 was very high, *"10, I would say 11 if I have a choice".*

Another had this to say regarding access to clean drinking water,

> *"One of my residents complained that his water was brown I demanded that a test sample be taken, I've got the test results on my Table that says that there was 200% E. coli. Because the sewer had leaked into the water pipes. Our lines are so damaged that if we have water damage, our sewer often flows into our water pipes".*

Another respondent reported the impact on sanitation is extremely high, noting toilets are destroyed during flood disasters and several months later, they are yet to be fixed. Respondents had the same very high impact grade on all other variables.

Theme 6 - Very high number of people are impacted and very high cost of damages incurred

Respondents all agreed there is a very high number of people affected by flood disaster in the study area, on a yearly basis in the past 20 years. One respondent attested that half the population in his ward is impacted, particularly from the informal settlements, and an estimate of more than 800 million Rands in damages was incurred. Another respondent explained the cost of damages this way, *"Can't even calculate I must be honest; my infrastructure is not fixed yet from the April 2022 floods. So, I can't even begin to quantify. If I must, I will say millions, hundreds of millions".*

2) Objective 2 - Identify the factors that increase vulnerability of community members to floods in the study areas

To address this objective, respondents in this category were asked three questions:

- Explain in your view, what are the underlying causes of floods in your ward.
- What are the factors that increase vulnerability of community members to floods in your ward?
- Name at least three coping strategies, if any, employed by community members in your ward.

The major theme generated from these questions, which was not a part of what the previous category had highlighted, is explained below. Concerning coping strategies, no theme was generated as all respondents echoed that the community members or entire community are not engaged in any coping strategies they are aware of.

Theme 1 – Illegal land use activities

The majority respondents explained illegal land use, but not in the form of construction of informal settlement, but as illegal mining activities. It was explained these illegal activities in one of the prominent settlements has encroached dangerously into the river banks. The respondent went further to explain, *"Which means that if there's a flood, we're going to have more lives and more houses destroyed. There are no banks now the water has nothing to turn against it only will flow into the houses.*

3) Objective 3 - Examine the disaster management practices employed by disaster managers in urban FRM in the study area

To achieve this objective from the perspective of the councillors and ward committee members, the same questions were put to the disaster management practitioners and senior disaster management officials. Their responses were completely different from the practitioners and officials of disaster and risk management. The major theme generated is explained below.

Theme 1 – Disaster management activities have political bias

The majority respondents are of the opinion that disaster management activities are biased and tend to be politically motivated. This statement is drawn from the fact that different wards are ruled by different political parties and some respondents claim the wards whose councillors are members of the ruling party have more privileges than others. They claim political bias has marred disaster management activities in many wards.

One of the respondents stated:

> *"[...] can you imagine if all our department can work together, can you imagine if we spend millions to elect people who are not politically motivated to services? I'm talking to you now and I'm getting emotional, I'm thinking about the people we love so much, and my emotion is not coming from love it's coming from frustration, nobody to listen to people, nobody is caring because we are so engrossed in politics, politics do not help human beings. The government has done nothing, they have not communicated as regards to how we could cope with these disasters.*

Political commitments are essential for people and the government to reduce disaster and potential human suffering (Lassa 2020). The SFDRR (2015–2030) stresses the need for political will to apply measures that are proactive, such as prevention and mitigation, rather than being responsive by allocating resources and funds to DRR. This action is, however, not felt as SA has disaster funds meant to be exclusively utilised for post-disaster financing

(Maher *et al.* 2022). These funds have different allocations and utilisation parameters. Implementation comes with many challenges, including slow allocation of funds, poor coordination and lack of trust from opposing political parties to the ruling government, as well as duplication of tasks and an incentive system that prioritises response rather than preparedness. Most governments of the world tend to be responsive rather than reactive and are inclined to spend more in emergencies. By so doing, the government in power appears to send a message of empathy to the public geared towards earning their trust.

Theme 2 – Very weak disaster management activities

All respondents complained of weak to non-existent disaster management activities in their wards. One respondent agreed they have been communicated with and told of trainings that will be embarked upon, with some support staff allocated for assessments and training; however, they reported not having seen any such activities going on. According to one of the respondents, *"I don't know of any disaster management practitioners that operate in my ward. I recently found out that there are people in my ward, who will get paid monthly, but I've never seen them before doing any work here".*

They say there is no DRM plan communicated to them and stormwater management is non-existent in their wards.

Disaster management activities concern the organising and directing resources to cope with disasters, as well as organising and coordinating the roles and responsibilities of all stakeholders. To be holistic, disaster management must include activities geared toward preparing for, responding to, recovering from and mitigating and preventing disasters and their impacts.

Theme 3 – Infrastructure is the major challenge to DRM

All respondents point at the fact that the major challenge in DRM is weak infrastructure, especially drainage systems. One respondent explained it this way:

> *"[...] these challenges that are faced are inhuman, I currently have like 65homes in my area where the stormwater drainage is not flowing, I have houses with very bad drainage and people in the houses have no clean water to drink. Homes are overflown with bad. People's houses are flooded".*

4) **Objective 4 - Examine the role of key stakeholders to urban flood management in the study area.**

To achieve this objective from the perspective of the ward councillors and ward committee members, the following questions were asked.

- Describe the nature of involvement of community members in your ward to flood disaster management.
- How do you respond to flood emergencies in your ward?
- Do disaster managers/practitioners work with members of the local communities in your ward on FRM?
- If yes, describe how disaster management practitioners work with the local community in FRM.

Various sub-themes were generated that all added up to form one major theme, as explained below.

Theme 1 – Stakeholder involvement in DRM is response-based

Respondents bemoaned the fact that stakeholder involvement was response-based. They explained mitigation activities were non-existent, and some assistance is received only during flood disasters, with the recovery and rehabilitation process basically promissory speeches that may never be actioned. Respondents further explained the community members were the very first respondents of flood disasters and were very efficient in looking out for one another in rescue operations and as groups, they make donations of blankets and other emergency supplies, as well as helping one another to rebuild. One respondent explained assistance from the disaster management practitioners was not forthcoming as quickly as it ought to.

The respondent explains it like this:

> *"There's nothing coming from them, they only concentrate on job allocation, there's no human concern at all, forget that one, they don't exist. In terms of what I have, it's just a plan that we have, our community. It's just a group of people trying to make a plan, because everyone knows they are not going to reach out".*

5.3.6 Analysis and interpretation of results collected from senior disaster management officials

Senior disaster management officials in this research represent officials from departments affiliated with the disaster management centre, for DRR and management. Such departments include: engineering, health, housing, and human settlement, as well as water and sanitation, development planning and environmental management, parks, along with recreation and culture. The researcher was able to obtain responses from some respondents that aligned with the objectives explained below.

1) Objective 3 - Examine the disaster management practices employed by disaster managers in urban FRM in the study area

The questions that addressed this objective and the themes generated are explained below.

i. What are your developmental options to address the flood patterns in the study area?

Theme 1 – Expansion of resources to meet the expanding population

Some respondents hinted at expanding their working tools, in order to meet the continuous increase in population, as a result of the influx of people from rural to urban areas, as well as migration from neighbouring countries. One respondent very passionately addressed the desire to have more rain gauges to cover the 7 400km of river and improve on EWS.

Another developmental option is the constant supply of electricity to power the radar that transmits early warning signals to the municipality from the SAWS, as they are constantly limited by regulated power outages known as load shedding. Receiving constant signals from SAWS is very important for flood forecasting. This is a developmental issue that should be properly addressed. Other suggestions provided were the need for capacity building, not just in working materials, but human and financial resources as well, as that was lacking.

ii. What do you believe, in your opinion, is the biggest barrier to FRM in the study area?

Theme 1 – Insufficient data and resources

In response to this question, the majority respondents agreed that a major barrier was insufficient data necessary to draw up an effective preparedness plan. They also agreed unanimously that financial constraint was a significant barrier. In their opinion, should they receive financial allocations as and when due, there will be sufficient personnel and material for FRM. Some respondents said financial resources needed to maintain and replace infrastructures were not frequent and the population load was too heavy for the current infrastructure.

iii. What are the lasting measures that can be put in place to mitigate against flood disasters in the study area?

Theme 1 – Prioritisation of important issues on flood risk

Respondents believe if FRM was proactive instead of reactive, damages and losses can be minimised. Their argument was that the government did not prioritise flood risk and was mostly present when the disaster occurred. A further assertion was that recovery efforts were very slow, and in most cases, abandoned.

iv. How can the damage to flood disaster in the study area be reduced?

Theme 1 – Community engagement

All respondents agreed that when community members, as major stakeholders, can be concerned regarding their environment and take part in flood risk activities, then flood disasters can be reduced. Community members were said to be nonchalant with regard to vital matters such as waste disposal, construction of houses with substandard materials and on flood plains and refused to participate in engagements to mitigate floods. The community members are solely reliant on the government to do everything and do not realise that DRR is everybody's business.

v. Where do you suggest additional efforts be put by disaster managers/practitioners in mitigating flood disaster in the study area?

Theme 1 – Building and cultivating flood risk awareness in community members

The majority respondents believe flood risk awareness is done on a very low profile and with a select few. Community members should be trained on a regular basis how to be responsible for their own lives, livelihood and belongings.

vi. If you were to anticipate future changes to mitigation of flood risks, what changes will you make?

Theme 1 – Relocating those in the informal settlements

Most respondents agreed the major problem they faced was the informal settlements and the inhabitants. The respondents explained, if they were able to relocate them to safer places it would go a long way to mitigate flood risk, as those informal settlements were constructed on flood lines and flood prone areas. One respondent, however, pointed out doing that was a herculean task, as it has been attempted before, but the beneficiaries immediately relocated back to the previous informal settlements. These are his own words:

> *"[...] we have moved people, giving them free houses and then found them back in the settlement and when we asked the question why they returned, they've said they had a choice to make between their new location and their job. The houses they were given were nice houses and with the services etcetera, but the cost of them getting to where they had found work was more than what they were earning".*

This issue of relocation of people from informal settlements has been an on-going struggle in SA. Land invasion and its subsequent conversion to informal settlement has been a tough problem for the government to manage. Severally, people have been relocated to houses built for them, but they sell those homes and return to the place they were moved from.

2) Objective 4 - Examine the role of key stakeholders to urban flood management in the study area

To address this objective, the disaster management officials were asked the questions below. Several sub-themes were generated from each question. These sub-themes were put together to form major themes, explained as follow.

i. Describe the nature of involvement of your department in flood disaster management

Theme 1 – flood preparedness and recovery

The different departments have various functions in the management of floods in the study area, mostly preparedness and recovery activities; response activities are basically supportive. The department responsible for stormwater management was very commendable in their preparedness and recovery activities, ranging from maintaining the flood lines, flood predictions and forecasting, to maintenance of damaged bridges.

ii. How does your department respond to flood emergencies?

Theme 1 - Collaboration with various departments and local communities.

The respondents all agreed they acted in the capacity of support to the disaster management practitioners. They cited the flood disaster of April 2022 that was overwhelming and all hands were required to assist the practitioners. When asked whether they collaborate with local communities, they agreed, stating this mainly happens through collaborations with ward committee members and ward councillors.

iii. Do you have effective storm water management in place in the EMA? If no, what are the challenges faced?

Theme 1 – Effective stormwater management

Stormwater management in the municipality was agreed to be effective but insufficient. It was reported they have all the basic requirements that meet global needs but when faced with the flood disasters in 2017, 2019 and 2022, they did not have sufficient capacity to manage. The flood disaster of 2017 was recorded as the most devastating flood disaster to have ever happened in SA; however, this record was erased by the April 2022 flood disaster that left several hundreds dead and thousands of households displaced.

iv. Do you have any plans in place to overcome the recurrent flood disasters in the study area?

Theme 1 – Sufficient human and material resources for FRM

The majority respondents are of the opinion when they have adequate human and material resources, flood risk will be better managed. A storm water management official hinted they had adequate budget to deal with the flood risk, but it was a challenge to manage the constant movement of people and land invasions, which necessitated more coverage and the need for more equipment to manage the flood risk, as well as monitor the migration of people into the study area. According to him,

> *"We do not have sufficient budget within the city to house all the movement of people. With the migration of people into our city making our city grow at quite a significant rate in terms of population and there is insufficient housing. So, a lot of the new migrants coming in are ending up in informal settlements, so we are seeing them growing. And so that is the biggest risk that I see from a disaster management point of view is how we manage the migration issue and the proliferation of informal settlements because most of the areas that are not developed are within floodplains. This means we need more equipment, financial and human resources to access those areas".*

There is, in addition, a "great plan in store for the informal settlements", however, it still amounts to insufficient budget to execute the plan. As the participant explained:

> *"So, since the land has already been invaded, we are looking at if there is a way to channelize the rivers around those areas, maybe possibly raise a lot of the platforms. In order words, we are actually looking at developing a housing program where the people already are existing, if that's possible and that comes down to now again budget, we were planning to channelize the river".*

v. What kind of information, maps and data do you use in the case of flood disasters in the study area?

Theme – Hazard maps

While some departments such as those in-charge of storm water management have well-established hazards maps, others complain of not being able to obtain sufficient information with which to work. Using the hazard maps has been very successful as they train community members in the use of these maps, who in turn, go to other communities to train them, leading to buy-in from other community members, because one of their own with knowledge on the problem they are facing is able to advise them how to manage.

vi. Rate the accuracy of the data you use in flood disaster predictions on a scale of 1-10 (where 1 is very low and 10 is very high)

Theme 1 – Very high

The hazard maps were rated as having very high accuracy, as they can capture the flood lines and settlements, as well as individual dwellings in the settlements. Flood lines and flood modelling are used by the stormwater management and department of housing for flood modelling and determination of dwellings affected by floods. These are used to develop further hazard mapping, through the GIS. In addition, regular rainfall measurements are taken; thus, while some departments are working tirelessly with the data they have, other departments are not receiving sufficient data to match, thus causing a gap in management. Hence, the saying that disaster management does not work in a silo.

vii. Rate the level of cooperation between your department and the eThekwini Municipality disaster management centre on FDM on a scale of 1-10 (where 1 is very low and 10 is very high)

Theme 1 – Average

Approximately 50 percent respondents agreed they have a good level of cooperation with the disaster management centre, while the others affirmed there is a big gap in communication that hinders effectiveness. One of the respondents had this to say:

> *"And so, we've got a fairly close relationship. The issue here is that, we are reliant on a few individuals and so that is where the risk is. If one of those individuals is not available and there is no backup plan. So, we've got a succession plan in place for the management of the fuse system. But what we're seeing on the disaster management side is that there isn't sufficient capacity to match up with our plans and efforts".*

viii. Do you have a dedicated budget in your department for FDRM in eThekwini Municipality?

Theme 1 – No

The majority respondents affirmed there is no specific budget dedicated to FRM, but rather for DRM in its entirety. They agreed, though there were no budgets for risk management, there were readily available financial resources for response activities. Only one participant attested to a budget for FRM in their department. Not having a specific budget for flood risk could be seen as an error in governance. In developed countries such as the USA, budgets are proposed and adopted each year for flood risk, considering it is one of the major disasters with huge consequences. In the 2024-2025 fiscal year in California, USA, the governor's budget was as high as $95.1 million for urban flood risk reduction projects (Petek 2024).

5.4 DEVELOPMENT OF FRAMEWORK FOR INTEGRATED FLOOD RISK MANAGEMENT (IFRM)

IFRM is an approach that utilises a holistic way of managing floods effectively and efficiently. The concept of IFRM in this research involved the principles of FDRM, disaster resilience and international good practices and policies. The IFRM in this research seeks to control the extent and frequency of flood disaster, involve community members in CBDRM practices, as well as examine international good practices and policies for subsequent adoption. Using the interpretation of the analyses of the questionnaire, semi-structured interview responses and review of international good practices and policies from developed and developing countries, using the technique of triangulation, the IFRM framework was developed (objective 6 below).

5.4.1 Achieving the plan for the IFRM framework development

The plan for achieving the IFRM framework involved integrating the knowledge on procedures to control the extent and frequency of floods, different techniques that should be employed to achieve CBDRM and international good practices and policies obtained via extensive review. This is explained in the following sections.

5.4.1.1 Control of the extent and frequency of flood disaster

This was achieved through the principle of FDRM, where the process involved the integration of flood risk assessment and stormwater management. Flood risk assessment was conducted by assessing hazards, vulnerabilities and exposure of the study area and the impact of floods on the people, their property and livelihood, as well as how flood disaster is managed by all stakeholders of the study area (section 4).

Assessment of flood and stormwater management was also carried out to examine existing flood and stormwater drainage systems, their refurbishment and mitigation measures. The assessment examined the link between flood risk and stormwater, as well as the stormwater drainage system, its impact on water quality and health of the study area residents. These assessments were conducted through questionnaires and semi-structured interview, with responses analysed and interpreted. The results obtained paved the way forward on the arm of the IFRM framework.

5.4.1.2 CBDRM

This was achieved through the principle of flood resilience in the study area. A resilient community can prevent, reduce and cope with flood risk. They are knowledgeable on flood risk and well prepared in the event of a flood disaster, responding better and recovering faster. Community participation is very important in achieving community resilience to flood disasters. This research examined the engagement of community members in all areas of FRM in the study area, the motivation received by community members in the form of activities that addresses vulnerabilities common to the community such as water supply, sanitation facilities, health care and more., along with cooperation between community members and authorities responsible for FRM.

5.4.1.3 Adoption of international good practices and policies

Global frameworks were reviewed to understand how global FRM policies have advanced over the years. The causes of floods and their management across the continents of Africa, Europe, Asia, and South and North America were reviewed and the good practices employed examined. Several policies across the continents were also reviewed, where the review determined that the Netherlands in Europe had the best flood risk good practices, and the adoption of these good practices was used to develop the IFRM framework.

5.4.2 Objective 6 – Develop A FRM Framework for the Study Area

Floods are a global dilemma that needs an integrated approach to manage. Economic losses and the loss of human life cannot be ignored. Floods cannot be treated as problems in isolation in a localised approach. The IFRM is a change in basic assumptions put forward by the traditional approach of fragmented flood management. IFRM recognises there are many interactions between land, water and humans (WMO 2009b). Incorporating sustainable FRM involves searching for ways of identifying opportunities to enhance FRM performance.

The necessity of all aspects of flood management are acknowledged in the IFRM framework, which deals explicitly with three very important components: the Flood Risk Management Component (FRMC), Resilience Component (RC) and Policy and Practice Component (PPC) in urban FRM. Information in the FRMC and RC were obtained from questionnaire surveys and in-depth interviews from stakeholders of the study, while information on the PPC were obtained through an extensive literature review of flood management practices from around the world.

The IFRM framework illustrated in the diagram below (Figure 5.42) represents an all-inclusive approach to managing flood risk through three interconnected components; FRMC (brown shade), RC (green shade) and PPC (yellow shade). Each component addresses unique aspects of FRM, creating a thorough system that combines proactive, adaptive, and regulatory measures. Each of these components are explained below:

i) The IFRM component (blue shade)

   This component depicts the integration of the FRMC, RC and PPC. These components are projected out of the FRMC to show their contents as illustrated. The integration of all the components as one FRMC depicts the holistic management of urban floods.

ii) FRMC (brown shade)

   FRMC is an important component that lays the groundwork for reducing physical exposure to floods, as well as addressing both natural and infrastructural vulnerabilities. This component focuses on the direct mitigation and prevention of flood risks that unlock key actions, including:

   - DRM activities geared toward implementing strategies to reduce the immediate impact of floods.
   - Risk prevention and management aimed at the use of proactive measures to limit vulnerabilities and safeguard both communities and infrastructure.

- Hazard mitigation and Stormwater Management that employs engineering solutions and environmental approaches to manage excess water flow and minimise flood risks.

iii) RC (green shade)

The RC emphasises community engagement and adaptive capacities, fostering a culture of preparedness and resilience. This component ensures local populations are not mere passive recipients of aid but active participants in creating resilient communities that can withstand flood-related disruptions. Key elements in this component include:

- Stakeholder involvement, which involves the encouragement of collaboration among government agencies, NGOs, and local communities.
- Community-Based Disaster Risk Reduction (CBDRR) aimed at fostering local participation in disaster readiness and resource management and ensures communities are equipped to handle potential risks.
- Policy and resource management that ensures policies support community incentives, motivation, and efficient resource allocation, which contribute to sustainable resilience practices.

iv) PPC (yellow shade)

This component integrates international standards and frameworks into local practices, providing a solid regulatory foundation. The PPC ensures flood management practices are not only locally relevant but also globally aligned, promoting sustainable and scalable solutions. Major focus areas in this component include:

- International Good Practices and Frameworks that align with global best practices, such as the SDGs and the SFDRR, to create a unified approach to FRM.
- Institutional Frameworks, which establish policies that translate international commitments into actionable local strategies, ensuring consistency in FRM policies across all levels.

The arrows in the diagram (Figure 5.42) illustrate the connectivity between the three components: FRMC, RC and PPC. These arrows are feedback loops that signify the continuous interaction between the components. The broken two-sided arrows originating from the IFRM component to the FRMC, RC and PPC indicate a central hub of integration of the three components. The arrows suggest the IFRM component shapes the FRMC, RC and PPC focus areas. This shows each of the components operate within a broader context of the IFRM, aligning their individual activities with one another. It also shows the collaborative and complementary nature of effective FRM. The arrow between FRMC and RC signifies the dependency of community resilience with the reduction of immediate risk, through hazard mitigation and risk prevention, to foster long-term community resilience in the place of reactive flood management. The arrow connecting RC and PPC depicts that resilience promoting activities can be influenced by policy and practices. Policies in the PPC component provide guidelines that enable resilience efforts in the RC.

The link between the FRMC and the PPC highlights the interplay between FRM activities and the policy frameworks that support them. Policies within the PPC regulate the actions in the FRMC and set standards for stormwater management and risk prevention measures. Conversely, the FRMC activities feed back into the PPC, leading to policy updates that reflect on technological advancements. The cyclic flow created by the arrows between FRMC, RC and PPC represents a feedback loop that highlights FRM as an adaptive process. These components provide insights into one another, which allow the framework to evolve and adapt to changing environmental conditions and community needs. Finally, the arrows in the IFRM framework illustrate the interplay and connectedness of the components within the IFRM framework, with each component relying on and informing the other, thus creating an integrated and balanced approach that combines technical, regulatory and social facets in a comprehensive FRM.

In conclusion, the three components in the IFRM framework depict the synergy required for effectiveness of the framework, indicating FRMC, which manages immediate and technical risk reduction and the RC, building on the adaptive capacity within the communities. This will be more effective when good practices and policies are enforced in its operations and aligned with global standards. It also illustrates the importance of mainstreaming good practices and policy, resilience and FRM in the management of flood disaster risk in the study area to foster a prepared and sustainable society.

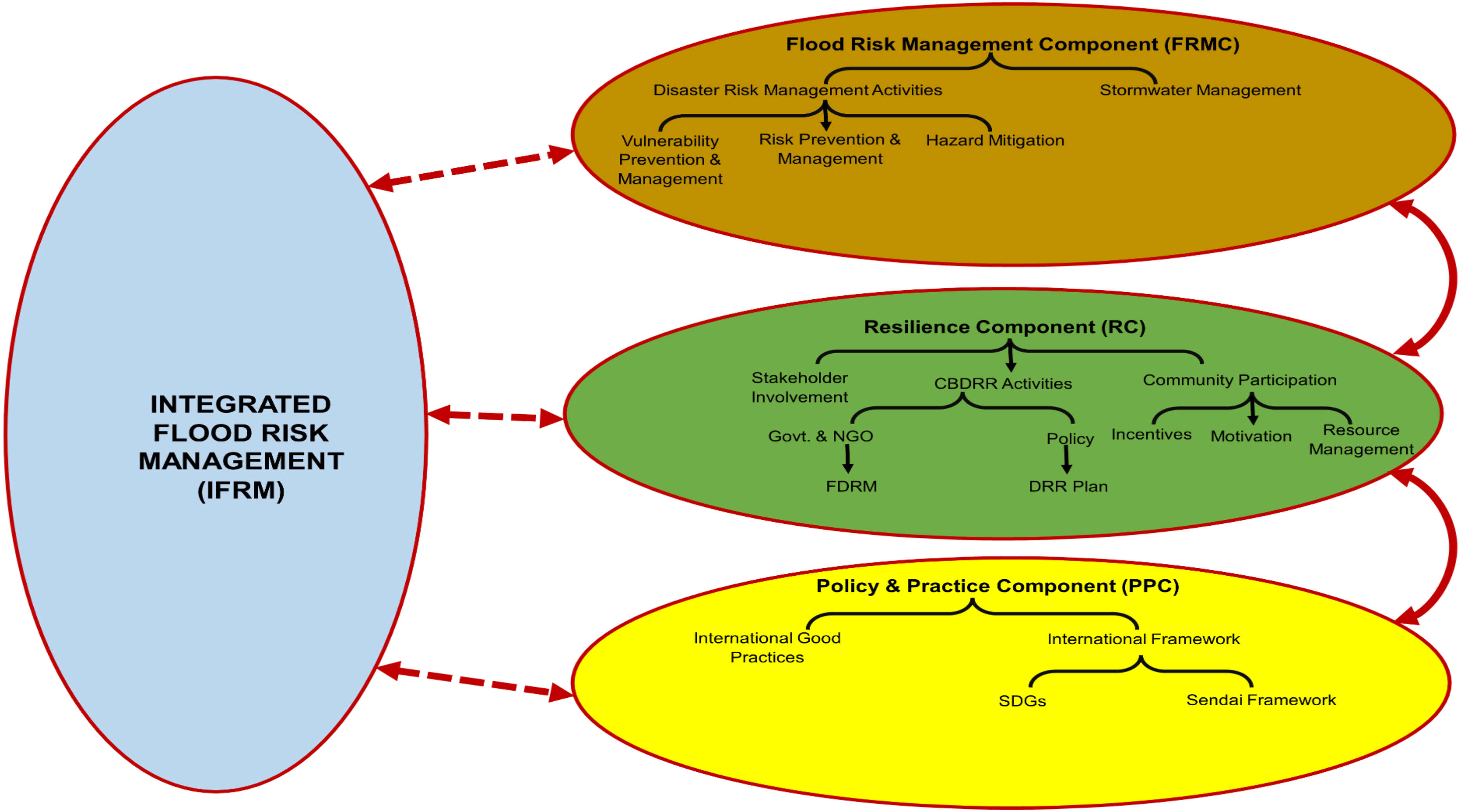

Figure 5.42: Integrated Flood Risk Management (IFRM) Framework for the EMA

Source: Author's own composition (2024)

Application of this IFRM framework will ensure policy development and adoption in response to long-term needs, addressing both normal and extreme FRM, while providing for stakeholder participation in the process. Details on how the components are assessed within the framework and an explanation on their connectivity is offered below.

5.5 IFRM FRAMEWORK

Climate change and its consequences exacerbate the risk of flood to modern societies. eThekwini municipality, having a large section of its populace living in informal settlements (where most are located on flood plains), must consider the very high risk of loss to life and damage to property. The survey conducted has shown FRM is poorly managed. Polluted flood waters leave behind consequences that are very direful to lives and livelihood.

Policy design should consider flood risk in the context of other prevailing risk to communities, households and individuals. Most people living in informal settlements have been found to live below R3 500 income per month, with numerous family members and being enveloped in poverty. Flood disaster policies should also consider the risk associated with poverty, if not, these policies may unintentionally reduce opportunities for livelihood through measures such as restrictive floodplain regulations, and resettlement programmes based on an imperfect understanding of socio-economic implications.

The framework advocates for the application of a risk management approach, which provides measures for preventing a hazard from becoming a disaster, with the focus to reduce vulnerability. Risk management in this framework emphasizes on the identification, assessment and minimization of risk and the elimination of unappropriated risk through appropriate policies and practices. The management of flood risk also calls for more effort to the reduction of residual risk through measures such as spatial planning, EWS, evacuation plans, and flood sensitive land-use, as well as adequate preparedness for disaster relief, insurance and other mechanisms of risk sharing.

Considering the plight and suffering of community members from flood disasters, the framework emphasises the use of flood reduction strategies to manage flood and reduce susceptibility to damage from floods. These strategies include development and redevelopment policies geared towards sustainable development and, considering the constantly increasing population, forceful incorporation of housing and building codes, along with more accurate flood forecasting and flood proofing. Other strategies required to mitigate flooding impact should include: more effort in flood preparedness, flood disaster information and education, flood insurance, and post-flood disaster recovery, as well as flood-plain zoning and regulations. Strategies directed at reduction of flood risk through lessening flood hazards using flood embarkments and afforestation should, furthermore, be properly maintained. Catchment management, in addition, requires more investment as regards to necessary funds.

It was identified and verified through this research that a major problem of the municipality to flood risks is the habitation of people on “at-risk” lands. Relocation policies have proved very expensive, extremely slow and mostly unachievable. In such cases, the most appropriate strategy to reduce vulnerability would be through flood disaster preparedness and efficient emergency flood response. As the study also identified loss of property and life, the model instigates vulnerability reduction through appropriate flood disaster response plans, which should be supported by reliable and accurate flood forecasts.

A further measure would be to promptly circulate flood hazard maps showing areas at risk of flooding within a given period among the disaster management stakeholders. These flood hazards maps provide the most advanced warnings of likely hazards and help in prompt decision-making. Flood plain zoning has been found to be very difficult, particularly due to population pressures and unplanned developments, coupled with inadequate institutional capacity and enforcement. However, flood management plans will help minimise losses and guard against inclinations of adopting only short-term interventions. Flood management plans must include long and short-term interventions.

The IFRM framework encourages stakeholder participation that includes public involvement at all decision-making levels. The approach advocates for openness, communication and inclusiveness, as well as public consultation. The stakeholder communication process should be free from any form of bias and clear for everyone. Furthermore, gender should be kept in perspective in decision-making, as this research found women are mostly the primary providers of family healthcare and child rearing, which disproportionately sees them dealing with the burden of recovering from floods. Hence, there should be a special requirement in dealing with flood situations reflected in the institutional arrangement, with participation of minorities, socially and economically weaker sections of society, as well as indigenes among the stakeholder consultation forums. Moreover, the interest of other vulnerable sections of society, such as children and the elderly, should be accounted for in flood planning. Indigenous knowledge of coping with floods should, therefore, be among the adopted measures.

Successful implementation of disaster management strategies should involve individuals, families and communities, along with research institutions, government and NGOs or voluntary organizations. Members from all sectors of work involving different disciplines must be involved in carrying out activities that support the implementation of disaster management plans and play vital roles in transforming risk warnings into preventive action. Relationships among stakeholders should be transparent, having a clear set of rules for stakeholder participation.

Effective implementation of the IFRM components requires an enabling environment, in terms of policy and practice with clear roles, functions and effective regulation and enforcement. The nature of flood disasters in the eThekwini municipality creates a situation that requires prompt action to meet ambitions in the municipality. Thus, political commitment to flood risk principles and practice is critical. The risk reduction strategies developed should be translated into specific policies for effective planning and management of resources. In all sectors (governmental and non-governmental) having an influence on FRM.

Linking FRM with good practice and policy provides linkage with economic and social development and forms the basis for stakeholder participation. This approach may imply a substantial redress of policies related to water resources and flood management. Clear and objective policies for the declared goals of the government, supported with appropriate legislation and regulations to enable the process of integration, are necessary prerequisites. The policy stipulation should provide a legislative framework that defines and powers the obligations of the concerned institutions and people occupying flood plains. The regulations should cover matters such as flood plain zoning, severe weather and flood forecasting and warning services, disaster response and recovery, as well as disaster preparedness. It is essential to have a long-term political commitment for the effective implementation of legislation and policies.

Flood risk good practice in Europe was found the best where multiply strategies are engaged to manage flood risk. These strategies include preventing new risk through spatial planning, reducing existing risk by way of flood defence, and mitigation and management of residual risk by efficient preparedness, response and recovery mechanisms. The Netherlands, with very high population in the urban areas and a similar topography as the study area; of low elevations and many water bodies, with two thirds of its area vulnerable to flooding, was found to have very good success rate in managing flood disaster, thus, their techniques and practices are adopted in this IFRM framework.

The good practices adopted include sufficient opportunity for public participation integration at all levels of FRM, with appropriate coordination mechanisms. This will make citizens more receptive towards diversification and other risk safety developments. Measures should be put in place for FRM, such as various steps used to embrace flow of water in the municipality and a reconceived landscape, in order to provide better protection from flooding. This should include the use of protective structural measures such as construction of bridges and dykes as preventive and proactive measures against the threat of floods along coastlines, lowering flood plain in-depth to allow free passage of water and prevent forceful relocation of inhabitants living alongside rivers inland.

The prevention and preparedness strategy approach should include refusal of local government in granting building permits in high flood prone areas and enforceable policies prohibiting rebuilding in such areas, as well as an effective evacuation plan in place to move people to higher ground. Elaborate systems of dams, storm surge barriers, dykes and other protective measures allow people to be protected from water-related disasters, while living with water as it flows through manufactured and natural water ways.

The post-2015 global agendas, such as the SFDRR (2015-2030), the 2030 SDGs and the Paris Agreement should be strictly followed to fortify FRM effectiveness. Although these frameworks have been adopted in SA, they should be re-evaluated in the study area for effective implementation.

5.6 APPLICABILITY OF THE FRAMEWORK

The framework offers a guideline for the holistic management of floods through the integration of all stakeholders viz-a-vis the government, the actors of disaster management and the public. The framework emphasises the interconnectedness of these three components. The FRMC underlines the importance of building strong relationships between key FRM stakeholders. In addition, community participation emphasises the risk ownership of every member of the community and the importance of their involvement in flood management, while the PPC highlights the importance of sound and implementable policies and legislations and the linkage to all facets of FDRM, as well as the benefits of adopting practices used with great success in other parts of the world with similar flood challenges.

5.7 CONCLUSION

This chapter captured the analysis of the quantitative and qualitative data, illustrating these in charts and themes, respectively, and interpreting the findings. With understanding from the interpretations, an IFRM framework was developed. The chapter concluded by discussing the applicability of the IFRM framework in the EMA. The next chapter contains the final conclusion of the research, providing a summary of the study findings. The chapter also offers recommendations and areas for further research, all towards improving FDRM in the study area.

CHAPTER 6
CONCLUSION AND RECOMMENDATIONS

6.1 INTRODUCTION

The aim of this research study was to develop an IFRMF for the EMA. The journey through the study area involved examining flood risk in selected flood prone areas, identifying factors that increase vulnerability of community members to flood risk, examining the role of key stakeholders to urban flood management, and exploring disaster management practices employed by disaster managers in urban FRM, as well as examining the FRM good practices employed by developed and developing countries from around the world. Information obtained was used to develop an IFRM framework for effective FDRM in the EMA. This chapter, therefore, summarises the extent to which the research questions were addressed. Considering the study findings, recommendations are provided in line with developing a FDRMF for the EMA. This chapter finally concludes with recommendations and subsequent unfolding directions for future research.

6.2 CONCLUSION

Flood disasters in the eThekwini Municipality have been extreme, with devastating consequences, as seen through the literature findings. Several efforts have been recommended to be put in place by different researchers to prevent or reduce the consequences, with little success. This research introduced the concept of an IFRM, comprising three components for possible implementation in the study area.

These components included FRM, which examined the disaster management activities and management of stormwater in order to identify gaps, have a good understanding of the study area and incorporate appropriate flood prevention and mitigation measures. The resilient component, which involves incorporating CBDRR activities, community participation and participation of other stakeholders (both governmental and non-governmental) as disaster management is everyone’s business and, finally, the PPC, involving international good practices and frameworks. In order to achieve the research objectives, the study unveiled various valuable pieces of information, put together to develop the IFRM framework. These are summarised below.

6.3 SUMMARY OF FINDINGS

Responses were collected via questionnaires and semi-structured interviews. The summary of the interpretations of findings is highlighted below.

6.3.1 Summary from quantitative analysis

The sample distributed for the questionnaire survey in the study area expressed a representation of the study area. A 100 percent response rate was obtained, indicating the quantitative research lacked a non-response bias. The questions in the questionnaire answered research objectives one, two and four, which are as follows:

- Objective one – Examine flood risk in the selected flood prone area.
- Objective two – Identify factors that increase vulnerability of community members to floods in the study area.
- Objective four – Examine the role of key stakeholders in urban flood management in the study area.

The research showed 58.3 percent female participants, indicating more females than males in the study area. Females are, furthermore, 14 times more vulnerable to flood disasters than their male counterparts (Okai 2022). In addition, 32.4 percent of the population in the 18–24year age group, amongst five age range categories, was found the highest age range; this population group is in the working age category, thus, flood disasters influence their livelihood status and increase social vulnerability, as this age range is also among those that suffer from disaster impact the most. It was further shown 75.5 percent of the population in the study area is unmarried and single, thus leading to high unpreparedness to flood disasters. A further 20 percent of the population constituted a minority with tertiary education. This could add to the lack of preparedness, as highly educated people are often better informed, with more effective preparedness initiatives to flood disasters. It was further found that 56 percent of the population in the study area were unemployed, leading to a low economic status and slow recovery rate from flood disasters.

More than 50 percent participants resident in the study area has a household size of 6–8 people. Coupled with other demographic variables observed in the study area, this will lead to weak and ineffective disaster response and recovery. An additional 58.3 percent houses in the study area are constructed with mud and wood, leading to very high physical vulnerability to flood disasters. Previous analysis has shown more than 50 percent of these houses are constructed from wood and mud. Home ownership status, furthermore, showed 59.9 percent residents own the houses they live in and 40.1 percent are rented. In addition, a high percentage of rented houses in the study area implies a low level of prevention and preparedness measures to flood disasters.

It was further shown by the findings that 80.9 percent residents of the study area have lived there for more than six years, indicating an excellent knowledge of their community and the happenings in it. It was further found that more than half the residents (59.1 percent) have a basic income of below R3 500, explaining the high level of socio-economic impact of flood disasters in the study area, as total recovery is not achieved for many residents.

The impact of flood on property addressed objectives one and two. In this regard, frequency and duration of floods on property can ascertain the degree of damage experienced. Almost 50 percent residents continuously experience flood disasters on their property, for up to 10 hours in some cases. These instances lead to vulnerabilities such as health challenges, PTSD and mortality, as well as high cost of damages to property. The research also showed a relationship between the study area and flood frequency. This can be properly explained by reason of the study area location and its topography. In addition, residents of the study area were found to have received little or no assistance during the flood disaster, as response starts many hours after the floods have occurred.

The analysis of the impact of flooding on individuals in the study area identified the factors that increased vulnerability of community members to flood disasters. The majority respondents, representing 45 percent, agreed the study area vulnerability to flood disasters was due to nearby water bodies. The research also revealed other causes of vulnerability, including overpopulation, poor infrastructure and vulnerability of community members, with a response percentage of 71.1 percent, 93.7 percent and 82 percent, respectively. In addition, 63 percent respondents indicated poor access to clean drinking water during flood disasters, leading to water-borne diseases. This could also be attributed to water sources being affected during flooding. A further 59 percent respondents agreed water sources are affected, due to large volumes of sewage spilling into water bodies in and around the study area.

During flooding, vital infrastructure such as telecommunication, power and energy, the road network, and schools, as well as hospitals and waste management are affected. This was confirmed by 96.6 percent respondents that collectively strongly agreed and agreed vital infrastructure was affected during flooding in the study area. The research also revealed a positive correlation between the contribution of poor infrastructure and its impact during flooding, indicating that communities with poor infrastructure were highly impacted by flood disasters. The analysis showed these damages hindered access to healthcare facilities, which was validated by 74.7 percent respondents that collectively strongly agreed and agreed healthcare provision was disrupted, since healthcare practitioners did not have access or were impacted by the flood disasters.

Flood is a precursor of water-borne diseases. In this regard, 52.8 percent respondents affirmed an increase in disease outbreak from flood disasters. Further analysis to ascertain the relationship between flood frequency and its potential impact on disease outbreak in the study area revealed the outbreak of disease does not necessarily occur in every flooding event. However, flood frequency in the study area is a contributing factor in disease outbreak. In addition, 95.5 percent respondents affirmed (agreed and strongly agreed collectively) flooding negatively impacted the livelihood of residents of the study area. The research exposed residents had no security against flood, as attested by 89.6 percent respondents that collectively agreed and strongly agreed.

An effective flood response will lead to better flood disaster management. The research gathered mixed reactions from respondents on government response to flood disasters. While almost 30 percent respondents declined to respond, 39.8 percent affirmed prompt response by the government, while 38 percent disagreed on government promptness in responding to flood disasters.

The research also revealed 82 percent respondents has some level of vulnerability to flood disasters by reason of their exposure to flood risk. Exposure to floods addressed study objectives one and two, which analysed the vulnerability of community members to floods and the flood risk they are exposed to by virtue of their proximity to waterbodies. It was determined 52.6 percent respondents have their homes close to waterbodies. On further analysis, the research showed a significant relationship between the closeness of respondents' homes to waterbodies and the impact on their health.

It was also revealed, while 65.1 percent respondents in the study area have lost their property to floods, only 27.9 percent have lost family members during flood disasters. The research additionally exposed the fact that the study area has very few functional drainage systems, as attested by 67.4 percent respondents. The relationship between functionality of drainage systems in the study area and the loss of property during flood disasters was also ascertained in the study. It showed a significant association between functionality of drainage systems and loss of property during flood disasters.

An analysis of FRM strategies employed in the study area addressed objective 4. According to 88.8 percent respondents, there are no effective flood prevention and mitigation measures by the municipal authority. On further examination, it was shown the majority community members were unaware of the preventive and mitigation measures employed by the authorities, as only 11.2 percent residents were aware of mitigation activities occurring in the study area. However, 88.3 percent respondents affirmed the lack of community participation concerning flood risk mitigation in the study area. The research showed whilst 82.3 percent respondents received early warning forecasts on floods via various social mediums, nevertheless, 58.1 percent respondents who had received warnings are not prepared for flood events.

It was, furthermore, revealed that 77.1 percent respondents are concerned regarding flood risk in the study area. Close to 50 percent respondents believe the flood response plan in the study area is very weak, as seen from the constant flood disasters, with 76.6 percent respondents reporting they do not receive incentives for flood disaster risks and 77.6 percent expressed their disappointment on the absence of sufficient flood relief packages by the municipality. On further analysis on incentive to floods and flood risk concern, the research found the study area residents were more inclined to flood risk concerns when they received incentives for floods from the municipality.

6.3.2 Summary from qualitative analysis

The semi-structured interview was sectioned into three categories, namely: Disaster managers/practitioners, senior disaster management officials and ward councillors and ward committee members. These categories were created to obtain a variety of informed responses from each group and remove the bias of professionalism. Responses obtained from each category was very rich in articulating and further confirming responses received from a previous group, hence leading to very reliable analysis of all responses.

The qualitative analysis from the different categories of disaster managers aided in answering the research questions. The findings from the qualitative analysis addressed objectives one, two, three and four. A thematic approach was employed to analyse the data, where a 75 percent response rate was obtained, which made the analysis valid and reliable. Themes were generated and clearly identified. These themes highlighted the story the data told.

6.3.2.1 Summary of findings from disaster management practitioners.

Analysis of responses on examining flood risk in the study area, which answered objective one, showed various factors contributed to flood risk in the study area. These included construction of informal settlements anywhere vacant lands were found which, in most cases, were flood prone areas, weak legislation and enforcement where illegally occupied lands were not able to be reclaimed by government, and penalties not being enforced on building code defaulters. In addition, poor service delivery, which has led to neglect of basic services by the government such as waste removal, tap-borne water, the transportation network and electricity, increases flood risk.

The research also uncovered the trend of flood disasters in the past two decades, spanning the years 2000–2020. All respondents elucidated there were more frequent flood disasters as the years progressed. On analysing the impact of flood disasters, the research uncovered the following:

i) Flood disasters impacted highly on livelihood, health, sanitation, and infrastructure, as well as clean drinking water and housing.
ii) A high number of people were impacted and there was very high cost of damages.

On identifying the factors that increase vulnerability of community members to flood in the study area, it was found human behaviour is a major contributing factor, as residents are identified to lack flood risk perception. Socio-economic factors such as education, employment, income, housing and more, were seen to impact highly on the vulnerability of community members in the study area. Respondents stated the lack of employment, poor income, housing and food insecurities contributed to making residents vulnerable to flood risks. Also identified to cause vulnerability were inadequate infrastructure and poor urban planning.

Infrastructure such as electricity, health services, roads, and telecommunication, along with waste and sewage treatment, as well as drinking water facilities, was said to be highly inadequate in townships and informal settlements, thus hindering effective FRM. The governments' inability to provide adequate housing to its citizens has led to the formation of informal settlements at an alarming rate in the study area. Respondents believe poor urban planning is a primary cause of the erecting of informal settlements that are extremely vulnerable to floods.

Several questions were asked in order to obtain results for objective three, which entailed an examination of disaster management practices employed by disaster managers in urban FRM in the study area. All the respondents highlighted insufficient human and material capacity as a hindrance to effective FDRM in the study area, while roughly 50 percent respondents affirmed the lack of a clear response plan and budget for FRM as a major hinderance to its implementation. All respondents agreed emergency response, disaster recovery and rehabilitation activities were reactive instead of proactive. The disaster management practitioners also pointed out that storm water management was inadequate in the study area. The researcher, however, observed a gap in the linkage between DRM and storm water management from their responses.

Objective four examined the role of key stakeholders such as community members and the provincial and local government in urban FRM in the study area. The research uncovered weak community engagement and participation by community members and a lack of inter-departmental cooperation. The majority respondents would want transparency in governance and better enforcement of laws and penalties, as well as better preparedness activities.

6.3.2.2 Summary of findings from ward councillors and ward committee members

Responses analysed from this category in addressing objective one, which entailed examining flood risk in the selected flood prone area, authenticated the responses received from the disaster management practitioners. This ascertained the construction of informal settlements; lack of education and flood preparedness were major causes of flood risk in the study area. Respondents also unanimously agreed the lack of inter-departmental co-operation intensified flood disaster prevention and recovery efforts in the study area. Departments such as disaster management, housing and human settlements were said to work in silo and thus did not produce an effective compound result. The respondents pointed out that flood risk has been very high, with devastating consequences, resulting in high cost in damages to individuals and infrastructure.

In response to objective two, on identification of factors that increase community member vulnerability to floods in the study area, analysis of the responses indicated illegal land-use activities were a major cause of vulnerability. On examining disaster management practices employed by disaster managers/practitioners in urban FRM, addressing objective three, the research unveiled through analysis of the responses that disaster management activities had political biases. Respondents claimed politics marred disaster management practices in many wards. They complained disaster management activities are very weak in the study area and weak infrastructure such as drainage systems were poor and hindered effective disaster management. In examining the role of key stakeholders in the study area, which addressed objective four, respondents echoed the responses of the disaster management practitioners that disaster management is reactive, not proactive, as stakeholder involvement is only felt when there is a flood disaster.

6.3.2.3 Summary of findings from senior disaster management officials

This category of respondents addressed objectives three and four via a series of questions asked. To address objective three, which was to examine the disaster management practices employed by disaster managers/practitioners in urban FRM, respondents are of the opinion the major developmental options to address flood patterns in the study area would be to expand working tools, such as capacity building both in human, material and financial resources, to meet the needs of the expanding population. They unanimously agreed insufficient data and resources were the biggest barrier to FRM in the study area. Respondents believe prioritising important issues on flood risk will make its mitigation more effective, as this will make FRM proactive instead of being reactive.

Respondents also believe community engagement can reduce damages incurred during flood disasters, in addition to disaster managers and practitioners building and cultivating community members' flood risk awareness, which will go a long way in mitigating flood risk in the study area. Some respondents believe relocating people from informal settlements would be the best solution to mitigate flood risk in the study area. However, they agreed it would be a very challenging task, as it has been an unending battle the government has been unable to win.

Addressing objective four, which was to examine the role of key stakeholders in urban flood management in the study area, respondents representing different departments highlighted their different roles and functions were mainly geared towards preparedness and recovery activities. They all agreed they offered supportive functions during response activities, in terms of collaborations with disaster management practitioners and local communities. In response to stormwater management, the respondents purported they met all basic global needs requirements but lacked adequate capacity to deal with overwhelming flood disasters, such as those in 2017, 2019 and 2022, recorded as the most devastating flood disasters to have happened in the study area. Respondents also agreed sufficient human and material resources are crucial to overcome the recurrent flood disasters in the study area.

Rated on a scale of one to 10, where one was very low and 10 very high, respondents had different ratings on the accuracy of data used to mitigate flood risk. Whereas the stormwater management department rated hazard maps to have very high accuracy and be extremely reliable, other respondents reported they do not have sufficient data to work with. Respondents also agreed the level of cooperation between different departments and the eThekwini disaster management centre on FDRM in the study area was average. The majority respondents hinted they do not have a budget dedicated to FRM, but did have access to funds for general disaster management activities. Having a budget set aside for FDRM will prioritise flood disaster, the main and most devastating disaster in the study area, by virtue of its location.

Analysing all the qualitative and quantitative responses, as well as information obtained from the extensive literature review, provided the researcher with a working tool to develop a framework for IFRM in the study area.

6.4 RECOMMENDATIONS

Devastating effects of floods in the study area cause damages worth millions of Rand, as well as trauma to the victims, who lose their homes and livelihoods, and in some cases, the result is morbidity and mortality. Recent flood events in the study area have shown a high rate of destruction; with the use of flood risk maps and EWS, indicating they are insufficient to prevent flood disasters. From the findings in this research, the following recommendations are put forward.

i. Development and implementation of FRM good practices, tailored to meet the needs of the municipality, must be adopted.

ii. Pro-active DRM good practices should be employed. This enables applicable pre-emergency planning and activities that enhance disaster prevention and preparedness, while laying the groundwork for a holistic and faster recovery. This proactive approach should include early formulation of measures to prevent flood disasters, including stakeholder participation and availability of related planning tools. Preventive measures incorporated should include better land-use planning, nature-based solutions in the management of water resources, better water drainage and storage and smart strategies for the recycling of water.

    Preparedness measures should include a timeous EWS of flooding, risk analysis, public awareness and the identification of vulnerable communities, with disaster alert signals, as well as provisions for immediate physical intervention and rescue. In the aftermath of the disaster, effective post-disaster activities should be implemented, such as clean-up and restoration of infrastructure, as well as financial assistance for disaster victims. Temporary or permanent relocation activities should also be maintained more efficiently. All these will contribute to sustainable, safer and more resilient communities. Recovery of the livelihood of the victims is also extremely crucial and should not be overlooked.

iii. International frameworks on FRM should be implemented and should benefit all communities in the municipality. The SFDRR (2015-2030) adopted in SA aims at preventing new and reducing existing disaster risks, as well as managing residual risk geared towards contributing to strengthening resilience and achieving sustainable development.

iv. CBDRR should be encouraged in the municipality. Participation of community members in FRM is very important in creating ownership, trust and buy-in by community members. These are essential in combating some challenges that may arise, while it will also enhance better use of the available data. To facilitate ownership, a bottom-up approach is required for participation, readiness and support of community members. Buy-in can be achieved through rapid release of emergency and recovery funds to community members, ensuring community involvement in all aspects of decision-making, bottom-up approaches that facilitate collaboration and building of transparency and trust.

v. Co-ordination and collaboration among stakeholders are paramount in facilitating dialogue and enhance decision-making. All stakeholders, including national and local government, civil society organizations, professional associations, and academia, as well as international donors and community members should be involved in FRM. This approach will increase community resilience.

vi. Risk financing and insurance solutions proffers faster and more effective recovery. Pre-arranged risk finance and insurance should be made available to everyone in the municipality. The vulnerable people in the municipality do not benefit from disaster relief pay-outs, because insurance is unavailable or extremely expensive. Those who are insured wait for several months to receive a pay-back, as reports from damage assessments and onsite visits needed prior to payments are slow and delayed. In addition, there should be transparency in reimbursement, which is believed to either not be given or reduced before it reaches the end user.

vii. Urban areas are at high risk of flooding, not only because of extreme weather but also as a result of rapid growth (faster than the construction or improvement of infrastructure) and unplanned urban development, as in the case of the eThekwini Municipality. Thus, a risk-based approach to land-use planning is essential, with a balance of competing needs. This involves balancing the benefits from economic and recreational activities and ensuring minimum loss to life and property through enforcing safe construction and location. There should be a mainstreaming of conventional (grey) built infrastructure, with green infrastructure to manage water resources and protect against flooding. Further to this, proper land-use planning can minimise development in flood-prone zones, map-out routes and open spaces for effective response and recovery activities and efforts, while also accommodating urban growth and expansion to areas safe from floods. National policies on land-use planning should also be enforced, with regulatory instruments that must be enforceable with local capacity and resources.

6.5 AREAS FOR FURTHER RESEARCH

Based on the research study findings and recommendations, the following areas are recommended for future research.

i) Risk insurance solutions available for all levels of income earners in EMA, to ascertain various ways everyone can access risk insurance, as many people are unaware of or assume this is not accessible to everyone.
ii) Risk-based approach to land-use planning to foster proper land-use in the study area and perhaps help minimise the rapid growth of informal settlements.
iii) Investigating the roles and functions of disaster management practitioners in the study area. This will enable insight and better coordination and collaboration between all stakeholders of disaster management and improve FDRM.

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APPENDICES

APPENDIX 1: DURBAN UNIVERSITY OF TECHNOLOGY ETHICS APPROVAL

DUT
DURBAN UNIVERSITY OF TECHNOLOGY
INYUVESI YASETHEKWINI YEZOBUCHWEPHESHE

INSTITUTIONAL RESEARCH ETHICS COMMITTEE

Institutional Research Ethics Committee
Research and Postgraduate Support Directorate
2nd Floor, Berwyn Court
Gate 1, Steve Biko Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

Tel: 031 373 2375
Email: lavishad@dut.ac.za
http://www.dut.ac.za/research/institutional_research_ethics

www.dut.ac.za

21 April 2023

Ms C C Olanrewaju
5 Michealden Mews
15 Eland Avenue
Amanzimtoti
4125

Dear Ms Olanrewaju

Flood Risk Management in Urban Settlements in the eThekwini Area
Ethics Clearance Number: IREC 093/21

The DUT-Institutional Research Ethics Committee acknowledges receipt of your notification regarding the piloting of your data collection tool.

Kindly ensure that participants used for the pilot study are not part of the main study.

In addition, the DUT-IREC acknowledges receipt of your gatekeeper permission letter.

Please note that FULL APPROVAL is granted to your research proposal. You may proceed with data collection.

Any adverse events [serious or minor] which occur in connection with this study and/or which may alter its ethical consideration must be reported to the DUT-IREC according to the DUT-IREC SOP's.

Please note that any deviations from the approved proposal require the approval of the DUT-IREC as outlined in the DUT-IREC SOP's.

It is compulsory for a student or researcher to apply for recertification on an annual basis. The failure to do so will result in withdrawal of ethics clearance. It is the responsibility of the researcher and the supervisor to apply for recertification.

Please note that you are required to submit a Notification of Completion of Study form together with an abstract to the DUT-IREC office on completion of your study.

Yours Sincerely

Prof J K Adam
Chairperson: DUT-IREC

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APPENDIX 2: PERMISSION TO CONDUCT RESEARCH

Faculty of Management Sciences
Department of Public Management & Economics
21/06/2020

Dear Participant

REQUEST FOR PERMISSION TO CONDUCT RESEARCH

Dear Sir,

My name is Olanrewaju, Caroline Chioma, a PhD student at the Durban University of Technology. The research I wish to conduct for my Doctoral thesis involves the development of an Integrated Flood Risk Management Framework for Urban Settlements: Case study of eThekwini Municipal Area.

I am hereby seeking your consent to conduct a survey on purposively sampled participants from uMlazi, Inanda, Cato Manor Townships and Clare Estate via questionnaires and key informants in disaster management via semi-structured interview. The key informants for the interview will include officials of flood disaster risk management of eThekwini Municipal Area (disaster managers/practitioners and senior disaster management officials), ward councillors and members of committee of the selected study area

I have provided you with a copy of my proposal, which includes copies of the data collection tools and consent forms to be used in the research process, as well as a copy of the approval letter which I received from the Institutional Research Ethics Committee (IREC).

If you require any further information, please do not hesitate to contact me on
Mobile Number: 061-4350192
E-mail: carolnwogu@gmail.com

Thank you for your time and consideration in this matter.

Yours sincerely,

____
Student

Contact Details
Olanrewaju, Caroline Chioma
Department of Public Management and Economics
Faculty of Management Sciences
Durban University of Technology

____
Supervisor / Promoter

Contact Details

APPENDIX 3: APPROVAL LETTER TO CONDUCT RESEARCH

COMMUNITY AND EMERGENCY SERVICES
Disaster Management and Emergency Control Unit

ETHEKWINI MUNICIPALITY

Disaster Management Building, 3 Jeff Taylor Crescent, Durban, 4001 PO Box 3965, Durban, 4000
Tel: 031 367 0001, Fax 031 307 3744
www.durban.gov.za

30 March 2023

Ms Caroline Chioma Olanrewaju
Department of Public Management and Economics
Faculty of Management Sciences
Durban University of Technology
Phone: 061 435 0192
Email: 22063587@dut4life.ac.za

Attention: Ms Olanrewaju

RE: PERMISSION TO CONDUCT RESEARCH AT DISASTER MANAGEMENT DEPARTMENT

Kindly be advised that your request to conduct research on "Flood Risk Management in Urban Settlements in the eThekwini Area" has been approved.

In exchange, you are to provide the Unit a full research report.

The person to assist you at Disaster Management will be:

Name : Mrs Dian Pillay
Cell : 084 7000 073
Office : 031 361 0004
Email : dian.pillay@durban.gov.za

Thanking you kindly and wish you well.

Yours Sincerely,

MR VB NGUBANE
HEAD: DISASTER MANAGEMENT & EMERGENCY CONTROL UNIT

CC – Ms Nomvuyo Zulu — Senior Manager: Disaster Management
Ms Dian Pillay — Disaster Management

APPENDIX 4: LETTER OF INFORMATION AND CONSENT TO CONDUCT INTERVIEW

DUT DURBAN UNIVERSITY OF TECHNOLOGY

INSTITUTIONAL RESEARCH ETHICS COMMITTEE

LETTER OF INFORMATION

Qualitative Data Collection (Semi-structured Interview)

Title of the Research Study : Flood Risk Management in Urban Settlements in the eThekwini Area

Principal Investigator/s/researcher: Caroline Chioma Olanrewaju, Master of Disaster Mgt.

Co-Investigator/s/supervisor/s: Maliga Reddy, PhD

Brief Introduction and Purpose of the Study:

Good Day,

I am a post-graduate student in the department of Public Management and Economics at Durban University of Technology doing my research for my Doctor of Philosophy in Management Sciences specializing in Public Administration: Disaster and Risk Management. I would like to invite you to participate in the research.

What is Research: Research is a systematic search or enquiry for generalized new knowledge. This research will focus on the management of floods. Floods in eThekwini municipal area is very destructive with devastating and fatal impacts due to vulnerability of community members and lack of adequate capacity to manage it. Lack of clear strategies in place to reduce vulnerability to flood risk and weak implementation strategies to integrate all stakeholders of disaster risk management is also seen to be another reason for devastations of flood disasters.

This research will focus on the use of Integrated Flood Risk Management (IFRM) to improve the effectiveness of flood risk management in the study area. The IFRM framework is expected to enhance disaster risk reduction practices, develop strategies to encourage and ensure a participatory approach of community members as well as ensure the cooperation between different stakeholders of flood risk management to achieve an effective flood management in the study area.

For you to qualify for this research, you must be a disaster management official of the eThekwini Municipality or involved in disaster management in and around eThekwini. You must fall within any of the three categories of disaster managers. These include: Disaster management practitioners qualified in disaster management, senior disaster management officials from other government departments attached to the disaster management center and ward councilors and committee members from the selected flood prone areas working hand-in-hand with the disaster practitioners for the reduction of disasters in eThekwini area. Should you need more clarity on the research feel free to ask questions. You are not under any obligation to participate in this research; however, your participation will be highly valuable.

Outline of the Procedures: Semi-structured interviews enabling the collection of detailed views from 35 purposively sampled officials of disaster management is used. Interview will be conducted face-to-face or telephonically. The interview between you and myself (should you consent) will take place in the municipality offices at mutually agreed time or via your preferred telephone contact and should last for a maximum of 30 minutes. Notes and tape recorder will be used for the interview. Snowball sampling will also be used during the interview to gain more insight in the problem from disaster management practitioners working in eThekwini

6 August 2020

disaster management center.

Risks or Discomforts to the Participant: You will not be subjected to any form of risk or discomfort

Explain to the participant the reasons he/she may be withdraw from the Study: Your participation is voluntary and you can opt-out whenever you so desire. You will not be subjected to any physical, psychological or moral abuse and will in no way be exploited for any form of gain.

Benefits: The research will mitigate and reduce damages from flood disasters in the selected flood prone area. Information on vulnerabilities faced by the community members will be highlighted. This will be very helpful in building up capacities to flood disasters and increase the coping strategies of the community members. This study will also suggest ways to enhance the capacity of disaster managers and other stakeholders thus improving disaster risk reduction practices in eThekwini municipal area. This research will increase the knowledge base of Integrated Flood Risk Management through publications in relevant journals in the world.

Remuneration: Participation is free and you will not receive monetary or any form of remunerations.

Costs of the Study: You will not be expected to cover any cost towards the study.

Confidentiality: In this research, extreme measures are taken to protect your identity and the information you give. Your identity will be kept secret and any information you give will be protected though out the period of the research.

Results: The result of the research will be disseminated all over the world through thesis, conferences and journals to DHET approved journals. Should you be interested in the significant new findings of the research, a summary of the research will be made available to you through the university library.

Research-related Injury: There will be no injuries or adverse reaction as a result of this research.

Storage of all electronic and hard copies including tape recordings Data of the research is kept secured through password-protected files and locked drawers. This is made available only to the supervisor of the research. Also, results to identifying information is coded by the use of pseudonyms. Aggregate findings is reported to the public and not individual-level data.

Persons to contact in the Event of Any Problems or Queries: Please contact the researcher on 061 3 0192, my supervisor on 031 33 612 or the Institutional Research Ethics Administrator on 031 373 2375. Complaints can be reported to the Director: Research and Postgraduate Support Dr L Linganiso on 031 373 2577 or researchdirector@dut.ac.za.

6 August 2020

CONSENT

Full Title of the Study: Flood Risk Management in Urban Settlements in the eThekwini Area

Names of Researcher/s: Caroline Chioma Olanrewaju

Statement of Agreement to Participate in the Research Study:

- I hereby confirm that I have been informed by the researcher, Caroline Chioma Olanrewaju, about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number: ___________,
- I have also received, read and understood the above written information (Participant Letter of Information) regarding the study.
- I am aware that the results of the study, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.
- In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.
- I may, at any stage, without prejudice, withdraw my consent and participation in the study.
- I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.
- I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

______________________ ___________ _______ ________________

Full Name of Participant **Date** **Time** **Signature / Right Thumbprint**

I, Caroline Chioma Olanrewaju herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

Olanrewaju, Caroline Chioma 31/05/2021 ____________________

Full Name of Researcher **Date** **Signature**

__________________ ___________ ____________________

Full Name of Witness (If applicable) **Date** **Signature**

__________________ ___________ ____________________

Full Name of Legal Guardian (If applicable) **Date** **Signature**

6 August 2020

APPENDIX 5: LETTER OF INFORMATION AND CONSENT FOR QUESTIONNAIRE SURVEY

DUT DURBAN UNIVERSITY OF TECHNOLOGY

INSTITUTIONAL RESEARCH ETHICS COMMITTEE

LETTER OF INFORMATION

Quantitative Data Collection

(Questionnaire)

Title of the Research Study : Flood Risk Management in Urban Settlements in the eThekwini Area

Principal Investigator/s/researcher: Caroline Chioma Olanrewaju, Master of Disaster Mgt.

Co-Investigator/s/supervisor/s: Maliga Reddy, PhD

Brief Introduction and Purpose of the Study:

Good Day,

I am a post-graduate student in the department of Public Management and Economics at Durban University of Technology doing my research for my Doctor of Philosophy in Management Sciences specializing in Public Administration: Disaster and Risk Management. I would like to invite you to participate in the research.

What is Research: Research is a systematic search or enquiry for generalized new knowledge. This research will focus on the management of floods. Floods in eThekwini municipal area is very destructive with devastating and fatal impacts due to vulnerability of community members and lack of adequate capacity to manage it. Lack of clear strategies in place to reduce vulnerability to flood risk and weak implementation strategies to integrate all stakeholders of disaster risk management is also seen to be another reason for devastations of flood disasters.

This research will focus on the use of Integrated Flood Risk Management (IFRM) to improve the effectiveness of flood risk management in the study area. The IFRM framework is expected to enhance disaster risk reduction practices, develop strategies to encourage and ensure a participatory approach of community members as well as ensure the cooperation between different stakeholders of flood risk management to achieve an effective flood management in the study area.

For you to qualify for this research, you must be 18 years and above, own a home or have rented a house or a business property in either Cato Manor, uMlazi, Inanda Townships or Claire Estate. You must have also lived in any of these urban areas for a minimum of ten years and have a basic knowledge of floods and its consequences. You must also have attained the minimum academic qualification. You can seek for clarity of the research by asking as many question as you wish as it is paramount you understand the purpose of the research. You are not under any obligation to accept to participate in this research until you are in full acceptance and understand the purpose of the research. You can take this letter of information home to discuss with your friends and family for better understanding.

Outline of the Procedures: Structured questionnaires will be used to collect information from purposively sampled residents of the study area whose livelihoods and property is affected yearly by flood disasters. Should you agree to participate in the research, you will be expected to tick the appropriate boxes and complete the questionnaires in approximately 10 – 15 minutes. The questionnaires will be collected immediately after completion. A total of 384 questionnaires will be used. An appropriate day and time will be selected to exclude

6 August 2020

rainfall or other harsh weather conditions. You will be communicated of the date and time the questionnaires will be administered at the time of distribution of the letter of information for your participation should you be interested in participating.

Risks or Discomforts to the Participant: You will not be subjected to any form of risk or discomfort

Explain to the participant the reasons he/she may be withdraw from the Study: Your participation is voluntary and you can opt-out whenever you so desire. You will not be subjected to any physical, psychological or moral abuse and will in no way be exploited for any form of gain.

Benefits: The research will mitigate and reduce damages from flood disasters to you and your community at large. Information on vulnerabilities faced by you and other community members will be highlighted. This will be very helpful in building up capacities to flood disasters and increase the coping strategies of your community members. This study will also suggest ways to enhance the capacity of disaster managers and other stakeholders thus improving disaster risk reduction practices in eThekwini municipal area. This research will increase the knowledge base of Integrated Flood Risk Management through publications in relevant journals in the world.

Remuneration: Participation is free and you will not receive monetary or any form of remunerations.

Costs of the Study: You will not be expected to cover any cost towards the study.

Confidentiality: In this research, extreme measures are taken to protect your identity and the information you give. Your identity will be kept secret and any information you give will be protected though out the period of the research.

Results: The result of the research will be disseminated all over the world through thesis, conferences and journals to DHET approved journals. Should you be interested in the significant new findings of the research, a summary of the research will be made available to you through the university library.

Research-related Injury: There will be no injuries or adverse reaction as a result of this research.

Storage of all electronic and hard copies including tape recordings Data of the research is kept secured through password-protected files and locked drawers. This is made available only to the supervisor of the research. Also, results to identifying information is coded by the use of pseudonyms. Aggregate findings is reported to the public and not individual-level data.

Persons to contact in the Event of Any Problems or Queries: Please contact the researcher on 061 3 0192, my supervisor on 031 33 612 or the Institutional Research Ethics Administrator on 031 373 2375. Complaints can be reported to the Director: Research and Postgraduate Support Dr L Linganiso on 031 373 2577 or researchdirector@dut.ac.za.

6 August 2020

CONSENT

Full Title of the Study: Flood Risk Management in Urban Settlements in the eThekwini Area

Names of Researcher/s: Caroline Chioma Olanrewaju

Statement of Agreement to Participate in the Research Study:

- I hereby confirm that I have been informed by the researcher, Caroline Chioma Olanrewaju, about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number: ___________,
- I have also received, read and understood the above written information (Participant Letter of Information) regarding the study.
- I am aware that the results of the study, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.
- In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.
- I may, at any stage, without prejudice, withdraw my consent and participation in the study.
- I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.
- I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

______________________ ___________ _______ ________________

Full Name of Participant **Date** **Time** **Signature / Right Thumbprint**

I, Caroline Chioma Olanrewaju herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

Olanrewaju, Caroline Chioma 31/05/2021 ____________________

Full Name of Researcher **Date** **Signature**

__________________ ___________ ____________________

Full Name of Witness (If applicable) **Date** **Signature**

__________________ ___________ ____________________

Full Name of Legal Guardian (If applicable) **Date** **Signature**

6 August 2020

APPENDIX 6: RESEARCH QUESTIONNAIRE

An Integrated Flood Risk Management Framework in urban settlements: A case study of eThekwini Municipal Area

MUNICIPALITY: eThekwini Municipal Area

TOWNSHIP/CITY: ---

QUESTIONNAIRE ID: ---

DATE: DD/MM/YYYY

PLEASE ANSWER THE FOLLOWING QUESTIONS BY MARKING THE APPROPRIATE CHOICE ANSWER(S) WITH A TICK (√) OR CIRCLE EITHER YES OR NO

1 DEMOGRAPHICS

1.1 GENDER

Male ☐

Female ☐

1.2 What is your age category (Years)?

18 -34 ☐

25 – 50 ☐

51 – 70 ☐

Above 70 ☐

1.3 What is your marital status?

Single ☐

Married ☐

Divorced ☐

Separated ☐

Widowed ☐

No response ☐

1.4 What is your level of education?

Primary education
Secondary education
Tertiary education
No formal education

1.5 What is your occupation?

Unemployed
Public sector worker
Self employed
Retired

1.6 What is the size of your household?

Below 5
6 – 8
9 - 12
Above 12

1.7 Type of residential property

Mud house
Brick house
Wooden house

1.8 Length of time you have been living in the community

1 – 5 years
6-10 years
11-15 years
Above 15 years

1.9 Ownership status of the house you are living in

Owner
Renting

Sharing

1.10 Basic income

Below R3, 500

R3, 500 – R7, 000

R7, 100 – R10, 000

Above R10, 000

2 IMPACTS OF FLOODS

2.1 IMPACTS OF FLOOD ON PROPERTY

2.1.1 What type of property was affected by flood disaster?

Formal

Informal

2.1.2 What is the approximate age of the property?

Below 5 years

6 – 10 years

11– 20 years

Above 20 years

2.1.3 How long have you lived in the property?

Below 5 years

6 – 10 years

11– 20 years

Above 20 years

2.1.4 How many times has your property been directly affected by flooding?

All the time

Once in a while

2.1.5 How often do you experience floods in your community?

Once a year

Twice a year

Not often

2.1.6 What was the duration of the flood?

0– 1 hour

3– 4 hours

5- 7 hours

8– 10 hours

Over 10 hours

2.1.7 Did the inside of your house/property get flooded? YES/NO

2.1.8 If yes, how long did it take the water to drain away from your property after the flooding occurred?

0– 1 hour

3– 4 hours

5- 7 hours

8– 10 hours

Above 10 hours

2.1.9 To your knowledge, where do you suppose the water came from?

Drain, gully or sewer cover

Land overflow or surface water

2.1.10 How much will you estimate is the cost of the damage caused by the flood disaster on your property

Up to R1000

R1001 – R2000

R2001 – R4000

R4001 – R6000

Above R6000

2.1.11 Was there any help given to by the community, local or provincial government during or after the flooding? YES/NO

2.2 IMPACTS OF FLOOD ON INDIVIDUAL

PLEASE READ THE FOLLOWING STATEMENTS AND RATE THEM BY TICKING (√) THE

COLUMN THAT BEST CORRESPONDS TO YOUR RESPONSE.

2.2.1 Flooding is a yearly occurrence in the community

- Strongly Agree ☐
- Agree ☐
- Disagree ☐
- Strongly Disagree ☐
- Neutral ☐
- Not sure ☐

2.2.2 Flooding occurs only as a result of surrounding rivers and creeks

- Strongly Agree ☐
- Agree ☐
- Disagree ☐
- Strongly Disagree ☐
- Neutral ☐
- Not sure ☐

2.2.3 Due to floods there is poor access to clean drinking water in the community during the rainy season

- Strongly Agree ☐
- Agree ☐
- Disagree ☐
- Strongly Disagree ☐
- Neutral ☐
- Not sure ☐

2.2.5 During floods the infrastructures such as local schools, offices, markets, electricity, roads, transportation are affected

Strongly Agree ☐
Agree ☐
Disagree ☐
Strongly Disagree ☐
Neutral ☐
Not sure ☐

2.2.6 Access to healthcare facilities is disrupted during floods

Strongly Agree ☐
Agree ☐
Disagree ☐
Strongly Disagree ☐
Neutral ☐
Not sure ☐

2.2.7 Healthcare provision services are interrupted during floods

Strongly Agree ☐
Agree ☐
Disagree ☐
Strongly Disagree ☐
Neutral ☐
Not sure ☐

2.2.8 During floods there is an increase in disease outbreak

Strongly Agree
Agree
Disagree
Strongly Disagree
Neutral
Not sure

2.2.9 Common water sources in the community are affected as a result of floods

Strongly Agree
Agree
Disagree
Strongly Disagree
Neutral
Not sure

2.2.10 The disaster management officials of the eThekwini Municipality are prompt in response to floods and its consequences

1. Strongly Agree
2. Agree
3. Disagree
4. Strongly Disagree
5. Neutral
6. Not sure

2.2.11 Floods have impacted negatively on the livelihood of the community members

Strongly Agree
Agree
Disagree

Strongly Disagree
Neutral
Not sure

2.2.12 Over-population in the community is a contributing factor for flooding in the study areas

Strongly Agree
Agree
Disagree
Strongly Disagree
Neutral
Not sure

2.2.15 Poor infrastructures such as drainage channels, bad roads and poor waste management contribute to flooding in the study areas

1. Strongly Agree
2. Agree
3. Disagree
4. Strongly Disagree
5. Neutral
6. Not sure

2.2.16 Community members are highly vulnerable to floods and its subsequent water-borne diseases.

1. Strongly Agree
2. Agree
3. Disagree

4. Strongly Disagree
5. Neutral
6. Not sure

1.2.17 The community is not secured against flooding

1. Strongly Agree
2. Agree
3. Disagree
4. Strongly Disagree
5. Neutral
6. Not sure

3 EXPOSURE TO FLOODS

3.1 How vulnerable were you in the last flood disaster you experienced?

Very

Slightly

Somewhat

Not Vulnerable

3.2 Is your home located close to a river or stream or any other watercourses? YES/NO

3.3 Have you lost any relative or family member to floods disaster before? YES/NO

3.4 Have you ever lost household and other personal items from flood before? YES/NO

3.5 Do you have a functional drainage system in your community? YES/NO

3.6 Have you fallen ill after a flood event before? YES/NO

4 FLOOD MANAGEMENT

4.1 How prepared are you to deal with flood events?

Very prepared

Not prepared

Not sure

4.2 Do you have any kind of incentive form the Municipality to prepare for flood events? YES/NO

4.3 Has the Municipality carried out any flood preventive work to prevent your property from future flood damage? YES/NO

4.4 Do you receive forecast of possible flood disasters? YES/NO

4.5 If yes, how do you get the forecast of possible flood disasters

Radio

Television

Internet

Newspaper

4.6 Does the Municipality provide any flood relief packages after flood disasters? YES/NO

4.7 Is there any mitigation activity occurring in your community? YES/NO

4.8 If yes, do you participate? YES/NO

4.9 Are community members consulted about flood mitigation activities? YES/NO

4.10 How would you rate the flood response plan by the disaster management practitioners in your community?

Good

Very good

Excellent

Adequate

Poor

Very poor

4.11 Do you have concerns about your community related to flood risks? YES/NO

THANK YOU FOR YOUR COOPERATION

APPENDIX 7: INTERVIEW GUIDE

SEMI-STRUCTURED INTERVIEWS

(A)

TITLE: An Integrated Flood Risk Management Framework in urban settlements: A case study of eThekwini Municipal Area

PROVINCE NAME: KwaZulu-Natal Province

MUNICIPALITY: eThekwini Metropolitan Municipality

DISTRICT/COMMUNITY: Durban

DATE OF INTERVIEW: DD/MM/YYYY

NAME OF INTERVIEWEE: ----- (Administered to only disaster managers /practitioners)

1 Position

POSITION	**YEARS OF EXPERIENCE**

2. Risk factors

2.1 What in your opinion will you say are the causes of floods in the study area?

2.2 What is the trend of flood disaster in the study areas in the past 20 years (2000-2020)?

3. Impacts of flood

3.1 How would you describe flood experience in the study area in the past 20 years (2000-2020)?

3.2 How would you describe the impact of floods on the affected community on the following (on a scale of 1-10 where 1 is very low and 10 is very high) in the past 20 years (2000-2020)?

i. Livelihood

ii. Access to clean drinking water
iii. Health
iv. Sanitation
v. Infrastructure
vi. Housing

3.3 Indicate an estimate of people affected by the flood disaster in the selected flood prone areas

Name of flood prone area	**Total Population**	**Estimated population**	**Cost of damages (R)**
uMlazi	404,811		
Cato Manor	5,996		
Clare Estate	6,190		
Inanda	158,619		

4. Causes of Vulnerability to floods

4.1 Explain in your view, what are the underlying causes of floods in the study areas

4.2 What are the factors that increase vulnerability of community members to floods in the study area?

4.3 Name at least three coping strategies if any, employed by people in the study areas

5. Flood Disaster Management

5.1 Does the eThekwini Municipal Area have a flood disaster management plan in place?

5.2 Is there a budget for flood disaster related activities? If yes, is the budget adequate?

5.3 Is there a budget in other departments of the eThekwini Municipal Area for flood disaster management?

5.4 What approach do you believe the eThekwini Municipal Area uses to manage flood disasters? Proactive or reactive approach?

5.5 If proactive (i.e., focused more towards prevention, mitigation and reduction), what measures are used to manage flood disaster in eThekwini Municipal Area?

5.6 If reactive (i.e., focused on emergency response, disaster recovery and rehabilitation), explain why such an approach is adopted

- Do you have an effective storm water management in place in the eThekwini Municipal area? If No, what are the challenges faced? If YES, what types/models do you have in place?

5.7 Is there any community participation in flood disaster management in eThekwini Municipal area? If No, why? If Yes, to what extent?

5.8 Do you have sufficient capacity in the Municipality for flood risk management?

5.9 Is there any cooperation between the Provincial Disaster Management Center and the eThekwini Municipal Area disaster management centre on flood disaster management? If yes, what is the degree of cooperation?

6. Disaster Management Activities

6.1 What are your developmental options to address the flood patterns in the study area?

6.2 What do you believe in your opinion is the biggest barrier to flood risk management in the study area?

6.3 What are the lasting measures that can be put in place to mitigate against flood disasters in the study area?

6.4 How can the damage to flood disaster in the study area be reduced?

6.5 What additional role do you suggest stakeholders can play in mitigating flood disaster in the study area

6.6 If you were to anticipate future changes to mitigation of flood risks, what changes will you make

SEMI-STRUCTURED INTERVIEWS

(B)

TITLE: An Integrated Flood Risk Management Framework in urban settlements: A case study of eThekwini Municipal Area

PROVINCE NAME: KwaZulu-Natal Province

MUNICIPALITY: eThekwini Metropolitan Municipality

DISTRICT/COMMUNITY: Durban

DATE OF INTERVIEW: DD/MM/YYYY

NAME OF INTERVIEWEE: ----------- (Administered to Senior Disaster Management officials)

1. Position

PARTICIPANT CATEGORY	Select category (X)	POSITION	YEARS OF EXPERIENCE
Engineering Unit			
Development Planning and Environmental Management			
Housing Unit			
Water and sanitation			
Parks, Recreation and Culture Unit			
Emergency Medical Rescue Services			
Academia in Disaster Management			

2 Disaster Management/ Key stakeholder involvement

2.1 Describe the nature of involvement of your department in flood disaster management

2.2 How does your department respond to flood emergencies?

2.3 Does your department work with the local communities in the study areas?

2.4 If yes, describe how your department/agency works with the local community.

2.5 Do you have an effective storm water management in place in the eThekwini Municipal area?

2.6 If No,

2.6.1 what are the challenges faced?

2.7 If Yes,

2.7.1 What drainage models/drainage control exist in the study area?

2.7.2 What mitigation measures are used to maintain them?

2.8 Do you have any plans in place to overcome the recurrent flood disasters in the study area?

2.9 What kind of information, maps and data do you use in the case of flood disasters in the study area?

2.10 Rate the accuracy of the data you use in flood disaster predictions on a scale of 1-10 (where 1 is very low and 10 is very high)

2.11 Do you have sufficient capacity in your department for flood risk management?

2.12 Rate the level of cooperation between your department and the eThekwini Municipality disaster management centre on flood disaster management on a scale of 1-10 (where 1 is very low and 10 is very high)

2.13 Do you have a dedicated budget in your department for Flood Disaster Risk Management in eThekwini Municipality?

2. Disaster Management Activities

3.1 What are your developmental options to address the flood patterns in the study area?

3.2 What do you believe in your opinion is the biggest barrier to flood risk management in the study area?

3.3 What are the lasting measures that can be put in place to mitigate against flood disasters in the study area?

3.4 How can the damage to flood disaster in the study area be reduced?

3.5 Where do you suggest additional efforts be put by disaster managers/practitioners in mitigating flood disaster in the study area?

3.6 If you were to anticipate future changes to mitigation of flood risks, what changes will you make?

SEMI-STRUCTURED INTERVIEWS

(C)

TITLE: An Integrated Flood Risk Management Framework in urban settlements: A case study of eThekwini Municipal Area

PROVINCE NAME: KwaZulu-Natal Province

MUNICIPALITY: eThekwini Metropolitan Municipality

DISTRICT/COMMUNITY: Durban

DATE OF INTERVIEW: DD/MM/YYYY

NAME OF INTERVIEWEE: ------ (Administered to Ward councillors and ward committee members only)

1 Position

PARTICIPANT WARD	**Select ward (X)**	**POSITION**	**YEARS OF SERVICE IN WARD**
Ward Councillor			
uMlazi Township			
Inanda Township			
Cato Manor Township			
Clare Estate			

2 Risk factors

2.1 What in your opinion will you say are the causes of floods in your ward?

2.2 What is the trend of flood disaster in your ward in the past 20 years (2000-2020)?

3 Impacts of flood

3.1 How would you describe flood experience in your ward in the past 20 years (2000-2020)?

3.2 How would you describe the impact of floods on your ward on the following (on a scale of 1-10 where 1 is very low and 10 is very high) in the past 20 years (2000-2020)?

i. Livelihood

ii. Access to clean drinking water
iii. Health
iv. Sanitation
v. Infrastructure
vi. Housing

3.3 Indicate an estimate of people affected by the flood disaster in your ward

Name of flood prone area	Total Population	Estimated population	Cost of damages (R)
uMlazi	404,811		
Cato Manor	5,996		
Clare Estate	6,190		
Inanda	158,619		

4 Causes of Vulnerability to floods

4.1 Explain in your view, what are the underlying causes of floods in your ward

4.2 What are the factors that increase vulnerability of community members to floods in your ward?

4.3 Name at least three coping strategies if any, employed by community members in your ward.

5 Stakeholder involvement

5.1 Describe the nature of involvement of community members in your ward to flood disaster management.

5.2 How do you respond to flood emergencies in your ward?

5.3 Do disaster managers/practitioners work with members of the local communities in your ward on flood risk management?

5.4 If yes, describe how disaster management practitioners works with the local community in flood risk management.

5.5 Do you have an effective storm water management in place in your ward? If No, what are the challenges faced

5.6 Do you have any community measures in place to overcome the recurrent flood disasters in your ward?

6 Disaster Management Activities

6.1 What are your developmental options to address the flood patterns in your ward?

6.2 What do you believe in your opinion is the biggest barrier to flood risk management in your ward?

6.3 What are the lasting measures that can be put in place to mitigate against flood disasters in your ward?

6.4 How can the damage to flood disaster in your ward be reduced?

6.5 Where do you suggest additional efforts be put by disaster managers/practitioners in mitigating flood disaster in your ward?

6.6 If you were to anticipate future changes to mitigation of flood risks, what changes will you make.

7 Disaster Risk Reduction Activities

7.1 Rate on a scale of 1-10 (where 1 is very low and 10 is very high) Disaster Risk Reduction measures on floods put in place in your ward

7.2 Is there a dedicated budget for Flood Disaster Risk Management in your ward?

7.3 Is there effective collaboration between officials in your ward and the eThekwini Municipality on Flood Disaster Risk Management?

APPENDIX 8: PHOTOGRAPHIC REPRESENTATION OF STUDY AREA

Aerial view of eThekwini Municipality (Durban). Photo credit: wikiland

APPENDIX 9: TURNITIN REPORT

Chapter 1-6 Flood Risk Management in Urban Settlements

ORIGINALITY REPORT

17%	12%	12%	7%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Caroline C. Olanrewaju, Maliga Reddy. "Assessment and prediction of flood hazards using standardized precipitation index—A case study of eThekwini metropolitan area", Journal of Flood Risk Management, 2022 Publication	1 %
2	hdl.handle.net Internet Source	<1 %
3	docshare.tips Internet Source	<1 %
4	research.aalto.fi Internet Source	<1 %
5	researchspace.ukzn.ac.za Internet Source	<1 %
6	Submitted to University of KwaZulu-Natal Student Paper	<1 %
7	listens.online Internet Source	<1 %
8	Submitted to University of Zululand Student Paper	

APPENDIX 10: EDITOR'S LETTER

Helen Richter
Advanced Editing & Proofreading

editassist2023@gmail.com
+27 729227221

19 November 2024

To whom it may concern

CERTIFICATE OF EDITING & AUTHENTICATION

I have proofread and language edited the PhD thesis titled:

"Flood Risk Management in Urban settlements in the eThekwini Area"

by

Caroline Chioma Olanrewaju
22063587

To the best of my knowledge, the work is free of spelling, grammar, structural and stylistic errors and the contents are certified as the author's own work, with adherence to DUT technical parameters.

With thanks.

H. S. Richter