Investigating flood prevention measures adopted in flood-prone areas of Centurion, City of Tshwane Metropolitan Municipality.

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DECLARATION

I, **Ofentse Annah Kutumela**, student number **1351080**, declare that this Research Report submitted as part of the Degree of Master of Science in Development Planning at the University of the Witwatersrand is my own work and that I contributed adequately towards research findings published in my Research Report.

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ABSTRACT

Globally, many countries such as Mozambique, Afghanistan, India, Brazil, the United States (US) and China among others continue to face the persistent challenge of climate change aftermaths, such as rising temperatures, extreme weather patterns and floods. South Africa is no exception, and similar to other countries, especially in the African continent, they lack strategy on how to respond to climate change impacts owing to continuously changing environmental patterns and trends. Therefore, the United Nations (UN) has drafted and implemented the Sendai Framework since 2015 to address disaster risk reduction worldwide, which goes concurrently with the Sustainable Development Goals (SDGs), in particular Goal 13 that deals with a call to Climate Action.

The aim of this research was two-fold – first, to investigate prevention measures related to urban planning and land use management regulations that prevent flooding through disaster risk reduction. For instance, interrogating various policies, legislations, plans and programmes that have been sourced to prevent flooding in Centurion such as the Disaster Management Act, City of Tshwane (CoT) Disaster Risk Mitigation Plans, City of Tshwane Flood Incident Management Plan, Water Use Licence Policy, Flood Mitigation Plan and City Support Programme that are categorised as non-structural measures Secondly, to review flood risk reduction and the impact prevention measures that have been adopted in urban flood-prone areas in the CoT, particularly Centurion.

The methodology used during this research was the qualitative approach. With this approach, I followed mixed methods research, where in the first stage, I collected primary data through one-on-one interviews through semi-structured interviews, while in the second stage, I conducted site visits as part of my observation. For sampling, I applied non-probability sampling technique known as purposive sampling to select research participants. In analysing the collected data, I adopted inductive thematic analysis to identify, interpret and report the existence of patterns in the data. The aim was to provide meaning to the findings and recommendations of the research. The findings reveal that protection of blue infrastructure is important as encroachment of wetlands continues to be a challenge. Nonetheless, this protection remains preventative measures in the lower catchment. Also, the integration of transboundary municipalities is important as it is not only the town planners' responsibility as professionals to implement disaster risk management but also all internal departments within a municipality.

Failure to implement urban planning and land use management regulations, policies and or plans within the municipality, especially in Centurion, will potentially lead to significant implications, which may manifest themselves through an increase in debris, sinkholes, more deadly floods along the Hennops River, and adverse impacts as a result of changes in the environment.

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LIST OF ACRONYMS

African National Congress	ANC
African Union	AU
City of Cape Town	CCT
City of Ekurhuleni	CoE
City of Johannesburg	CoJ
City of Tshwane	CoT
Democratic Alliance	DA
Disaster Management Act	DMA
Disaster Risk Management	DRM
Disaster Risk Reduction	DRR
Environmental Impact Assessment	EIA
Global Assessment Report	GAR
Hyogo Framework for Action	HFA
Integrated Development Plan	IDP
Low-Impact Development	LID
Memorandum of Understanding	MOU
Microsoft Teams	MS Teams
Non-Governmental Organisation	NGO
Southern African Development Community	SADC
Special Report on Extreme Events	SREX
Sustainable Development Goals	SDGs
United Nations	UN
United States	US
University of South Africa	UNISA
Water Use Licence Policy	WUL

CHAPTER 1: INTRODUCTION AND BACKGROUND

1.1 Introduction

Flooding has become the most common and destructive natural disaster affecting most countries and it prevalence is attributed to effects of climate change, which affects a city's attractiveness and competitive edge (; Yang, Zhang, Dai, & Yao, 2020; Axelsson, Soriani, Culligan & Marcotullio, 2021). Countries such as Mozambique, Afghanistan, India, Brazil, United States (US) and China among others continue to face the persistent challenge of climate change aftermaths, such as rising temperatures, extreme weather patterns and floods. South Africa is no exception as it is also prone to floods, and cities like Tshwane, eThekwini, and Cape Town are often heavily affected.

Owing to increased urbanisation, the risk of flooding can be exacerbated by rapid increase in surface runoff, overwhelmed drainage systems as well as reduced vegetation area (United States Environmental Protection Agency, 2024). With these climate change developments, cities need to adapt to necessary changes, upgrade and maintain the ageing infrastructure systems to cope with urban flooding occurrences (Yang *et al*., 2020; Axelsson *et al*., 2021). However, the global community is taking into consideration and implementing prevention measures to help prevent and mitigate flooding and its effects from a development planning perspective. Such measures entail the drafting and adoption of the Sendai Framework (2015-2030) and the 2030 Agenda for Sustainable Development in response to flooding (Uddin, Hasan, Eisenreich, & Quevauviller, 2019).

Equally, physical structural prevention measures include merging green, blue and grey infrastructure to prevent and mitigate flooding in urban areas. This is significant in terms of how individual countries participate in responding to Sustainable Development Goals (SDGs), for example such as focusing on reducing poverty (SDG 1), building sustainable cities and communities (SDG 11), providing decent work and economic growth (SDG 8),providing clean water and sanitation (SDG 6), ensuring affordable and clean energy (SDG 7) and committing to climate action (SDG 13) to mention the few.

If such standards were established, either in developed or developing countries, they have potential of assisting affected cities in identifying resources such as finances, undertaking research and improving monitoring to make well-informed and measurable policy decisions on how to deal with extreme flooding disasters. On a global scale, guidance can be created for urban areas in developing countries, which face difficult adaptation decisions within a short period of time, with fewer financial resources (Axelssson *et al*., 2021).

1.1.1 Study Area

This research was conducted in Centurion, in the City of Tshwane (CoT) Metropolitan Municipality, which is in Gauteng, one of the nine provinces of South Africa. During the cause of the investigation, numerous flooding hotspots have been identified that occur under low-lying bridges and where the Hennops River runs divergent to the road causing flooding during heavy rains. These hotspots were identified in the following locations: Lyttleton Road, End and Rabie Road, Jean Avenue, Hendrik Verwoerd Drive, Centurion Hotel - Lenchen Ave N, West Avenue at SuperSport Park, and Nellmapius Drive (M31) (iAfrica, 2020). These are some of the major hotspots that have been identified to be experiencing heavy floods during the rainy season. Figure 1.1 depicts the regional map of Centurion and where it is located in South Africa and CoT respectively.

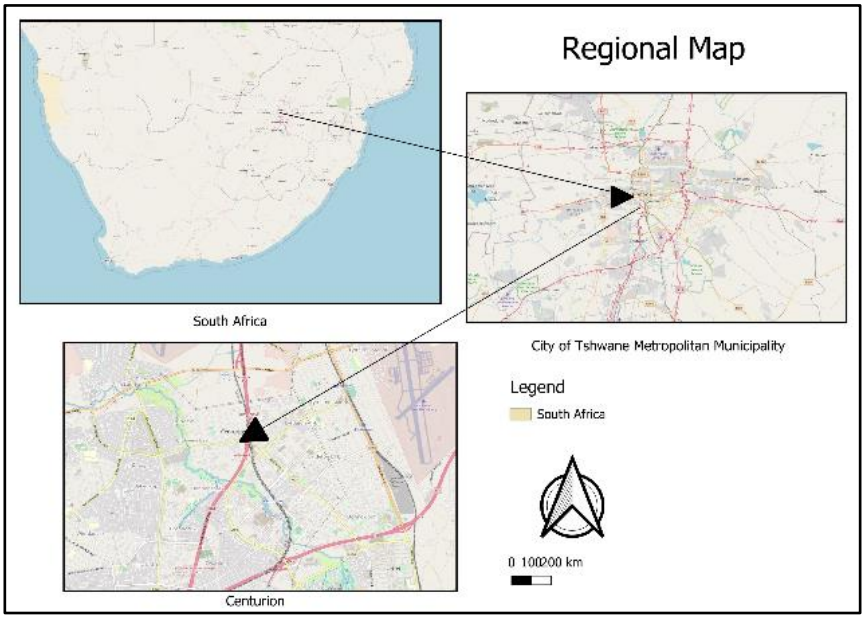

Figure 1.1: From a regional to local view.

Figure 1.2 highlights the study area, Centurion, specifically the identified hotspots that were studied. These three hotspots as depicted in Figure 1.2 are all connected by the Hennops River and are in close proximity to one another.

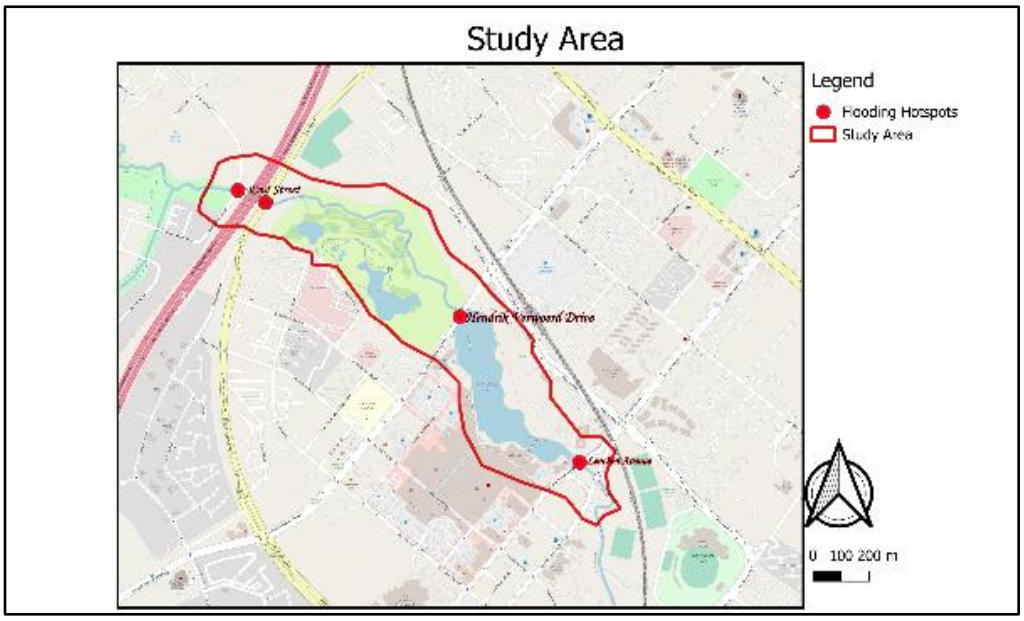

Figure 1.2: Study Area

Having discussed the introductory section, the rest of the chapter is structured as follows: Section 1.2 provides a discussion on the background, which highlights global flooding disasters and disaster risk reduction measures while engaging key scholars in the field. This discussion is followed by the problem statement in section 1.3, and it articulates the nature of problem under investigation. The discussion on the rationale of the study which justifies why this research is of critical importance follows in section 1.4. Following the problem statement, the aim of the study and research questions, including sub-questions are presented in sections 1.5 and 1.6 respectively. Section 1.7 is the last one for the chapter and presents brief overview of the chapter.

1.2 Background

Climate change is defined as the "significant changes in the average values of meteorological elements, such as precipitation and temperature," (Malhi, Kaur, & Kaushik, 2021: 1). According to Perera, Nik, Chen, Scartezzini and Hong (2020), half of the world's population will be living in urban areas by 2025. Therefore, different stakeholders need to work together to address climate change through prevention measures within urban areas to minimise vulnerability in the long-term.

One of the major influences of climate change is land use, land change, urbanisation, and unsustainable exploitation of natural resources (Perera *et al.,* 2020; Malhi *et al*., 2021; Parmesan, Morecroft & Trisurat, 2022). Hence the increase in disaster events

across the world and the increase in movement from rural to urban areas contribute immensely to climate change, especially flooding. For instance, the increased river flows during the heavy rainfalls in Southern and Eastern Asia, with the increased drought in Southern Africa and South America have shown the world the extreme changes to global warming because of the environmental changes caused by the land changes and urbanisation (Malhi *et al*., 2021). However, in this research, the main focus was on natural disasters caused by flooding.

Flooding is defined as the presence of a substantial volume of water beyond its normal limits, that is, across terrain that is normally dry land but is not covered with water (Kundzewic & Pinskwar, 2022; Zurich, 2023). This body of water creates several types of floods that affect different environments in different ways, such as fluvial floods, which are known as river floods. These occur when water levels in a river, stream or dam overflow onto the flood line due to extreme rainfall or snowmelt (Zurich, 2023). Pluvial floods, known as flash floods and surface water floods, on the other hand, occur when there is extreme rainfall that creates independent floods from overflowing water bodies. There are two forms of pluvial floods: surface water floods and flash floods. Surface water floods occur when urban drainage systems are overwhelmed, and water flows out into the streets and nearby structures, whereas flash floods happen when there is torrential rainfall within a short amount of time in a vicinity or nearby elevated terrain. In contrast, continues Zurich (2023), coastal floods impact coastal areas through seawater; and they are based on intense windstorm events occurring at a high tide, storm surges and creations of tsunamis.

Despite the environmental and social impacts of fluvial floods in urban areas, there is a significant gap in the literature regarding their prevention and the specific characteristics that define them. For example, assessing the impact of past and future development on flooding is hindered by a lack of comprehensive information on fluvial floods, despite oftentimes existence of environmental and social incidents in urban areas as highlighted by Kundzewicz and Pinskwar (2022). With this type of flooding, the need to implement flood management to control the flow of water into urban and coastal areas is key to flood prevention and control measures for floods in this case flood risk reduction strategies (Boulmaiz *et al.,* 2023).

The significance of understanding prevention measures of all the afore-mentioned floods remains central to the objective of this research. Therefore, this research study aimed at investigating and identifying prevention measures by the CoT on the most significant type of flooding by considering factors such as drainage infrastructure, wetlands,

urbanisation, and flood lines. This study focused on urban areas in the CoT that have been developed on ancient flood lines and have a combination of river floods, flash floods and surface floods that are usual occurrence during heavy rainfalls.

1.2.1 Flooding Prevention Techniques: A Global and South African Perspective

This section concentrates on flooding from both global and South African perspectives, with a particular interest on antecedent to extreme flooding, associated disasters and also strategies that local and international authorities implement as prevention techniques. Global scholars such as Wentink and van Niekerk (2017); Axelsson *et al.* (2021); Chapungu and Nhamo's (2021) and Johnston (2022), highlight that urban policies surrounding urban stormwater systems are categorised either as green, blue, or grey infrastructure to address and understand the variety of infrastructure flooding management techniques. The importance of this is that flooding disaster risk reduction measures can be approached through green-blue and grey infrastructure development planning and priorities maintenance as a key policy. Cities such as New York, Vancouver, Sydney, Auckland, and parts of China use these techniques to prevent urban flooding and mitigate its impacts in urban areas (Axelsson *et al.,* 2021).

South Africa is also affected by flooding with recent events in the CoT, City of eThekwini, and City of Cape Town (CCT) stemming from heavy rainfalls over a short period of time. Scholars such as Chapungu and Nhamo (2021) highlight that local government needs the necessary human capital and financial resources to address flooding by implementing stormwater management plans. In the same vein, Wentink and van Niekerk (2017) support the assertion of Chapungu and Nhamo (2021) that disaster risk management related to stormwater has been implemented slowly in South Africa since the enactment of the Disaster Management Act of 2002.

Hence, Departments such as Roads and Transport, Planning and Environment should aim for integrated institutional structures on prevention measures for flooding in all three spheres of government. The adequate implementation of the SDG Framework is a step further toward ensuring sustainable drainage systems in urban, rural and regional areas in South Africa (Kunene, Ntombela & Madikizela, 2021). Therefore, it is important to understand that achieving a resilient city entails efficient stormwater management systems that prevent flooding (Chapungu & Nhamo, 2021).

Following recent floods at Centurion Hotel, a notable success emerged as staff demonstrated resilience in overcoming their fear of water. The hotel's subsequent

rebuilding efforts prioritised the development of more robust and sustainable infrastructure. The hotel had a flood insurance, which enabled a quick recovery from the disaster (Nhamo & Chikodzi, 2021). However, the City council's lack of maintenance of the lake resulted in the rising river waters flooding the basement and first level of the hotel during the floods (Milella 2012; Nhamo & Chikodzi, 2021). The rising water levels in the area are a result of the encroaching flood lines, leading to minimal regulations of flood lines within the municipality. This is fundamentally due to over-development, environmental degradation and overwhelmed stormwater drains along the river and in the inner city (Johnston, 2022). For instance, the Centurion Hotel has used all its resources to address the increasing water levels in the lake in collaboration with the local municipality (Nhamo & Chikodzi, 2021). This is one of the typical examples that businesses and other stakeholders face when it comes to flooding in the area.

According to Nhamo and Chikodzi (2021), the lake was not supposed to be silted because of the recent floods, but the CoT was supposed to maintain the lake for the past 15 to 20 years removing the silt. The silt blocked the flood waters as they rose, which forced water back into the hotel from the lake (Nhamo & Chikodzi, 2021). Due to the lack of maintenance by the municipality, one alternative suggestion that needs to be implemented is the removal of heavy silt and debris from the lake, as proposed by the CoT (Mahlokwane, 2021; Nhamo & Chikodzi, 2021). The purpose of this alternative is to clear debris and ensure that water flows smoothly from the upper catchment to the lower catchment.

The CoT planned to drain the lake to allow for the removal of all silt and other debris from the lake (Nhamo & Chikodzi, 2021). Nhamo and Chikodzi, (2021) continue to explain that this process to remove the heavy silt and debris from Centurion Lake started in February 2020. However, the City failed to continue this task due to COVID-19 pandemic as lockdown was implemented throughout South Africa and globally. Moreover, there were plans to also implement the Centurion Lake Rehabilitation Plan for the area to address the extensive damage that flooding would cause in the identified hotspots, this decision was made following the appointment of an engineering consultant to review the plan. In addition, the Hennops River Forum, a discussion forum with participants from local governments, government environmental departments, members of academia, civic organisations, and other experts, is an excellent place to start when looking to address the flooding dilemma in Centurion (Nhamo & Chikodzi, 2021). Drawing from this background, it is therefore necessary to explore what preventive measures has the CoT put in place to prevent or minimise the impact of floods whenever they occur, and how effective are these measures.

1.3 Problem Statement

The Hennops River is flowing towards the north of Centurion interacting with various urban areas and infrastructure along its pathway. When there is heavy rainfall, the river creates flash floods, which then lead to surface water floods as a result of the blockage of stormwater drainage systems next to low-lying bridges and heavy silting and debris from the Centurion Lake. Another crucial component contributing to these floods is the area's ancient floodplain along the Hennops River, which has not been protected by urban planning and land use management policies practised by the local municipality (Jack, 2022). In addition, the wetlands located along the upper catchment of the Hennops River are not protected, and these are some of the key elements that control flooding in urban areas (Nhamo & Chikodzi, 2021). These issues are incongruent with the anticipated flood control capabilities of the blue-green and grey infrastructure systems. Within this integrated infrastructure framework, urbanisation and the neglect of disaster risk reduction strategies have exacerbated flooding vulnerabilities. A compelling argument posits that Centurion's urban development trajectory has disregarded the historical floodplain of the Hennops River. This oversight is evidenced by the concentration of identified flood hotspots within ancient floodplains, reaching elevations of 50-100 meters, which were overlooked by previous administrations prior to the establishment of urban planning and land use management regulations.

At the heart of this research lies an inquiry into the flood vulnerabilities impacting Centurion, the existing mitigation measures implemented to reduce flood risk and impact within the area, and the institutional barriers hindering the effective implementation of preventative measures. Key contributing factors to the uncontrollable flooding in Centurion include:

- Blockage of stormwater drainage systems.
- Accumulation of debris from Centurion Lake.
- Insufficient protection of wetlands in the upper catchment.
- Inadequate integration of blue-green-grey infrastructures.
- Rapid urbanisation in both the lower and upper catchment areas, exacerbated by encroachment into the floodplain along the Hennops River, as evidenced by identified hotspots.

This research investigation seeks to propose preventative measures to address flooding in Centurion through the strategic application of urban planning, land use management, and disaster risk reduction principles.

The significance of this problem is that low-lying bridges when flooded are impacting the livelihoods of the surrounding area crossing the Hennops River and interacting with various urban areas and infrastructure along its pathway. Therefore, the research problem needs to be addressed through the use of urban planning, land use management and disaster risk reduction.

1.4 Rationale of the research

This research aimed to investigate the effectiveness of flood prevention measures implemented by the CoT within the Centurion area. Given Centurion's historical development along the floodplain of the Hennops River, understanding the municipality's approach to local flood mitigation strategies was crucial. Centurion was selected as a case study due to its urbanised character, its location within the floodplain, and the interplay of various factors influencing flood risk, including urban planning, land use management plans, building regulations, the Water Use Licence Policy (WULP), and stormwater management plans.

The research was further motivated by a growing body of scholarly literature emphasising the importance of blue infrastructure and the implementation of non-structural measures in flood-prone areas. This study aimed to contribute to the development of effective policies and recommendations for flood prevention in urban areas similar to Centurion. Potential limitations, such as the influence of external factors on municipal decision-making, are discussed in detail within the methodological procedures in Chapter 3. Ultimately, this research sought to explore and evaluate the specific flood prevention measures employed by the CoT within the Centurion area, with the goal of providing insights that can be applied to other municipalities facing similar challenges.

1.5 Research Aim

The aim of this research was two-fold. First, to investigate prevention measures related to urban planning and land use management regulations that prevent flooding through disaster risk reduction that have been adopted in urban flood-prone areas in the CoT, particularly Centurion. Secondly, the intention of the study was to review effectiveness of these measures in preventing the risk and impact of flooding in the area of Centurion. Furthermore, this study examined the consequences of inadequate implementation of existing flood mitigation plans and the insufficient protection of the Upper Catchment

Areas, which significantly impact the Centurion region. The figures presented below illustrate the extent of flood damage within the area. Moreover, the research aimed to assess the degree to which the lack of maintenance and upgrades to stormwater infrastructure has contributed to the flooding challenges faced by Centurion.

Figure1.3: Flooding by the Hennops River in Centurion (Sefularo, 2022).

Figure 1.4: Flooding by the Hennops River next to the Centurion Hotel, Lenchen Ave N (Thoughts of the Bulldog, 2014).

Figure 1.5: Centurion Area flooded (Oupa Mokoena, 2022).

The images above depict the consequences of heavy rains in the identified hotspots around Centurion. The river overflows, and the drainage pipes are overwhelmed by the large volume of water. As a result, the floods affect residential areas (see Figure 1.3), businesses (see Figure 1.4), and major secondary and tertiary roads in Centurion.

1.6 Research Question and Sub-Questions

What flood risk prevention measures have been adopted and to what extent do these prevent the impact of flooding in flood-prone areas of Centurion in the CoT?

1.6.1 Sub-Questions:

1. What attributes make Centurion vulnerable to flooding?
2. What measures have been put in place to reduce the risk of flooding in the area?

3. What institutional barriers constrain the uptake of adequate flood risk prevention measures?

1.7 Brief Chapter Overview

Overall, the current chapter as the first one for the study, has provided context on flooding and disaster risk reduction at both international and local levels. This further identified the problem investigated. As a result, the rationale, aim and research question have been determined based on the problem statement. Therefore, the upcoming chapters will delve into literature and primary data collection to either unpack the current situation on the ground or present existing prevention measures from the municipality.

Chapter two reviews the literature, understanding key academic works shaping the scholarship on disaster risk management with a particular focus on flooding disasters. It concludes with the conceptual framework that highlights the explanation of the major concepts and relationships that occur between and amongst them.

Chapter three describes the research methodology, in particular, key methods employed to investigate the problem, describes the data collection and analysis instruments, explains the ethical protocols adhered to during the research, and concludes with an explanation of the study limitations.

Chapter four reports on the findings and provides an analysis of these in relation to the conclusions drawn from the literature review and concerning the conceptual framework discussed in Chapter two.

The research report concludes with chapter five, which contains the conclusions drawn from key findings and draws recommendations from the conclusions.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The previous chapter provided context of the study through introduction and background. Centurion has been experiencing several flooding incidents in the past few years, with twenty-nineteen (2019) to twenty – twenty-two (2022), having major incidents. With the change in climate change, there has been more floods in the area but not as anarchic as the previous years. Major vulnerabilities that caused flooding in the Centurion area are due to the lack of maintenance of grey infrastructure, urbanisation, silting and debris, and lack of control over land use policies. In terms of disaster risk reduction, stakeholders such as government entities and spheres of government influence the response, recovery, and prevention of disasters. Building on this introduction, the rest of the chapter is structured as follows: section 2.2 on the unrestricted body of water in urban areas. This is followed by a discussion on disaster risk reduction measures in section 2.3. The breakdown of the Conceptual Framework is in section 2.4, while section 2.5 closes off with a brief chapter overview.

2.2 Unrestricted Body of Water in Urban Areas

Scholars highlight that urban flooding has number of undesirable eventualities having implications on economic activities, access to services and institutions, environmental care. In extreme turn of event, often a loss of life is the resultant (Poussard, Dewals, Archambeau & Teller, 2021; Andreasen, Agergaard, Allotey, Moller-Jensen & Oteng-Ababio, 2022; Novoa, Reyes-Silva, Helm & Krebs, 2023). Moreover, these consequences highlight the realities of flooding on vulnerability of habitant land (Poussard *et al*., 2021; Kundzewic & Pinskwar, 2022).

The contributing factor to urban flooding is extensive urbanisation, which leads to the pressure on existing catchments of urban water sources. This may further be attributed to lack of maintenance and upgrading on drainage systems and related infrastructure (Prokic, Savic & Pavic, 2019; Townshend, 2020; Kundzewic & Pinskwar, 2022). According to Townshend (2020) and Nhamo and Chikodzi (2021), well-established cities equally suffer from ageing and inadequate drainage systems infrastructure as they are normally blocked by litter and debris. This is one of the factors that leads to flooding in inner cities (Townshend, 2020).

Prokic *et al*. (2019) the European Agency on Climate Change has observed a growing incidence of pluvial flooding, which they attribute to the increasing mismatch between

the capacity of ageing drainage systems and the intensified rainfall patterns associated with urbanisation. This view is also affirmed by Townshend (2020) and Kundzewic and Pinskwar, (2022), as they state that urbanisation adversely influences the drainage system, such that old drainage infrastructure is not upgraded, thus exacerbating the effect of flooding. The other two risks of pluvial flooding as described by Prokic *et al*. (2019) is the transportation of sewage that is combined with rainfall drainage as well as the inadequate maintenance of drainage systems in inner urban areas that control debris and solid waste.

Silt-laden water is a global issue that impacts both rivers and dams that are surrounded by human settlements. Examples around the world are the Yellow-River in China, the Ganges and Indus River in South Asia, and the Amazon River in South America (Wu, Feng, Fu, Yin & He, 2023). Silt-laden rivers and dams are the most unstable fertile soils that have a build-up along the floodplains that cause flooding owing to sediments (Wu *et al*., 2023). However, there is a literature gap on river silting with the main concentration shifting towards silting in dams.

According to Pattanapanchai, Shah and Annandale (2002), the control of silting in dams is one of the most difficult processes owing to the build-up of sedimentation in dams that lead to flooding in close proximity to urban areas, in addition to that loss of capacity in the blue infrastructure. Consequently, this negatively impacts the main function of dams owing to structural damage and an increase in maintenance caused by sedimentation. To address this sedimentation, it would be through de-silting which includes flushing, mechanical dredging and or hydro suction to extend the longevity of the dam. Policymakers therefore need to implement management plans and account for the increase in sedimentation in urban areas to control flooding (Pattanapanchai *et al.*, 2002; Kang *et al.*, 2019; Wu *et al*., 2023). In order to de-silt dams and rivers, schedules need to be created by either local government or government entities according to silting management plans.

From the research by Prokic *et al*., (2019), the European Agency has managed to create a three-stage approach to identifying pluvial flooding resulting in flood risk management plans that are aligned to the area. The first step is a preliminary flood risk assessment that should be taken in the area; for instance, assessing the area on the extent of the flood risk and determining the vulnerabilities. The second approach is identifying the area and preparing flood hazard maps and flood risk maps. Lastly, the data collected should be able to allow members within three spheres of government to draft Flood Risk Management Plans for individual urban areas across the country.

Therefore, to address pluvial and fluvial flooding from structural and non-structural measures, components that influence pluvial and fluvial flooding such as green, grey and blue infrastructure in urban areas need to be investigated and then look at disaster risk reduction from a literature policy perspective on flooding on a global and local scale.

2.1.1 Green, Grey, and Blue Infrastructure

This section focuses on green, grey and blue infrastructure. The reason behind including this theme on grey, green and blue infrastructure is that prior research identifies that such infrastructure influences flooding and further provides disaster risk reduction measures. Therefore, the following sections will be defining the key concepts on grey, green and blue infrastructure and understanding the importance of having such infrastructures during flooding and prevention to disaster risk reduction in urban areas.

Grey infrastructure is the traditional mode of urban stormwater management techniques that include stormwater pipe networks, storage tanks and pumping stations, which is a combination of concrete and steel within the structure (Axelsson *et al*., 2021; Wang, Liu, Mei, Wang & Lu, 2022). For instance, grey infrastructure is systems that are underground and actively assist with the drainage of rainwater within urban areas (Wang *et al*., 2022).

Recent studies by Axelsson *et al.,* (2021) and Novoa *et al.,* (2023) have indicated that there are solutions to reusing grey infrastructure to benefit the prevention of urban flooding. Firstly, low-impact development (LID) approach will prevent the runoffs within urban areas and address the minimal urban spatial planning regulations relayed to stormwater management. Furthermore, the need to look at various flood prevention measures from an urban stormwater management side is critical before introducing disaster risk reduction. In addition, urban stormwater management is a type of disaster risk reduction in urban areas on grey infrastructure because the need to understand spatial planning and development control is important within this study. As urban stormwater runoff increases, more concerns arise such as water pollution and flood disasters changing urban living (Zhang *et al*., 2021). Notably, grey infrastructure would collect rainfall water through stormwater systems such as a combination of extraneous water, wastewater, and stormwater (Novoa *et al*., 2023). Nevertheless, there is a need to increase capacity in the network because of the excess of water during the rainy seasons. Furthermore, this exposes how vulnerable and high-risk urban areas are because of urban drainage systems, which the systems negatively impacted by urbanisation (Novoa *et al*., 2021). For instance, in China, the increase in urban population means that more grey infrastructure needs to be built to accommodate more

people (Zhang *et al*., 2021). Over and above that, blue infrastructure such as wetlands are being developed with hard infrastructure.

Secondly, urbanisation comes with challenges from both blue and grey infrastructure. The challenge is that the subsurface has been dominated by hard structures such as residential areas and other infrastructural properties that increase surface runoff. Therefore, this causes the inability of traditional urban drainage systems to accommodate these new changes in urbanisation (Li & Zhang, 2021). This means that these hard structures such as pavements, roofs and concrete surfaces have sealed off natural soils to process natural infiltration and evapotranspiration and transformation of rainfall into runoff (Qin, 2020). This has led to a lack of regulating development in terms of accommodating more space for maintenance and upgrading of infrastructure to control floods and flow, water improvement and water reuse in cities (Li & Zhang, 2021).

Qin (2020) identified the following regulation plans to address urbanisation, Integrated Urban Water Management, Sustainable Urban Drainage Systems, Sponge Cities, Active Beautiful Clean, Low Impact Development, and Water Sensitive Urban Design. In the case of this investigation, the key approaches that could be related to South Africa would be LID in cities. This will also feed into the development planning measures side of how to prevent urban flooding in cities. There is blue infrastructure, which refers to wetlands, ponds and many other water bodies in cities (Wang *et al*., 2022). Green infrastructure decentralises grey infrastructure practices by simulating and regulating the natural hydrological cycle process in urban areas in terms of reducing or delaying stormwater runoff and absorbing water (Axelsson *et al*., 2021; Wang *et al*., 2022), which is the main concept for this section of the report to understand ways on reducing stormwater systems runoff.

Besides, various scholars emphasise that there is a combination of blue-green infrastructure that provides natural solutions for controlling urban flooding. This was essential as it would be beneficial in the long run for stormwater management systems. Axelsson *et al*., (2021) are of the opinion that blue-green infrastructure was the best flooding management system, it integrated natural components that would be able to absorb, filter or delay rainfall volumes, thereby preventing urban flooding in the context of 21st century urban growth. Additionally, this sort of infrastructure was regulated under stormwater management systems which benefit urban green space components such as economical, ecological, technological, and social elements (Axelsson *et al*., 2021).

Blue infrastructure such as wetlands are key flood control tools that we underestimate as professionals. As a result of continuous urbanisation, blue infrastructure is replaced

by imperious surfaces that cause severe flooding problems in urban areas (Taug, Leon & Kavvas, 2020). Therefore, incorporating the dynamic of wetlands within urban areas is essential to control flooding. Compared with Axelsson *et al.* (2021), Nhamo and Chikodzi (2021) share similar sentiments thereby placing an emphasis on wetlands as a source of flood attenuation such that the mechanism is able to absorb rainfall water and release it into surrounding rivers. Likewise, Taug *et al*. (2020) raise the same sentiments that wetlands are one of the flood preventions to solving urban flooding. In such a way that wetlands control excess stormwater and reduce the rise and volume of flows into rivers downstream. Taug *et al.* (2020) allude to using the watershed approach, to attenuate flooding by prioritising flooding upstream and or in highly densified areas.

However, both Taug *et al.* (2020) and Nhamo and Chikodzi (2021) argue that previous literature lacks the importance of wetlands in terms of their location and size. For instance, in Belgium, it has been determined that the size of a wetland determines a greater attenuation of the system (Taug *et al.,* 2020). As a result, if there are more wetlands upstream in terms of size and location, they provide a greater attenuation impact on water levels downstream. However, the majority of wetlands are either removed because of development purposes and or located far from an area that experiences flooding (Taug *et al*., 2020).

Nonetheless, the study by Wang *et al*. (2022) concur with Axelsson *et al*. (2021) on the benefits of green infrastructure on urban green space that mitigates urban flooding. However, there are cases whereby green infrastructure has some setbacks in terms of controlling urban flooding. The implementation of green space could be limited in urban areas because of urbanisation and limited space for the development of catchment areas (Axelsson *et al*., 2021). As a result, this kind of infrastructure would work in small and medium-scale urban areas according to Axelsson *et al.* (2021). For instance, Michigan City in the US implemented the Sponge City concept which is a Chinese prevention to urban flooding based on green infrastructure. However, this concept was not as successful in Michigan City because the success rate was only 13.8% (Axelsson *et al*, 2021). This is a disadvantage because not all plans can work globally because of the infrastructure and landscape of the area.

Therefore, one could acknowledge that urban flooding prevention is limited in terms of the use of drainage systems. However, Axelsson *et al.* (2021) on the other hand, suggest that green infrastructure could assist stormwater systems in a dense urban area, and this can be implemented through policy and agendas on sustainable city goals. This is key as Kvamsas (2021) highlights that urban flooding can be addressed through

planning and implementation of stormwater management plans. Therefore, urban flooding can be addressed through the use of green-blue infrastructure.

Another solution to urban flooding is the combination of grey, blue and green infrastructure in urban areas. Wang *et al*. (2022) draw attention to the fact that a combination of green-grey-blue infrastructure would have a greater impact because it will focus more on reliability, resilience, and sustainability for a robust urban stormwater management plan and or infrastructure strategy. This would work in such a way that green infrastructure will assist in absorbing water and reducing runoffs. As a result, grey infrastructure will control the flow of rainfall water and blue infrastructure will assist in storing stormwater during floods through the use of wetlands.

Drawing from Kvamsas (2021) study, one conclusion is that the alternative to urban drainage management is green, grey and blue infrastructure owing to the new urban water paradigm that is occurring in urban areas. This approach will assist in addressing growing environmental complexity and uncertainty, technology, and social changes. Therefore, there is a need to understand how various infrastructure development that can be implemented within the urban space towards flood management.

2. 3 Disaster Risk Reduction Measures

2.3.1 Structural versus Non-Structural Measures in Disaster Risk Reduction and Management

Currently, disaster risk reduction and management stems from structural and non-structural measures that are set to prevent, mitigate, and prepare for any impact by addressing vulnerability and the use of technology to reduce risk (van Niekerk, 2006; Ray-Bennett, Mendez, Alam, & Morgner, 2020). Structural measures refer to hard interventions in the form of physical infrastructures used for risk reduction and management, which are based on land use planning and building codes (UN Office for Disaster Risk Reduction, nd; Katoch, 2022). In contrast, non-structural measures exclude physical infrastructure, however, refers to soft interventions such as the use of sharing knowledge, practices and/ or agreements on disaster risks through the use of policies and legislations, laws, public awareness, training, insurance, aid and education (UN Office for Disaster Risk Reduction, undated; Ray-Bennett *et al*., 2020; Katoch, 2022).

Part of the research matter is on non-structural measures to understand prevention measures in disaster risk reduction and management from a policy context. Furthermore,

there is a need to understand which non-structural measures are feasible and effective for managing flooding and other forms natural. A large number of existing studies in the broader literature have identified the following plans and legislative frameworks such as the Hyogo Framework for Action of 2005, the Sendai Framework for Disaster Risk Reduction of 2015, the Yokohama Strategy Plan of Action for a Safer World, the SDGs, Climate Action Plan, and the Paris Agreement on Climate Change. On an international level, these are known as non-structural measures (van Niekerk, Coetzee & Nemakonde, 2020; Ni'mah, Wibisono & Roychansyah, 2021; Nkombi & Wentink, 2022).

Figure 2.1 highlights a detailed perspective of structural and non-structural measures. As indicated earlier, disaster risk reduction and management are categorised into two components, namely structural and non-structural measures. Structural measures focus on green-blue and grey infrastructure meanwhile non-structural which are known as soft interventions focuses on policies, legislation, and agreements. This research examines international and local policies, legislation, and agreements relevant to flood prevention. These instruments, aligned in their principles and mandates, provide a framework for addressing flood risks globally and locally. The following sections will analyse each agreement in detail to understand its significance in mitigating flood hazards.

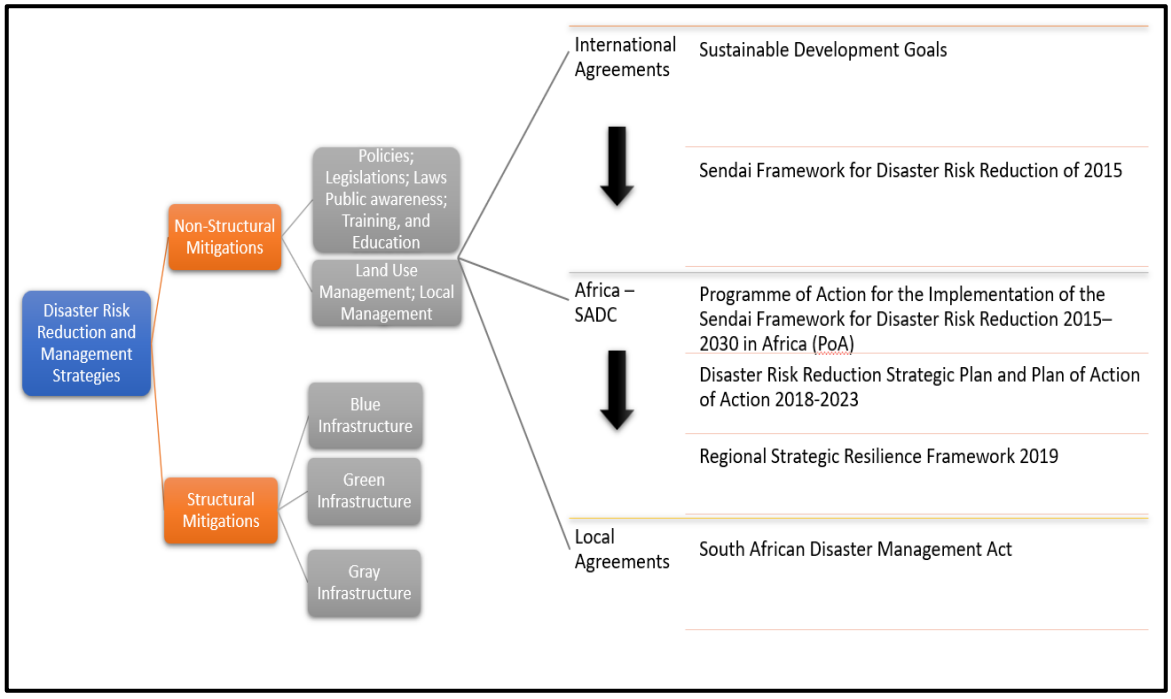

Figure 2.1: Structural Vs Non-Structural Measures in Disaster Risk Reduction and Management

Structural versus Non-Structural Measures in Disaster Risk Reduction and Management on an International Level

At an international level, developmental planning policies are key to implementing and driving a sustainable future across the world. Hence, disaster risk reduction is increasingly becoming a mandate within the levels of government as an imperative international agenda for all to address disasters that impact human lives and the environment (Wentink & van Niekerk, 2017). According to Terblanche, de Sousa and van Niekerk (2022), governance and legislation play a huge role in implementing a sustainable future through disaster resilience and sustainable development in cities. This suggests that the importance of building strong governance against disasters will determine the reduction of disasters through effective leadership, commitments and plans to implement disaster-resilient plans (Terblanche *et al.,* 2022).

Before the Sendai Framework for Disaster Risk Reduction of 2015-2030, there was a Hyogo Framework for Action of 2005-2015. The purpose of the framework was to introduce the understanding of the resilience of nations and communities towards a disaster (The United Nations Office for Disaster Risk Reduction, 2015). In addition, it was a combination and build-up from the following frameworks:

- the International Framework for Action for the International Decade for Natural Disaster Reduction of 1989;
- the Yokohama Strategy for a Safer World; and
- Guidelines for Natural Disaster Prevention, Preparedness and Mitigation and its Plan of Action, 1994 (The UN Office for Disaster Risk Reduction, 2015; the International Strategy for Disaster Reduction of 1999).

From the foregoing framework, the Sendai Framework for Disaster Risk Reduction of 2015-2030 was adopted by the UN in 2015 under the UN Office for Disaster Risk Reduction. The Sendai Framework focuses on addressing disaster risk reduction and building resilience within cities and towns to directly absorb sustainable development and eradication of poverty, integration of disaster risk reduction and resilience into plans, policies, programmes and finances in all levels of government (The UN Office for Disaster Risk Reduction, 2015). Moreover, the framework is positioned to address disaster risk reduction on the basis of disaster risk management (DRM) as an act of providing measures on disaster preparedness, risk management, mitigations, response, recovery, monitoring, and evaluations (Terblanche *et al.,* 2022). It is noteworthy that the

planning aspect of disaster risk reduction enables governments to manage the impact of disasters from a multisectoral perspective, rather than just relying on the national government to implement the Sendai Framework principles.

The preceding section of this chapter, which commenced by defining flooding as a disaster, served as a crucial foundation for exploring potential prevention measures applicable within urban environments. In addition, the study sought to investigate and understand the vulnerabilities that come with disasters such as flooding. The aim was to determine if alignment with the required policies that exist on international, national and local levels can be established. The Sendai Framework is mandated to look at components that address unplanned and rapid urbanisation, lack of land management or implementation and regulations on land use changes, unsustainable uses of green infrastructure, which are some of the causes of disaster and urban areas being vulnerable to disaster (The United Nations Office for Disaster Risk Reduction, 2019).

For the foregoing to happen in terms of implementation processes, there is a need to include stakeholders from various sectors. The United Nations Office for Disaster Risk Reduction (2019) advocates for stakeholder engagements to implement policies, frameworks, plans, other strategies and informal and formal education on disaster to assist in the prevention of disasters across the world.

The Sendai Framework is significant to interlink the sustainable development as a plan with disaster risk reduction because sustainable development is key to addressing vulnerabilities within the environment (The United Nations Office for Disaster Risk Reduction, 2022).

The UN 17 SDGs' main mandate is to eradicate poverty, address gender equality and climate change (The Global Goals, n.d.). It is essential to mention the SDGs because the goals emphasise the need to address climate change in our society. Relating to disaster risk, according to Terblanche *et al.,* 2022, nine out of 17 SDGs' targets address the disaster risk management and highlight the significance of disaster management in development. For instance, target 11.9 on implementing policies for inclusion resources efficiency and disaster risk reduction highlights that:

> *"By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resources efficiency, mitigation and adaptation to climate change, resilience to disasters and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2023, holistic disaster risk management at all levels" (The Global Goals, n.d.).*

Accordingly, the SDGs' mandate on climate change, policies are meant to assist national governments to implement these efficiently and align plans according to their needs of the country. Also, it prioritises the importance of timeframes during this period of implementation to policymakers. Successful international disaster risk reduction hinges upon strong organisational buy-in. This necessitates active stakeholder engagement, public awareness campaigns, a comprehensive understanding of disaster risk management principles, and a thorough investigation of vulnerabilities within infrastructure and vulnerable communities (Terblanche *et al.,* 2022). Therefore, implementation of disaster risk measures will be through investments, planning, policies, and law enforcement from government (*ibid*). Overall, each framework is interlinked and developed to support and form an integration between the Sendai Framework and SDGs from the UN Office for Disaster Risk Reduction Goals to ensure that strategic development plans are effortlessly drafted by national governments across the globe. Figure 2.2 illustrates the importance of interconnection between the Sendai Framework, SDGs and Disaster Risk Reduction and Management.

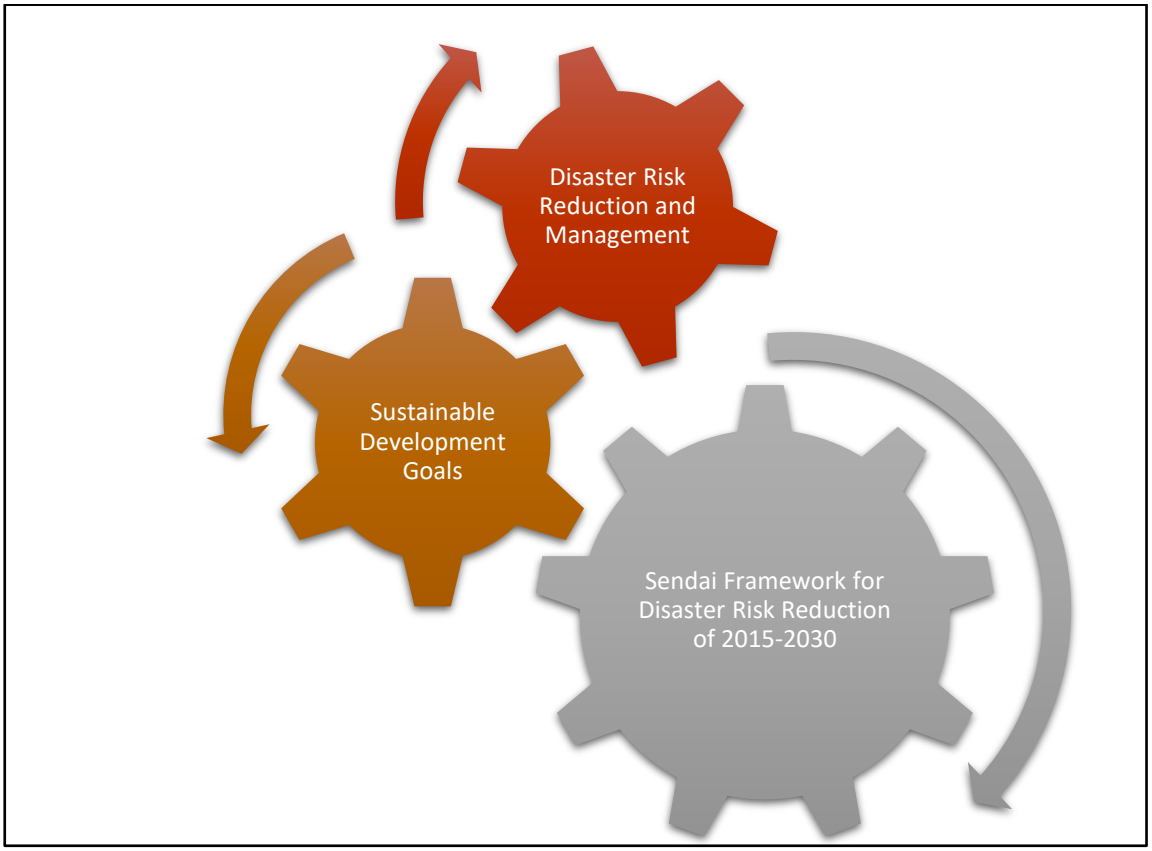

Figure 2.2: From an international goal to a local view of SDGs been integrated into policies such as the Sendai Framework and Disaster Risk Reduction and Management.

Structural versus Non-Structural Measures in Disaster Risk Reduction and Management on a Local Level

Disaster Risk Reduction versus Disaster Risk Management (DRM) in Africa and Southern African Development Community

Over 55 African countries under the African Union (AU) are part of the Sendai Framework for Disaster Risk Reduction (van Niekerk *et al*., 2020). As a result, the AU decided to create the Programme of Action for Implementation of the Sendai Framework for Disaster Risk Reduction, 2015-2023 for Africa, that will assist to further understand the prevention measures of disaster risk reduction from the international framework but based on the context of the African Continent (van Niekerk *et al*., 2020). Therefore, to expedite the implementation process of the Programme of Action for Implementation of the Sendai Framework for Disaster Risk Reduction, the Tunis Declaration on Accelerating the Implementation of the Sendai Framework for Disaster Risk Reduction and the African Regional Strategy for Disaster Risk Reduction were drafted (van Niekerk, *et al*., 2020) was signed by the African countries in 2018 to ensure that all institutions uphold this declaration for the remaining period to 2023.

The African nations focused on the following targets integrating the disaster risk reduction concept into the education system: integration of disaster risk reduction into all development planning documents such as sustainable development plans, programmes, frameworks, plans and processes; funding to be provided for disaster risk reduction programmes; increase the mandate of having plans that focus on testing vulnerability, preparedness, response, post-disaster recovery, and reconstruction mechanism; and increase partnership stakeholders in order to address knowledge management, capacity and networks within the disaster risk reduction frameworks (van Niekerk *et al*., 2020).

For the preceding targets to occur, the AU further decided to breakdown the implementation process into the Regional Economic Communities in order for each region to take responsibility of progress and strategies (van Niekerk *et al*., 2020). For instance, the Southern African Development Community (SADC) as a Regional Economic Community implemented the Disaster Risk Reduction Strategic Plan and Plan of Action 2018-2023 which is aligned to the Sendai Framework for Disaster Risk Reduction and the Programme of Action for Implementation of the Sendai Framework for Disaster Risk Reduction, 2015-2023 for Africa. Moreover, van Niekerk *et al.* (2020) highlighted that SADC included the Regional Strategic Resilience Framework in 2019 that is also aligned with the Disaster Risk Reduction Strategic Plan and Plan of Action.

From the foregoing, I conclude that the priority from each plan is to focus on implementing this goal of disaster risk reduction in Africa.

Disaster Risk Reduction versus Disaster Risk Management in South Africa

The Disaster Management Act No 57 of 2002

This sub-section of the chapter is directed to the Disaster Management Act based in South Africa and how it was formulated and implemented to date by all spheres of government. Scholars such as Wentink and van Niekerk (2017) and Pelling and Holloway (2006) identified three stages, that occurred during the development of the disaster risk reduction in South Africa. These stages are illustrated in Figure 2.3.

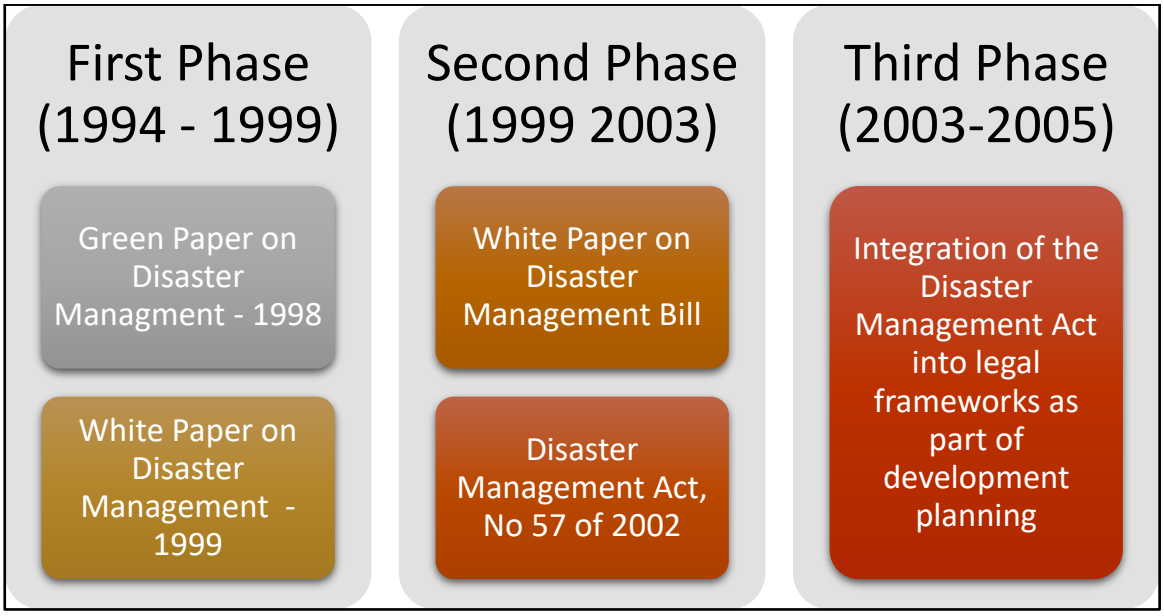

Figure 2.3: Disaster Management Act Stages

Firstly, the first phase was between 1994-1999, which included the development of the policy and stakeholder engagements (Wentink & van Niekerk, 2017). There were two papers, the Green and White Paper that were announced in 1998-1999 on Disaster Management, respectively. The White Paper further gave more detail into the definition of disaster risk management for the South African government.

The second phase between 1999-2003 was the further development and implementation of the Green and White Paper on Disaster Risk Management (Wentink & van Niekerk, 2017). This further led to the White Paper on Disaster Management Bill that now influenced the drafting of the Disaster Management Act of 2002, which was now fully implemented in 2003.

The third phase was between 2003-2005. This period was directed to implement the Disaster Management Act into all spheres of government based on development planning (Wentink & van Niekerk, 2017). Therefore, integration and development planning were supposed to be part of this process according to the Disaster Management Act in order to address disaster risk reduction in local vulnerable communities across South Africa.

A brief background on the formulation of the Disaster Management Act, No 57 of 2002 according to South African scholars Wentink and van Niekerk (2017) and Pelling and Holloway (2006). The following paragraphs underline the importance of the Disaster Management Act. The purpose of the Disaster Management Act is to provide:

> "*An integrated and co-ordinated disaster management policy that focusses on preventing or reducing the risk of disaster, mitigating the severity of disasters, emergency preparedness, rapid and effective response to disasters and post-disaster recovery and rehabilitation"* (South Africa, Disaster Management Act, 2002).

The Act provides guidance to all three spheres of government on disaster management focusing on prevention, reduction, preparedness, recovery, and rehabilitation which are key to addressing disaster risk reduction. In view of this, this investigation is on prevention measures within disaster risk reduction.

The importance of stakeholders within the Act is stressed multiple times, particularly on prevention on a national level with assistance from various stakeholders such as the private sector, organs of state, non-governmental organisations and communities and individuals to assist with disaster risk reduction (Disaster Management Act, 2002, section 20). This was also emphasised in both provincial and local government sections of the Act on the assistance of other stakeholders that are part of creating capacity to address disaster risk reduction. It can be seen that stakeholders play a major role in addressing pressing matters in all three spheres of government. Furthermore, government understands that there is a need to consult from other individuals other than them.

Prevention was determined by the following items levels of risk, assessing vulnerability, capacity on addressing risk to the environment, and monitoring of the actions taken by the state (Disaster Management Act, 2002, section 20 a). This suggests that in order to investigate prevention measures, government needs to determine the risk, vulnerability, human and financial capacity and have a monitoring plan to ensure that all plans are implemented. In that case, local government needs to ensure that they had identified disasters occurring in the municipality to investigate prevention measures.

Subsequently, the Act also reiterates the importance of development and implementation of prevention measures. It also advocates for the integration of prevention measures into the management of high-risk development measures (Disaster Management Act, 2002, section 20 a-d). In that case, individuals need to understand the importance of development planning, implementation, integration and management of prevention measures for disaster to reduce the impact it has on the environment, economy and communities. Nonetheless, disaster is based on vulnerability, risk and capacity from each level of government according to the Act. Additionally, the need for development, monitoring, implementation, and integration brings about the difference into fighting and providing prevention measures to flooding or another disaster that could present itself.

Capacity

According to Wentink and van Niekerk (2017), the necessary infrastructure that needs to be put in place for the implementation of the Disaster Management Act of 2002 has been going at a slow pace. This was owing to the lack of capacity in personnel, equipment, and funding from government. Therefore, the National Disaster Management Centre is unable to directly assist local government where necessary (Wentink and van Niekerk, 2017). The National Disaster Management Centre is there as an organisation/entity to coordinate disaster risk management in the Department of Cooperative Governance and Traditional Affairs, Intergovernmental Committee on Disaster management and National Disaster Management Advisory Forum (Nemakonde & van Niekerk, 2017).

Accordingly, the Disaster Management Act stipulates and advocates for spheres of government to have assistance from external stakeholders in terms of capacity and participation for this reason, monitoring, implementation, and integration from government should not be moving at the pace that it is going. This suggests that there seem to be a recurring theme within the South African government when it comes to challenges that prevent progress in development planning because of lack of capacity. Scholars such as Coetzee, Waldeck, le Roux, *et al.* (2014) highlight that capacity is an issue in local government to plan effectively because of the challenges highlighted by Wentink and van Niekerk (2017), namely, institutional and human capacity in this municipalities, provincial and national government, and government entities.

There seems to be a lack of basics in terms of the disaster risk management structures in South Africa. In addition, lack of capacity from the National Disaster Management Centre, according to Hattingh (2022), indicated that instead of constructing and

neglecting stormwater infrastructure, the focus should be on maintenance by municipalities on cleaning blocked drainage systems. Most importantly, addressing this challenge will significantly resolve flooding in urban areas.

As a result of the lack of capacity, September 1987, April 2019 and April 2022 periods have witnessed similar occurring events of coastal and flash floods happening in Durban due to heavy rainfalls which have left many communities in adverse conditions and loss of life (Nyoka, 2022; Naidoo, 2023). Recently, floods also occurred in the Western Cape impacting households, businesses, and service delivery in the province. The identified causes of these floods were new developments located on floodplains, a lack of enforcement of land use zoning and inadequate stormwater systems (Engelbrecht, Le Roux, Vogel & Mbiyozo, 2022).

Alternatively, it would not be beneficial for stakeholders such as government to approach policy planning using the bottom-up approach to address flooding in human settlements. For instance, during the April 2022 floods in Durban, there were two views on what caused the floodings from the President of South Africa and residents of Durban. The former was of the view that floods were caused by a force of nature, whereas the residents indicated that these flash floods were caused by poor drainage systems and houses in low-lying areas (Nyoka, 2022). Instead of having two contradicting statements from government and the community, the government should approach development planning from a bottom-up approach to address disaster or service delivery in local municipalities. In addition, government needs to create an environment whereby various stakeholders on a local level contribute to the integration of policy briefing in order to provide preventative measures on flooding to bring about disaster resilience in the long-term.

The move from structural measures to non-structural measures minimises a reactive response in a form of a top-down approach and traditional disaster management approach whereas a more proactive approach in disaster risk management will be factual (Nkombi & Wentink, 2022). Ray-Bennett *et al*. (2020) also emphasise that traditional disaster management approaches from a structural measure receive more budget than non-structural measures owing to reactive responses from government officials.

2.3.2 Disaster Risk Reduction versus Disaster Risk Management versus Disaster Management

Previous literature has shown that there is a difference between disaster risk reduction and disaster risk management. Combined disaster risk reduction and disaster risk

management are defined as “understanding disaster risk in all its dimensions of hazard characteristics, exposure, vulnerability, the capacity of people and assets, and the environment” (Yu, Park & Lee, 2021: 1). Disaster risk reduction is defined as “the systematic development and application of policies, strategies and practices to minimise vulnerabilities and disaster risks throughout a society, to avoid (prevention) or to limit (mitigation and preparedness) adverse impact of hazards, within the broad context of sustainable development” (van Niekerk, 2006: 5). In addition, Ray-Bennett *et al*. (2020) also indicate that disaster is inclusive of hazard, vulnerability and exposure of disaster be it short- or long-term.

In contrast, other scholars cite disaster risk reduction as plans and policies that are designed to mitigate hazard losses, build disaster resilience, and contribute to sustainable development (Bruijn *et al.,* 2022; Nohrstedt *et al.,* 2022). The policy objective of disaster risk reduction is to prevent new, reduce existing and manage residual disaster risk (Fortun, 2021). Disaster risk reduction consists of recovery, response, preparedness, and prevention to ensure that policy measures are implemented through policies and strategies within an area.

Disaster risk management is defined as a “systemic process of using administrative decisions, organisation, operational skills, and capacities to implement policies, strategies and coping capacities of the society and communities to lessen the impacts of natural hazards and related environmental and technological disasters” (van Niekerk, 2006:5). The final terminology under disaster risk is disaster management, which is defined as the “administrative decisions and operational activities which pertain to various stages of disaster at all levels” (van Niekerk, 2006: 5). This is achieved through the organisation and management of shared responsibilities and resources before, during, and post-disaster events to protect lives and property from severe disasters (van Niekerk, 2006; Katoch, 2021). The review of the literature further highlights that this concept is aimed at disaster prevention or/and reducing; mitigation; preparedness; effective response; recovery and rehabilitation (van Niekerk, 2006; Katoch, 2021).

2.4 Conceptual Framework

Figure 2.4 depicts the conceptual framework for the study. The reason for the sentiment “*Staying above Water*”, is the reflection of what happens when there is flooding occurring in an area because rainfall water negatively impacts infrastructure, the economy and other elements that might be in the way of runoff. Two concepts were identified during

the course of the investigation, namely, urban flooding and disaster risk reduction management.

The first concept is urban flooding, which consists of pluvial-fluvial flooding, which impacts urban areas in terms of river flooding, flash floods and surface flooding. For countries to resolve these flooding challenges in cities, they must align themselves to sustainable stormwater management plans and protect wetlands or any positive water features from urbanisation.

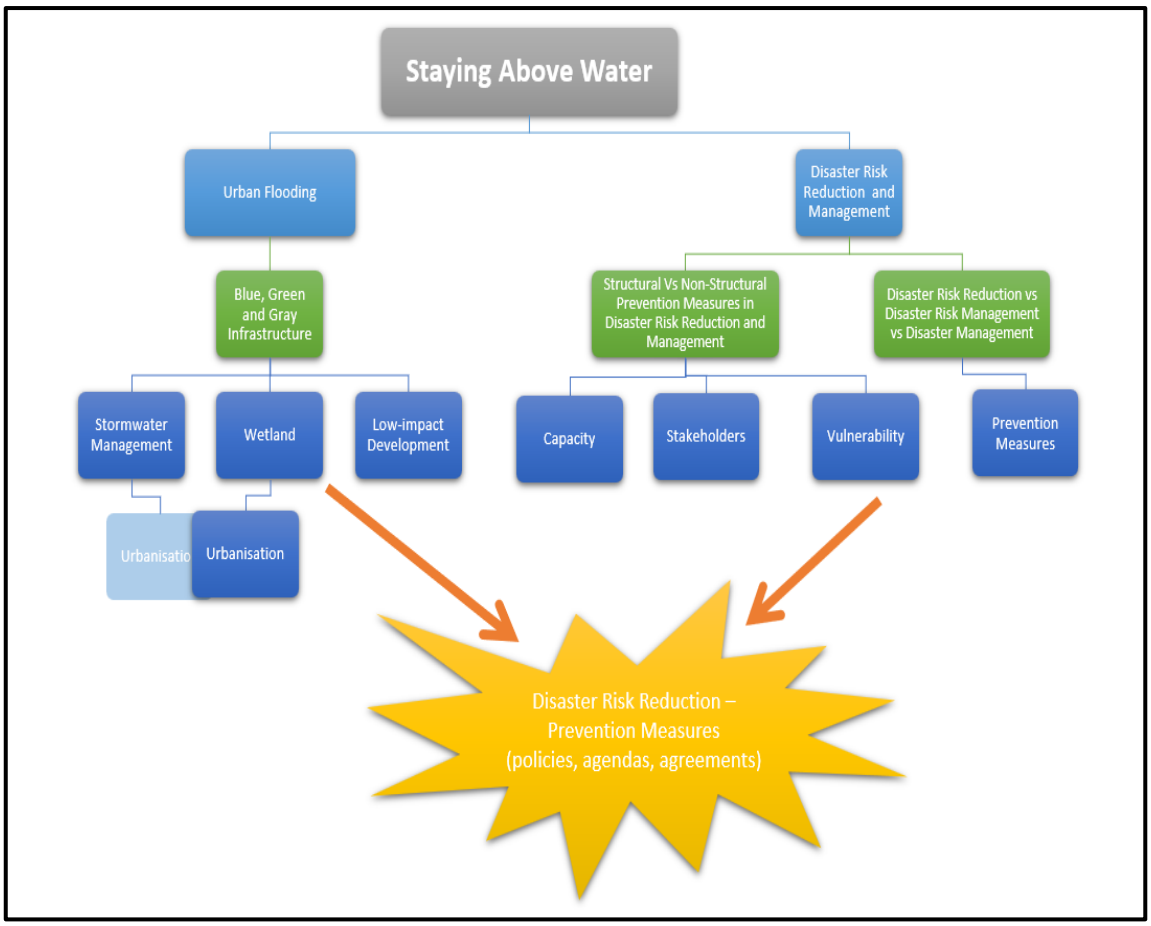

Figure 2.4: The conceptual Framework

Besides, there is an interlink between urbanisation and stormwater management in terms of the positive and negative impact of blue-green and grey infrastructure and sponge cities. In contrast, the LID technique approach is a strategic move to address urban flooding in developing counties. This is due to the fact that local governments are often unable to maintain traditional infrastructure such as stormwater drainage systems and allocate sufficient investment to prevent urban flooding.

The second key concept focuses on disaster risk reduction and management, specifically examining how to address urban flooding through a multi-faceted approach

encompassing prevention, recovery, and response measures. This investigation prioritised the exploration of prevention measures within the framework of disaster risk reduction and management. Identifying key stakeholders involved in addressing urban flooding is crucial for effective data collection. This necessitates an examination of the potential roles and contributions of global non-governmental organisations, international entities, national governments, and other relevant actors in implementing and monitoring mitigation efforts. Furthermore, the research sought to understand how flooding impacts urban vulnerabilities, recognising the significant social, economic, and environmental consequences of these events.

2.5 Brief Chapter Overview

Overall, the risk of pluvial-fluvial floods in the urban areas discussed in this chapter was mainly due to old drainage infrastructure, sewer systems, inadequate maintenance of drainage channels and displacement of excess water to regional water systems (Addei, 2016; Prokic *et al.,* 2019). Different countries and cities have approached flooding prevention measures in different ways, for instance, the Greenest City Action Plan and the 2016 integrated rainwater management plan in Vancouver, the spatial analysis framework in the United Kingdom (UK), and the installation and upgrading of internal stormwater drainages in Bangladesh.

However, strategic spatial planning, constructional measures, risk acceptance, reducing land sealing through policies and land use regulations, and adaptation measures such as green infrastructure and improvement of stormwater infrastructure should be the focus for flooding (Prokic *et al.,* 2019). Disaster risk reduction and management has numerous components in addressing disasters and providing prevention measures in urban areas. Scholars have taken into consideration stakeholders and vulnerabilities to develop effective prevention measures when addressing disaster risk reduction. Understanding the role of reduction and management plays in addressing disaster was of essential significance.

The chapter displayed several themes related to urban flooding and disaster risk reduction and management, blue, green, and grey infrastructure on urban flooding, and the importance of governance and legislation for disaster risk measures. Chapter three discusses the research methodology, in particular, the key methods employed to investigate the problem, discusses the data collection and analysis instruments, explains the ethical protocols adhered to during the research, and concludes with an explanation of the study's limitations.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

The previous chapter investigated several themes related to urban flooding and disaster risk reduction and management based on literature. The current chapter provides a discussion on the chosen research design and data collection processes as part of research methodological procedures to respond to the study's research questions. I employed the thematic analysis method to analyse data from interviews, and policy and legislation reviews pertaining to prevention measures in the area. The rest of the chapter is structured as follows: Section 3.2 discusses the research design undertaken during the study. Section 3.3 follows with a discussion of sampling strategies and data analysis techniques. Reflecting on the data collected during the investigation is unpacked in section 3.4. Section 3.5 presents a discussion on ethical protocols observed throughout the research and the limitations experienced during the course of the research. In section 3.6, the limitations of the study are presented and discussed. The chapter closes off with the concluding remarks to provide a brief overview of what has been discussed.

3.2 Research Design

3.2.1 Qualitative Approach

Owing to qualitative nature of the research question, the chosen research design leaned towards a qualitative research approach, following the investigation and reviewing of a specific area. Based on the following elements being bounded by the place that informed the problem, the discipline background in terms of professionals, the form of data collection in terms of interviews, observations and documents, and the themes captured through cross-case themes, that are related to addressing the research questions (Creswell, Hanson, Plano & Morales, 2007; Creswell, 2013). This implies that either quantitative research or mixed research approaches or methods would not be compatible with the study's research objectives. The rationale behind this choice is because the study does not focus on collecting and analysing numerical data or testing the hypotheses or a mixture of both. Furthermore, taking into consideration of the nature of the formulated research questions and subsidiary questions, nature of the study, resources used, and the objective of the study, qualitative research approach was deemed relevant. Hereof, the collection and analysis were based on the understanding and investigating the implementation process of urban planning and land use management regulations, plans and programmes and disaster risk reduction within the municipality, because of the nature of the study. On that account, qualitative research is

defined as the intent “to generate knowledge based on the human experience” (Nowell, Norris, White & Moules, 2017: 1). This research approach assists in conducting methodical and rigorous information in such a manner that it yields meaningful and usable information. Furthermore, Hammarberg, Kirkman and de Lacey (2016) describe using qualitative research to confront issues of experience, meaning and perspective. In contrast, Nassaji (2020: 427) states that “qualitative research is also systematic, involving a careful process of identifying the problem, collecting, analysing, explaining, evaluating, and interpreting the data”.

This research design was selected to investigate prevention measures related to urban planning and land use management regulations, plans and programmes that prevent flooding through disaster risk reduction that have been adopted in urban flood-prone areas in the CoT, particularly Centurion.

To further unpack the definitions by various scholars and the aim of the investigation above, the following explains why this approach was selected. Firstly, the reason for selecting qualitative research allows one to investigate the research problem that is connected to the broader objectives/aim of the study. In this case, the problem statement highlights, what needs to be investigated in terms of the investigation of the lack of implementation of existing plans, programmes, policies and regulations as well as the problem of lack of protection of the upper catchment areas that is currently impacting the Centurion area because of flooding in the area. Furthermore, the study sought to investigate the extent to which the lack of maintenance and upgrading of stormwater infrastructure impacted Centurion. Therefore, the qualitative approach has allowed one to investigate the problem from the root cause, which is the above. Secondly, the qualitative approach has allowed one to understand the linkage between flooding and disaster risk reduction during the data collection process. Hence, I used qualitative research to further interpret and analyse the data collected.

While the analytical process and data interpretation are self-evident, it became clear that flooding poses a significant global challenge, impacting both urban and rural communities. In the specific context of Centurion, an urban area, flooding has become a recurring issue. As a result, the primary focus has shifted towards recovery and response efforts, neglecting the crucial implementation of long-term preventative measures to mitigate future flood impacts on businesses, residents, and the municipality.

Qualitative research methodologies were employed to investigate effective flood prevention measures in Centurion-based on collected data. This approach facilitated an

in-depth exploration of relevant literature and facilitated engagement with key stakeholders involved in urban flood mitigation efforts.

The research recommendations emphasised the integration of disaster risk reduction measures and the strategic incorporation of green-blue-grey infrastructure, particularly in low-line bridges, as crucial components of a comprehensive solution to address identified flood hotspots within Centurion. Qualitative research typically involves a combination of primary and secondary data collection techniques. As outlined by Hammarberg et al. (2016), these may include small-group discussions, semi-structured in-depth interviews, and analysis of textual and documentary sources.

This research primarily relied on primary data collection through semi-structured in-depth interviews. The research participants were selected from a diverse range of stakeholders, including representatives from the local municipality, government entities, non-governmental organisations, businesses, and academic institutions within the surrounding urban area. These interviews provided valuable insights into participants' perspectives on past flooding events, the implementation of disaster risk reduction plans, and the perceived shortcomings of existing flood prevention measures.

3.3 Sampling Strategies and Data Analysis Techniques

3.3.1 Purposive Sampling

The initial stage of the research requires the option to select objects, participants, or units of analysis. These are sources from which data about the study is sought, whether through questionnaires, surveys, and or observation techniques (Islam & Aldaihani, 2022). Owing to qualitative nature of the study, non-probability sampling strategy through purposive sampling were employed as sampling techniques. Purposive sampling was selected as the appropriate methodology for this research. As explained by Islam and Aldaihani (2022), this approach allows researchers to strategically select knowledgeable and qualified respondents or participants who meet pre-defined criteria relevant to the research objectives. Similarly, Bakkalbasioglu (2020) and Mweshi and Sakyi (2020) concur with Islam and Aldaihani (2022) regarding the selection of specific professionals for interviews. This targeted approach is justified by the participants' specialised knowledge and experience, which are essential for gathering relevant data for the study.

For this research, possessing specialised knowledge within flood and disaster management arena was a requirement. Therefore, it was appropriate to select participants who are knowledgeable and qualified in this field or line of work in flooding

and disaster risk reduction. In addition, the professionals selected knew about what was happening in the international community and locally in South African context. Moreover, they are knowledgeable in terms of Centurion, flooding prevention measures related to urban planning of the area, as well as land use management regulations through disaster risk reduction.

So, the sampling inclusion criteria included professionals like engineers, town planners, disaster experts, and environmentalists. These professionals possess in-depth knowledge of existing flood prevention plans, programs, and policies within the region, as well as the practical implementation of disaster risk reduction measures. This includes the valuable insights of disaster experts, akin to town planners, who play a crucial role in the implementation of disaster risk reduction plans, policies, and programs in various parts of South Africa. Furthermore, the perspectives of environmentalists, particularly concerning their involvement in the rehabilitation of the Hennops River, were considered crucial for this research.

Sample size consisted of four to fifteen research participants. This study acknowledges the limitations of a small sample size, which are further elaborated upon in the limitations and data collection section. Due to late ethics clearance and delayed respondent availability, the final sample size was smaller than initially anticipated. To partially mitigate this, observational data was collected to supplement the interview data. It is important to note that purposive sampling, while suitable for this research, inherently presents limitations. Selection criteria for participants, focusing on highly professional individuals, may have inadvertently restricted the sample size.

Securing interviews with the target professionals proved to be more challenging than anticipated. As noted by Bakkalbasioglu (2020), gaining access to such individuals often requires persistent effort and persuasion. Despite these challenges, consistent email and phone communication strategies were employed to engage potential interviewees from all relevant professions.

3.3.2 Thematic Analysis

This section outlines the analytical approach employed in this research. Thematic analysis, a method for identifying, analysing, organising, and interpreting recurring patterns within collected data (Nowell *et al.*, 2017; Lochmiller, 2021), was selected as the primary analytical technique. Two primary approaches to thematic analysis exist: inductive and deductive. The inductive approach involves allowing themes to emerge

directly from the data, while the deductive approach involves identifying themes based on pre-existing theoretical frameworks or existing knowledge (Caulfield, 2019).

The implication is that identified themes during the analysis stage, subsequently informed the development of research recommendations. The inductive approach offers several advantages, including its flexibility, open-ended nature, and emphasis on constant comparison, enabling the exploration of diverse perspectives and the construction of resilient and alternative futures (Dudovskly, *n.d*; Creswell, 2013).

The open-ended nature of the interview questions further justified the selection of an inductive approach for this research. During the analysis of interview transcripts, key themes emerged, including inadequate maintenance of stormwater drainage systems, rapid urbanisation, floodplain encroachment, wetland degradation, the significance of the upper catchment area, municipal service delivery challenges, the importance of prevention measures, and the crucial role of disaster risk management and reduction.

Thematic analysis revealed several key themes, which are discussed in detail in the subsequent Findings and Analysis chapter. For example, the encroachment of wetlands and the impact of the upper catchment area were analysed together due to their interconnectedness in terms of both impact and potential mitigation strategies. Similarly, urbanisation and floodplain dynamics were examined jointly, drawing upon data collected through interviews and site observations. Grouping data into these thematic categories facilitated the organisation of the findings chapter and ensured alignment with the research objectives.

To enhance data validity and rigor, triangulation methods were employed. This involved comparing data from interviews with observations conducted over a three-month period. Additionally, participant validation was conducted by comparing interview findings with relevant literature and existing knowledge related to the Centurion area. These triangulation methods facilitated robust data interpretation and reporting, particularly given the relatively small sample size.

In conclusion, thematic analysis proved invaluable in organising and analysing the collected data, enhancing data validity through triangulation with literature and observations, and ultimately ensuring that the research findings effectively addressed the study's objectives.

3.4 Data Collection

3.4.1 Primary Data Collection Techniques

Primary data collection was crucial for this research, as it provided valuable insights from stakeholders directly involved in understanding flood dynamics and disaster risk reduction in Centurion. This firsthand data, gathered through semi-structured in-depth interviews, allowed for open-ended discussions and facilitated in-depth exploration of stakeholder perspectives on flood-related issues.

Semi-structured interviews were chosen for their flexibility, enabling spontaneous follow-up questions and encouraging open dialogue between the researcher and interviewees. This approach proved particularly valuable in understanding specific agreements between the municipality and stakeholders, such as the Centurion Hotel.

The selection of the research participants included individuals with diverse expertise, including municipal officials from relevant departments (Emergency Services, Stormwater Management, City Sustainability) and an academic expert from the University of South Africa (UNISA). These interviews provided valuable insights into municipal policies, perspectives from academic research, and a comprehensive understanding of flood-related challenges in Centurion. This research contributes to a limited body of existing literature on this specific topic, offering valuable insights into current municipal approaches to flood risk reduction.

The study included a total of four interviews. Three interviews were conducted virtually via Microsoft (MS) Teams, while one interview was conducted on-site at the Centurion Hotel. Table 3.1 depicts the interview schedule that was followed to guide interview sessions, including those interviews that were planned but ultimately could not be conducted due to unforeseen circumstances, is provided below.

Table 3.1: Participants within each stakeholder group.

Stakeholders	Departments	Addressed as in the report	The purpose for selecting this department	Interview Conducted Via	Interview occurred or not
City of Tshwane Metropolitan Municipality	Emergency Services Department	Participant One	The department was actively involved in the process of providing emergency services to the community of Centurion during the floods and was also aware of the disaster risk reduction and management plans within the city.	MS Teams	Yes
	Department of Stormwater Management	Participant Two	The department was actively involved in addressing stormwater management in Region 4 through maintenance of stormwater and flood management control during floods and also aware of disaster risk reduction and management plans within the city.	Physical meeting at the Centurion Hotel	Yes
	Department of City Sustainability	Participant Three	The department was actively involved in the process of providing prevention measures to the community of Centurion during the floods and was also aware of disaster risk reduction and management plans.	Physical meeting at the Centurion Hotel	Yes
Academia – Experts	UNISA	Participant four	Both individuals are experts in disaster risk reduction and management plans.	MS Teams	Yes
National Disaster Management Center	Department of Disaster Management Center Gauteng	Participant five and six	The centre was actively involved in the process of providing initiative to the national, provincial and local government on the prevention measures to disaster management departments in government. Therefore, being the interlink between the international community, African Union and SADC to address disaster risk reduction and management plans within the city	MS Teams	No

Non-Government Organisation	Hennops Revival	Participant seven	The department was actively involved in the process of providing prevention measures to the community of Centurion during the floods and also aware of disaster risk reduction and management plans within the city	Physical meeting at the Centurion Hotel	No
Academia – Experts	University of North West	Participant eight	Both individuals are experts in disaster risk reduction and management plans.	MS Teams	No
Surrounding Businesses	Centurion Hotel	Participant nine	The Centurion Hotel is directly impacted by the flooding so understanding their prevention measures and if there are any stakeholders that are part of assisting them in rehabilitating	MS Teams	No
	Residential Complexes	Participants ten – to fifteen	Identification of two apartment buildings that are within direct proximity to the river with the second one being abandoned, however with residents who are homeless. Building managers would be the sortable for the study.	MS Teams	No

The initial research plan included interviews with officials from the National Disaster Management Centre, representatives from the Hennops Revival Non-Governmental Organisation, academic experts from the University of North West and the UNISA, and representatives from businesses such as the Centurion Hotel and surrounding residential complexes. Despite persistent efforts to contact these individuals, their participation in the study could not be secured. The absence of these key stakeholders impacted the scope of the research findings and subsequent recommendations. Specifically, this limitation hindered a deeper understanding of:

- Inter-governmental collaboration between national, regional (AU, SADC), and international entities in disaster risk reduction.
- The role of non-governmental organisations, such as Hennops Revival, in providing structural prevention measures for the Hennops River.
- The perspectives of businesses and residents residing in close proximity to the river.

Interviews were conducted primarily via MS Teams, with some on-site meetings conducted to facilitate a deeper understanding of ground-level realities. While scheduling challenges were encountered, all interviews were successfully conducted within a two-month period (October-November). The collected data was subsequently analysed and used to formulate research recommendations.

Observation Method

During the investigation, the observation method was conducted, according to Baker (2006) and Ciesielska, Bostrom and Ohlander (2018), emphasised that observation is a key the research method and data collection method technique in qualitative research. Therefore, direct observation was chosen as the selected observation technique for this investigative study.

The plan of action during the direct observation study was to observe the major flooding hotspots in the Centurion area that were investigated during the first few chapters of the research. Firstly, a detailed description was required to be observed of the site, in terms going to site to observe the major flooding hotspots, which were End Road and Rabie Road, Hendrik Verwoerd Drive, and Lenchen Avenue North. Furthermore, this determined the short and long-term impacts of flooding in the surrounding community and the infrastructure that was used to prevent flooding in the area. Secondly, the method that was used to record the observation, was using a cell phone to capture the various hotspots and infrastructure for data analysis, which will be unpacked later in

Chapter Four. Thirdly, to ensure that everything was accurate for the observation, a site visit was conducted and the semi-interviews with the confirmation of officials indicated the alignment of the hotspots thus the direct observation. Other than the captured pictures, this would further answer the sub-questions in Chapter Four on “what attributes make Centurion vulnerable to flooding” and “What measures have been put in place to reduce the risk of flooding in the area?”

Lastly, in terms of timeframes, this occurred in a space of three months, which allowed one to observe if there are any occurring or common themes that one might have missed during the site-visits. This effective plan of action was suggested by Kumar and Sharma (2023), which I also used their guidelines to undertake a direct observation for this study. In summary, the following occurred during the direct observation, the following was not controlled or manipulated data during the process. Three side visits occurred as a process of observation to investigate the extent of the flooding that impacts this area. As highlighted, three site visits occurred during October, November, and December with the first alone, the second one with the officials from the municipality and the third on my own. The hotspots that were the focus include End Road and Rabie Road, Hendrik Verwoerd Drive, and Lenchen Avenue North. Additionally, the Hartbeespoort Dam in the North West was included as the participants mentioned it a couple of times in the interviews.

3.5 Research Rigour

3.5.1 Rigour – Trustworthiness Criteria

Rigour is a requirement for qualitative research with relevant criteria and appropriate strategies that build on the authenticity, credibility and validity of the research based on trustworthiness, in this case, the question of the reduced number of participants from 15 to 4 participants and if the study is trustworthy (Klopper, 2008; Liamputtong, 2013). This section will focus on trustworthiness based on truth value, applicability, consistency and neutrality. Below is the summary of how the data collection was based on theories from Creswell (2013), Klopper (2008) and Liamputtong (2013) in the case of this research since validity stems from trustworthy research, that is concerned with the integrity of the study with two compounds attached to it being the internal and external validity. In this study, internal validity was used due to the investigation method that was undertaken during the research which leaned to the purporting the data investigated (Liamputtong, 2013). Whereas, external relates to the generalisation of the study thus Ethnography would have directed the research to generalised beyond the research context or aim of the research.

Table 3.2: Trustworthiness Criteria

Trustworthy Standards	Strategies	Criteria Addressed	Defined in terms of the study
Truth Value	Credibility	Triangulation • Methods • Participants	Credibility is established through triangulation of various sources, data collection methods and observation techniques, and scrutiny of gathered sources. This approach enabled me to investigate and review the themes derived from the collected data on the participant's experience and perspective of the problem within the study area.
Applicability	Transferability	• Selection of sources • Saturation of data • Thick description	Transferability strategies are based on the generalises of data from the findings to a larger population. However, according to the literature and findings, this study can be applied to other settings due to the development planning based on urban planning and land use management regulations that impact communities and local government.
Consistency	Dependability	Triangulation • Methods • Participants	Dependability is established through triangulation of various sources, data collection methods and observation techniques, and scrutiny of gathered sources. This approach enabled me to investigate and review the themes derived from the collected data. Furthermore, the findings are well documented in order for other researchers to address similar problems in local government and surrounding areas.
Neutrality	Confirmability	Triangulation • Methods • Participants	The data is based on the literature and primary data collected in terms of the semi-structured interviews and the observation methods that were conducted and not based on my interpretation of the data.

Therefore, the above is based on the evaluation of the provided rigour of the data collected during the qualitative research to assist with the trustworthiness of the study.

3.5.2 Inclusive and Exclusive Criteria

This section of the research is based on the data collected during the investigation to develop and address Chapters 4 and 5 of the study. It discusses the inclusion and exclusion criteria used during the data collection process ensuring that the data is not generalisation, or biased, and it engages participants effectively. Furthermore, it also focuses on the accessibility of the data.

Table 3.3: Inclusive and Exclusive Criteria

Characteristics	Inclusive Criteria	Exclusive Criteria
Study Population	National, provincial and local government officials who are involved with flooding and disaster risk reduction in the CoT, Gauteng and South Africa	Official excluded from CoJ and CoE
	Urban/Town and Regional Planners, Engineers, Disaster Management experts and Environmental experts that are familiar with disasters within the Centurion and within their field or line of work.	Residents from the CoJ or/and CoE or outside of the floodline.
	NGO's within the Centurion area that focus on flooding in the area.	NGO's outside of the Centurion area.
	English Language	Sources not in the English language
	Building Managers working within the impacted buildings by the flooding in the Centurion area.	

Nature of the study area	Centurion is the study area in terms of the prevention measures related to urban planning and land use management regulations	Prevention measures outside of Centurion in terms of other cities and municipalities that are not similar to the situation in Centurion.
Time period	Reviewed articles from 1991-2024	
	Participants with more than five years' experience	Participants not less than five years.
	Policies, programmes, plans, and legislations implemented within the last three to 30 years.	Policies, programmes, plans, and legislations implemented not the last three to 30 years.
Demographic profile of the research participants	Gender both female and male	
	Education level, all participants had high institutional qualifications	
	Geographic location is aware of the location in Centurion.	Participants with no knowledge of the location of Centurion.
	Age is based on adults and/or the older adult population	Children and young people below 21,

	Employment status working with National Disaster Management Centre, NGO, academic experts from the University of North West and the UNISA, CoT, and surrounding business	Employment from other municipalities or other residences and surrounding business outside of the flood line.
Methods	Qualitative methodology	Quantitative methodology
	Primary data collection	Secondary data collection
	Sources based on prevention measures related to development planning	
	International and local literature	Sources not in the English language
	Observation method	

3.6 Ethical Considerations

Ethical clearance from the University of the Witwatersrand Ethics Clearance Committee was essential for this research involving human participants. The ethics application process required the submission of comprehensive documentation, including the research proposal, research instruments, participant information sheets, permission letters, and consent forms. Ethical clearance was granted on October 23, 2023, which unfortunately occurred relatively late in the research timeline.

Following ethical clearance, interviews were conducted with key stakeholders, including three municipal officials from the CoT (Departments of Stormwater Management, City Sustainability, and Disaster Management and Public Information) and an academic expert in disaster risk reduction from the UNISA.

Maintaining participant anonymity was of paramount importance to protect participants from potential legal repercussions and to minimise any undue attention. Strict adherence to ethical protocols was maintained throughout the research process.

3.7 Limitations and delimitations

Two primary limitations were encountered during data collection. Firstly, the three-month municipal strike (27th July – 10th November 2023) significantly delayed the research process. This disruption impeded the timely acquisition of necessary approvals from the municipality to conduct interviews with municipal officials. Secondly, securing interviews with other key stakeholders, including representatives from the National Disaster Management Centre, the Hennops Revival NGO, academic institutions, and local businesses, proved challenging despite persistent efforts through email and phone calls. Appendix F provides documentation of these communication attempts.

The absence of these stakeholders limited the scope of the research, particularly in exploring the role of inter-governmental collaboration, the contributions of non-governmental organisations, and the perspectives of businesses and residents directly impacted by flooding.

To mitigate these limitations, the research focus shifted towards gathering detailed insights from municipal officials and an academic expert on flood prevention measures within Centurion. All participants provided informed consent, ensuring the confidentiality of their identities throughout the research process. Interview data was securely stored on Google Drive with password protection and will be deleted after five years.

The research participants' confidentiality was ensured through the use of pseudonyms and secure data storage on Google Drive. All interviews were conducted within a two-month timeframe (October-November) utilising a combination of MS Teams meetings and on-site interviews. Despite these challenges, the research successfully gathered valuable data from key stakeholders, providing valuable insights into flood risk reduction strategies within the Centurion area.

3.8 Brief Chapter Overview

This chapter outlined the methodological approach employed in this research, including the rationale for selecting a qualitative research design. The qualitative approach, with its emphasis on in-depth exploration and understanding, facilitated the collection of rich and nuanced data from key stakeholders. Purposive and convenience sampling techniques were employed to select research participants with specialised knowledge and experience relevant to the research objectives.

Ethical considerations were paramount throughout the research process, ensuring participant confidentiality and adherence to all ethical guidelines. While challenges were encountered, including delays due to the municipal strike and difficulties in securing interviews with all intended participants, these obstacles were addressed through persistent efforts and adjustments to the research plan.

The methodological approach outlined here has guided the entire research process, ensuring the collection of robust and reliable data to address the research questions. This chapter has laid the groundwork for the subsequent analysis and discussion of findings presented in Chapter 4.

CHAPTER 4: FINDINGS AND ANALYSIS

4.1 Introduction

The previous chapter outlined the qualitative research approach employed in this study, including the rationale for selecting interviews as the primary data collection method. The chapter also detailed the ethical considerations, challenges encountered during data collection (such as the municipal strike), and the strategies implemented to overcome these challenges This chapter presents the findings derived from the primary data collected during the research. Data was gathered through in-depth interviews with four participants: three municipal officials from the CoT Metropolitan Municipality and one academic expert from the UNISA. Additionally, three site visits were conducted to further inform the research. Therefore, the current chapter aims to provide a comprehensive analysis of the collected data, drawing meaningful insights into the challenges of flood risk management in Centurion and identifying potential avenues for improvement.

This chapter delves into the findings and analysis of the results. The rest of the chapter is structured as follows: Section 4.2 begins with a brief presentation of the demographic profile of the research participants. Section 4.3 follows next and presents the key themes that emerged from the thematic analysis of the interview data. Section 4.4 discusses the implications of the findings in line with the literature, while Section 4.5 provides a brief overview of the chapter's key takeaways.

4.2 Findings and Analysis: Key themes emerged from thematic analysis

The analysis yielded four key themes that are directly relevant to the research questions. These themes were identified through a rigorous examination of the collected data, incorporating insights from both existing literature and the unique experiences and perspectives gathered during interviews with stakeholders impacted by flooding within the Centurion area.

4.3.1 Low-Impact Development Measures

Prior to delving into the thematic analysis of findings, it is crucial to examine existing LID measures implemented by the municipality. LID practices are fundamental to effective spatial planning and play a vital role in mitigating urban flooding. Table 4.1 presents a comprehensive overview of the identified LID measures within the municipality, analysing their relevance in the context of urban flooding, wetland conservation, and

flood prevention strategies. This analysis considers the integration of these measures with existing environmental and disaster risk reduction plans. The table provides detailed descriptions of key measures currently implemented by the municipality to reduce flood risk, including maintenance plans, flood mitigation plans, the Water Use Licence (WUL) Policy, and stormwater management plans, within the framework of LID principles

Table 4.1: Local impact development plans approach in the CoT in terms of flooding.

Policies and Regulations	Findings	Analysis
Land Use Management		
CoT – Centurion Town Planning Scheme (Urban Planning)	The town planning schemes define flood lines as "means the flood line referred to in Article 169 A(1)(a) of the Water Act No. 54 of 1956 and any amendments thereto." (Centurion Town Planning Scheme, 1992: 3) Referencing to Article 169 A(1)(a) of the Water Act No. 54 of 1956, mentions that layout plans need to be approved according to any water course with a known channel and water catchment area must take into consideration the maximum level to reach on an average of every twenty years by flood-waters on the land. Furthermore, when taking into account low-lying land without any drainage systems the flood line should be an average of every fifty years by such water on land.	Based on observations and findings from the CoT town planning scheme, it appears that the municipality approved the development of the township along the Hennops River, only taking into consideration an average of 20–50-year flood line from the water course. Participant Two also confirmed this and highlighted that the municipality took a risk by permitting property developers to build within the flood line based on the old town planning scheme for Centurion. ***"I'm assuming their risk would have been informed by Hydrological studies and the studies would never ever have anticipated What was going to happen upstream? No one anticipated the explosion of Tembisa, no one anticipated the invasion of the Koolfontein… wetlands that were invaded in the City of Johannesburg No one Anticipated the illegal sand mining that was going to take place. So, if you need to look at flooding here, you have to take into consideration What has happened upstream"*** Based on the risk taken by the municipality, the current change to an average of 100-year flood line does not protect properties along the Hennops River in Centurion. Therefore, the current town planning scheme does not accommodate the existing infrastructure and the never-expected growth in the CoJ and the CoE.
Tshwane Town Planning	The town planning schemes define flood lines as "defined in Section 144 of the	

Scheme, 2008	National Water Act , 1998 (Act 36 of 1998) including any other lines that the Municipality may require." (2008:15) Referencing Section 144 of the National Water Act , 1998 (Act 36 of 1998), highlights that layout plans should show a maximum level by floodwaters on the average of every hundred years.	
Disaster Risk Reduction		
CoT Disaster Management Plan, 2011	The purpose of the plan is to discover comprehensive disaster risk assessments within the municipality, furthermore, advocates for resilient communities in the city.	
WUL Policy/ National Water Act 36, 1998	Schedule 5: 4 highlights the regulating watercourses through cleaning its channels; rehabilitation of watercourses through reducing the risk of damaging the surrounding land to avoid alterations through natural causes according to the Act.	Based on the collected data, the municipality is currently utilising the WUL Policy to rehabilitate and realign the Hennops River in the Centurion area as a catchment area. The rehabilitation includes desilting the Centurion Dam to ensure proper water flow from the Hennops River to the dam and back into the river.
City Support Programme	The programme aims to improve capacity to municipalities and enable intergovernmental fiscal systems and policy environment to advocates for transformation in the city.	In terms of the data collected, the municipality is currently engaging the National Treasury to address flooding in the Centurion area. The aim of inviting the City of Johannesburg and the CoE in discussions to address the upper catchment area, as highlighted by Participant Two. "***National Treasury and World Bank through the City Support Program are working with the three metros to put a***

		funding proposal together to get the funding that we need to fix the Kaalspruit."
Gauteng City Region – Over Arching Climate Change Response Strategy and Action 2020	Safeguard and rehabilitation of wetlands in urban area is a priority through the use of municipal planning, building approvals and Environmental Impact Assessment (EIA) regulatory schemes in other to improve water management	The strategy and action plan go hand in hand with the WUL Policy and Tshwane Town Planning Scheme in addressing the encroachment of wetlands and rehabilitation of the Hennops River.
Kaalspruit Climate Resilient Catchment Management Plan	The plan is based on managing climate change impact in the CoJ, the CoT, and the City of Ekurhuleni. The Kaalspruit Catchment within the three municipalities impacts the Tembisa, Midrand, Irene and Centurion areas. Whereby the overall blue infrastructure is negatively impacted because the water quality has deteriorated, built impervious surfaces around the catchment area, and the aquatic biota (Nemai Consulting, 2021).	According to the plan, this will benefit the upper and lower catchment areas in terms of reducing flooding, urban drainage systems, and protecting blue and grey infrastructures according to their project announcement (Nemai Consulting, 2021)

4.2.2 Encroachment of Wetlands in the Upper Catchment

The first theme identified during the investigation highlights the critical role of blue-green-grey infrastructure in mitigating flood risks. This theme specifically emphasises the crucial role of wetland protection within surrounding areas. The impact of climate change has necessitated a transformation in development planning policies to address the evolving flood risks in urban areas. However, a lack of such transformation has resulted in inadequate wetland protection, leading to significant wetland encroachment due to urbanisation, illegal mining, soil erosion, siltation, and debris accumulation.

Findings from interviews with municipal officials and experts underscored the critical role of blue infrastructure, particularly in the context of urbanisation, sedimentation, and the spatial distribution and size of wetlands. Urbanisation has emerged as a primary driver of wetland encroachment, leading to a significant decline in wetland areas and consequently diminishing their capacity to regulate floodwaters within the Centurion region.

Research Participant Two emphasised the limited number of remaining critical wetlands within the CoT by stating that ***"before we overdeveloped, we had over 300 wetlands. When you have wetlands, you're not going to have flooding when you choose to build on a wetland and kill a wetland you're going to flood."*** This highlighted the critical need for enhanced wetland protection measures.

It was quite essential to notice that the research participant mentioned that without wetlands there is no control of flooding in an area. Currently, that is what is happening in the Centurion area, there is no control over encroached wetlands because of urbanisation.

This concept of absorbing, filtering and delaying the process of water flow during floods does not exist because of the upper catchment being impacted by encroachment with the following activities happening illegal mining and dump site, and building formal structures on wetlands such as housing for human settlements and malls for businesses this was affirmed by the Research Participants Two, Three and Four. Therefore, ***"filtering system is not there anymore, so I think part of the rehabilitation of the Kaalspruit, is to bring back that wetland to improve the embankments,"*** highlighted by Research Participant Three which we need to keep in mind.

Based on the primary data collection in this area of study, it is clear that wetlands are not prioritised by government bodies and community members. This is evident from the responses of the participants regarding the encroachment of wetlands. Centurion experiences flooding due to activities in the upper catchment.

As far as urbanisation is concerned, community members have been building in wetlands and flood line areas. Now in this case, it is the Tembisa area, which is in the CoT, according to Research Participant Four, community members invading vacant wetlands for human settlements, dumping sites as well as illegal sand mining. As a result, this is no longer an infrastructure that absorbs, filters and delays the process of water flow during the rainy session because these activities have been causing a build-up of rubbish from the human settlement. Debris from illegal sand mining flowing into the Hennops River causes a build-up of sand in the river, which, also impacts the

Hartbeespoort Dam through the flow of water that contains debris from the Hennops River to the Hartbeespoort Dam at the end of the channel. Additionally, the Hartbeespoort Dam is impacted by invasive alien plants, which is a huge issue that I observed when I visited the dam.

Urbanisation is an issue in the upper catchment area being in the CoJ and the CoE that are impacting Centurion and extending to the North West Province. Figure 4.1. illustrates how the Kaalspruit River flows from the Tembisa area, through Olifantspruit River then Irene to the Hennops River impacting the study area Centurion then leading to the Crocodile River that connects also the Swartspruit River into the Hartbeespoort Dam. Due to urbanisation, more needs to be done from a provincial level to merge and integrate policies that focus on flooding in terms of urbanisation and the control of debris and silting in rivers and dams in the Gauteng and North West province.

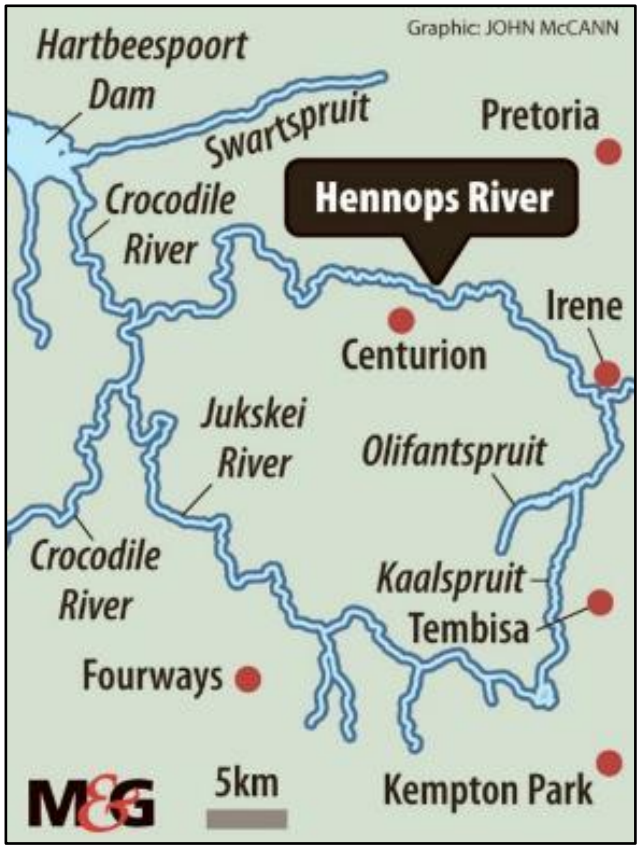

Figure 4.1: The lower and upper catchment areas (Bega, 2021)

Secondly, from the interviews, I observed that wetlands play a critical role in controlling flooding, regardless of their location and size. More awareness to the public of the importance of wetlands and their location There is a need for more comprehensive prevention policy measures to raise awareness among municipal officials about the importance of wetlands in urban areas. This includes the drafting and development of

management plans for wetlands in both the upper catchment and lower catchment areas. Planning policies should mandate the reclassification of wetlands as critical infrastructures in the development planning stages of Spatial Development Framework and Integrated Development Plans (IDP) within municipalities. The reason for this is that Pattanapanchai *et al.,* (2002), Kang *et al.,* (2019) and Wu *et al*., (2023) mention the importance of implementing policies and management plans that focus on wetlands across the board.

Therefore, one could argue that Centurion is vulnerable to flooding because of the upper catchment, whereby urbanisation is an issue that causes encroachment of wetlands and sedimentation in the rivers and dams. Furthermore, the location and size also influence how vulnerable an urban area can be to flooding as well. Additionally, the lack of comprehensive planning policies and management has made urban areas vulnerable to flooding.

However, the municipal officials highlighted that there are plans to ensure the protection of wetlands. In contrast, Research Participants two, three and four hinted that the local government was not effective in their attempt to stop the illegal sand mining, invasion of wetlands and encroachment onto the flood lines because of the mushrooming informal settlements in Tembisa, CoE. The debris from these activities impacts the Kaalspruit, Olifantspruit and Jukskei River, all of which lead to the Hennops River. The Crocodile River and the Hartbeespoort Dam are particularly affected by the delayed reaction from the municipality because of the lack of awareness of what is happening in the upper catchment area.

The municipalities in the upper catchment are not enforcing their Town Planning Scheme on the protection of wetlands and restrict the building lines of construction outside of the 100-year floodplain according to Section 144 of the National Water Act, 1998 (Act 36 of 1998). Hence, the Kaalspruit catchment has more negatives due to the illegal activities happening in the surrounding area than positives affecting the water flow of the river in the Centurion area and causing severe flooding.

4.2.3 Service Delivery for Grey Infrastructure is Lacking in Urban Areas.

The second identified theme from the literature review and data collection is infrastructure. This is in reference to bridges and stormwater infrastructure systems that either control the flow of water and a source of prevention for flooding. The elucidation behind this is that stormwater infrastructure systems as a grey infrastructure are there

to control the flow of water on hard surfaces within the city; however, this is not the case. Similar to urbanisation's impact on blue infrastructure, I have noticed that the expansion of new developments on open spaces within the urban edge does not always accommodate the upgrading of existing grey infrastructure within the urban area. This is the case with Centurion at the moment whereby lack infrastructure upgrading is problematic because of urbanisation and what is happening in the upper catchment with encroachments of wetlands.

In that case, from the data collected on stormwater management and development planning on flooding, with reference to Centurion and stormwater management, there seems to be a huge issue in the inner city of Centurion. The reason behind the blockage of drainage systems within the inner city according to Research Participant four is the "…***waste management plastics and other debris…"*** This has caused huge blockages in the stormwater drainage systems during heavy rains. Consequently, this leads to evidence of lack of maintenance from the municipality's side on keeping the system clean for the proper flow of water. With reference to lack of maintenance, Research Participant four makes mention of this further implying that it is possible that most drainage systems are not maintained, and this will be evident in the overwhelmed stormwater drainage systems during heavy rains "***So, there's ample evidence when it rains that not the drainage has not been regularly maintained and some of it we don't even know when it was last maintained…. here is a challenge when it comes to stormwater drainage and basically maybe other drainage systems…"***

On the contrary, the Department of Roads and Transport within the CoT has the duty to ensure that they are proactive in maintaining the stormwater systems in the inner city through preparing the city before flooding such as Research Participant Two indicated that "…***ahead of your rainy season you're going to start cleaning out your stormwater drains. Since blocked stormwater drains create pooling because this is also associated with flooding***."

There was a lack to maintenance created which caused an overwhelmed drainage system. With regards to this, the department was experiencing challenges according to Research Participant two. In addition to this, from the expert who is Research Participant four mentioned that the CoT needs a proper maintenance plan that will resolve clogging of the stormwater system:

> "***We need to have a proper maintenance system in place. So, even if we have got a plan and if that plan is not integrating proper maintenance. Regular scheduled maintenance for the City of Tshwane, then it becomes***

a problem because flooding is coming from the clogged stormwater drains, clogged and even blogged stormwater drains."

Furthermore, this is not clearly presented in the literature because Research Participant four highlighted that "***always spoke about the grass. And the trees growing in stormwater surface."*** In that event, additional studies to understand more completely the key tenets of the surrounding of the stormwater systems environment are required as it is key to note how to keep the environment clean such as maintaining the surrounding trees and grass.

As a final point, Research Participant four painted an imperative point that summarises everything that is related to the stormwater management plan in the inner city, mentioning that it all ends with service delivery provided to the maintenance of stormwater drainage systems across the city.

> ***"So generally, we can paint all the municipalities with one brush to say they are battling, but their levels of battles differ in terms of service delivery. In this case, you're talking about the drainage system is going to come to Department of Roads, basically in any municipality. It will be roads and maybe other infrastructure… There are other services that they are battling with generally around like just maintaining the roads, maintaining the water infrastructure..."***

Therefore, delivery of services is essential, therefore, to prevent flooding the implementation of maintenance or management plans on stormwater drainage systems is imperative in the long-term in the inner urban areas.

Stormwater management was related to the maintenance of drainage systems that was lacking from the municipality's side. In addition, the lack of providing services to the community falls under the umbrella of providing proper maintenance in the surrounding environment of stormwater drainage systems to prevent clogged drains. As a consequence, owing to the lack of inadequate maintenance and service delivery of drainage systems, flooding increases and becomes a concern that is uncontrollable because of the increase in debris and silting carried from the upper catchment impacts the lower catchment area.

In terms of the lower catchment area, which is in the Centurion area, the Hennops River running through the urban area is one of the greatest vulnerabilities identified by Research Participant four, who indicated that the lack of service delivery was causing these floodings. This suggests that the implementation of providing proper and

scheduled drainage maintenance in the Centurion area will assist in relieving the pressure on the Hennops River and drainage system. On the contrary, Participant one emphasised that there are scheduled stormwater maintenance for the removal of debris from the stormwater drainage systems. This is true from Research Participant two, highlighting that the Hennops Revival NGO does assist through the Adopt-a-Warrior/Adopt-a-River Programme from this non-governmental organisation. The Adopt – A – Warrior/ Adopt – A – River , the purpose of this programme or initiative is to employ homeless people to clean out the stormwater drains as a maintenance tool from the municipality. This is spearheaded by the Hennops Revival NGO. Currently, this programme is fully functional, and it is a seasonal initiative in seasons where there is no rain. According to Research Participant two, this has been successful for the area because it also reduces the debris in the Hennops River, for an easy flow of the water. However, this is seasonal and not scheduled monthly or weekly as seasons have changed due to climate change.

4.2.4 Integration Between Transboundary Municipalities

The third theme that was identified is transboundary municipality integration, reference to four municipalities that are impacted by debris created by the upper catchment area from flooding. The reason behind selecting the theme on integration of transboundary municipalities Firstly, the influence and support from political leaders; secondly, the challenges and implementations of disaster risk reduction plans within the municipality; lastly, the importance of stakeholder engagements.

As indicated previously, politics play a role in disaster risk reduction and how policies can be implemented within a municipality. As a consequence, Research Participant four stated that political administration inside the municipality is a challenge in any capacity before addressing disasters. The participant indicated that,

> ***"In terms of political administration, they [the political party in office] are adding to the lenses of challenges we are facing before you even start talking about is our drainage systems being maintained or not… So, if we're in a situation where the service delivery has been hampered by political bickering, I think it was squandered at some stage, it was under ANC (*African National Congress*), it went to DA (*Democratic Alliance*), it went to other parties and in the last ten years or so, we have seen a lot of movement and instability, serious instability in terms of the fundamentals that make the city work."***

Political imbalance could be one of the reasons why there has been no progress in addressing flooding in Centurion because of change in political leadership within the municipality. This is a challenge from a political perspective. Therefore, nothing much can be done to change the maintenance plan of the municipality without the necessary support from local politicians. Keep in mind that all four municipalities are run by different political parties. Therefore, the risk of integration and collaboration could affect the implementation of prevention measures that could assist the lower catchment area, in particular, Centurion.

Regarding implementation, Research Participant two mentioned that one of the three challenges faced by the municipality in terms of implementation: ***"…Flood Mitigation Plan by the Department of Roads and Transport are experiencing challenges and not being able to be reactive."*** The reason that was given is that the department needs to prepare for the rainy season in terms of removing any obstacle that could clog the stormwater drainage systems. Debris from the upper catchment area needs to be removed during the off-season in order to prevent flooding in the Centurion. Therefore, it is important for the municipality to prioritise maintenance plans in the municipality.

As previously indicated from literature, capacity seems to be an issue in local government, and this is evident in the CoT. According to Participant One, ***"Current economic conditions are impacting everyone in terms of the delivery of services, including the implementation of policies, where capacity, as well as the issue related to budget cuts and so on, are a problem."*** Therefore, the importance of inviting public-private partnerships and legislation such as the Disaster Management Act advocates for stakeholder engagements in all spheres of government.

As highlighted previously, disaster risk reduction advocates for integration or intergovernmental integration for all activities related to disaster implementation. Research Participant One further stated that it is imperative that everyone speaks one language in terms of implementation.

> ***"Hence, when you look into the Flood Incident Management Plan, it's an integrated plan that brings the various departments within the city and the resources from various departments in dealing with issues of flooding. It's not a one-department matter. And then obviously, the local government does report to its activities related to the implementation of the disaster management plan to the provincial disaster management centre, which also then links the municipal plans to them and then including them to be a provincial plan that feeds into a national plan…***"

As a result of the preceding findings on the integration between transboundary municipalities, from the upper catchment area, there are various catchment areas that all lead to the Hartbeespoort Dam, in the Madibeng Local Municipality, in the North West Province from the three major metropolitans CoT, CoJ and CoE in the Gauteng Province, see Figure 4.1. This is significant because two provinces are impacted by what is happening in COJ and the CoE. According to the views of Research Participants two, three and four, the local government has not actively attempted to stop the illegal sand mining, invasion of wetlands and encroachment onto the flood lines because of the mushrooming informal settlements in Tembisa, in the CoE Metropolitan Municipality. The debris from these activities listed impacted the Kaalspruit, Olifantspruit and Jukskei River which all feed into the Hennops River with the Crocodile River and the Hartbeespoort Dam. Therefore, there is lack of inter-governmental integration if not transboundary integration of municipalities in Gauteng to address what is happening in the upper catchment area that is negatively impacting the lower catchment area.

Evidence illustrate that plans such as the Rehabilitation of the Kaalspruit Spreads, the Gauteng City Region Climate Change Response Strategy, and Climate Kaalspruit Spreads Catchments Resilience Strategy Kaalspruit Climate Resilient Catchment Management Plan do exist. It seems that the CoT is attempting to engage local stakeholders such as the CoJ, the CoE, the provincial government and national departments such as the National Treasury to address these challenges that are impacting the environment but receiving limited interaction from the CoJ and the CoE. On the contrary, Research Participant two indicated that the ***"National Treasury and World Bank through the City Support Programme are working with the three metros to put a funding proposal together to get the funding that we need to fix the Kaalspruit."*** With reference to addressing the upper catchment activities that are occurring in and around the Kaalspruit River that are impacting the river negatively. In spite of this, there is no guarantee that the other two municipalities will collaborate as the CoT was trying to be proactive in reducing flooding in the Centurion area.

Local officials according to Research Participant two need the support of politicians to actively implement certain plans that need public participation from residents. Without support, plans will take forever to be implemented. However, Research Participant four highlights that politicians only came to the party recently to advocate for residents to occupy vacant space for residence purposes. This has caused a huge impact on wetlands and flood lines, therefore, impacting the Hennops River in Centurion.

Instead, partnerships or stakeholders assist local governments such as the City of Tshwane to implement certain activities that prevent flooding in the Spatial Development Framework and the IDP in the municipality. As indicated multiple times, the Disaster Management Act advocates for integration within all three spheres of government, the private sector, and non-governmental organisations. Therefore, private and public partnerships are imperative to address disasters and probably assist with capacity be it funding or human capacity.

From the first-hand data collected, the main partnerships that are part of addressing flooding within the municipality and from Research Participant one highlights that it is according to legislation that intergovernmental integration is actively there. Figure 4.2 illustrates some of the identified major stakeholders that influence disaster risk reduction and flooding either in a positive or negative light. For instance, the Hennops Revival NGO is a positive stakeholder in terms of Adopt-a-Warrior and being part of the Centurion Lake Rehabilitation Task Team to provide structural prevention.

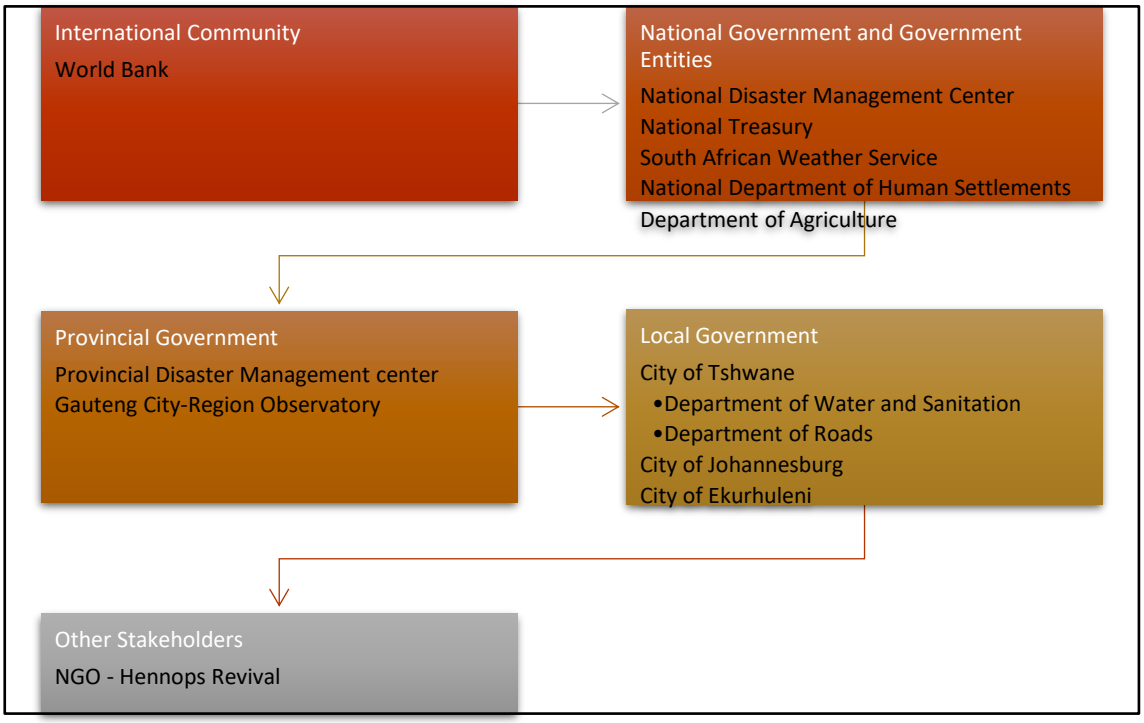

Figure 4.2: Active partnerships and potential partnerships'

Given full funding from the National Treasury and the World Bank for the proposed City Support Program, can the CoJ and the CoE effectively enforce their by-Laws and collaborate with the CoT to minimise activities that adversely impact the ecological integrity of the Hennops River catchment area and the Centurion Lake.

4.2.5 What's really on the ground through site observation?

Table 4.2 reflects sites captured during three visits that occurred on three different days within a space of three months. In addition to that, media reports of flooding within the site area have been included.

Table 4.2: Observation

First Site Visit 14th October 2023			
Lenchen Avenue North Road *Photograph by author, 2023* This is the first hotspot that was identified and experiences flooding during heavy rains. The identification is based on a high flooding risk area, as the Hennops River passes through this road and there is a low-lying bridge, according to participate two	 *Photograph by author, 2023* Surrounding area of the first hotspot along the Lenchen Avenue North Road.	 *Photograph by author, 2023* The Centurion Hotel is one of the businesses within the vicinity of the Hennops River affected by flooding in the area. The river flows underneath the hotel.	 *Photograph by author, 2023* The Centurion Hotel is one of the businesses within the vicinity of the Hennops River affected by flooding in the area.

 Photograph by author, 2023 Meersig is one of the many businesses along the Hennops River affected by flooding in the area that were granted permission to build next to the floodl line..	**Hendrik Verwoerd Drive** *Photograph by author, 2023* The second hotspot that was identified and experiences flooding during heavy rains. Identification is based on a high flood-risk area, the Hennops River passes underneath the road and there is a low-line bridge	 *Photograph by author, 2023* Anew Hotel Centurion and the Centurion Mall are some of the many businesses within the vicinity of the Hennops River affected by flooding in the area.	**Corner End and Rabie Road** *Photograph by author, 2023* The third hotspot that was identified and experiences flooding during heavy rains. Identification is based on a high flood-risk area, the Hennops River passes underneath the road and there is a low-line bridge.
 Photograph by author, 2023 Surrounding area of the third hotspot along Corner End and Rabie Road. The road is on a	 *Photograph by author, 2023* Surrounding area of the third hotspot along Corner End and Rabie Road. The	 *Photograph by author, 2023* Surrounding area of the third hotspot along Corner End and Rabie Road. The road is on a low-line bridge with the Hennops River	 *Photograph by author, 2023* Surrounding area of the third hotspot along Corner End and Rabie Road.

low-line bridge with the Hennops River flowing below.	road is on a low-line bridge with the Hennops River flowing below.	flowing below. There is an abandoned residential apartment next to the river.	The road is on a low-line bridge with the Hennops River flowing below.
Second Site Visit 01st November 2023			
Lenchen Avenue North Road *Photograph by author, 2023* This is the first hotspot that was identified and experiences flooding during heavy rains. Identification is based on a high flooding risk area, the Hennops River passes through this road and there is a low-line bridge.	 *Photograph by author, 2023* This is the river flowing into the Centurion Lake from the Upper catchment area. With surrounding businesses experiencing the flooding.	 *Photograph by author, 2023* Debris caused by rubbish from the Upper Catchment Area.	 *Photograph by author, 2023* Debris caused by rubbish from the Upper Catchment Area.
Recent Floods from Social Media Images			
Corner End and Rabie Road	 *Gauteng Weather, 2023*	 *Gauteng Weather, 2023*	 Post Jacaranda FM Traffic @jaca traffic Follow CENTURION FLOODING on End Street at the N14 Highway bridge. ROAD CLOSED. AVOID IF POSSIBLE. #PTATraffic #JacaTraffic #PTAWeather 5:50 PM · 07 Nov 23 · 218 Views *Jacaranda FM, 2023*

 Gauteng Weather, 2023 The Gauteng Weather Services posted images and notified the community on the 7th of November 2023 of multiple road closures due to flooding in the Centurion Area on X.	Images that were posted on the flooding incident.	Images that were posted on the flooding incident.	Jacaranda FM Traffic notified the community on the 7th of November 2023 on X to avoid End Street due to flooding.
Third Site Visit 13st December 2023			
 Photograph by author, 2023	Hartbeespoort Dam at the end of the channel from the Upper catchment in City of Johannesburg and City of Ekurhuleni. With the Hartbeespoort Dam impacted by invasive alien plants which is a huge issue when I conducted the site visit.	 *Photograph by author, 2023*	Hartbeespoort Dam at the end of the channel from the Upper catchment in City of Johannesburg and City of Ekurhuleni. With the Hartbeespoort Dam impacted by invasive alien plants which is a huge issue when I conducted the site visit.

4.4 Implications of the findings

This chapter explores the alignment between the research findings and relevant literature. Regarding LID measures, the literature emphasises the crucial role of stormwater management plans in mitigating urban flooding. Studies by Wang *et al.* (2022) advocate for the implementation of LID strategies to address stormwater management challenges within the context of land use management regulations.

Furthermore, building upon the work of Prokic *et al.* (2019), the importance of comprehensive flood risk assessments is highlighted. The European Agency's three-stage approach underscores the need for a thorough understanding of high-risk areas to guide the implementation of effective flood prevention measures, including LID strategies.

The Disaster Management Act of 2002 provides a legislative framework for disaster risk reduction, emphasising the need for integrated and coordinated disaster management efforts at all levels of government. The CoT has implemented several relevant initiatives, including a Flood Incident Management Plan and a focus on stormwater drainage maintenance. However, as highlighted by Participant Two, the effectiveness of these initiatives is hindered by inadequate proactive maintenance.

Regarding wetland protection, studies by Prokic *et al.* (2019), Townshend (2020), and Kundzewicz and Pinskwar (2022) underscore the critical role of wetlands in regulating water flow and mitigating flood risks. The loss of wetland areas due to urbanization and inadequate drainage infrastructure significantly increases flood vulnerability within urban areas, as emphasised by Research Participant Two.

Furthermore, as noted by Axelsson *et al.* (2021), the increasing pressure of urbanisation on limited land resources within urban areas necessitates the protection and restoration of existing wetlands as critical components of green infrastructure for flood mitigation.

In conclusion, this analysis demonstrates a clear alignment between the research findings and existing literature on flood risk management and urban planning. The findings emphasise the critical need for a multi-faceted approach to flood mitigation, encompassing the implementation of LID measures, the protection of wetlands, the enhancement of stormwater drainage systems, and effective inter-municipal collaboration.

4.5 Brief Chapter Overview

The current chapter focused on the analysis of four key themes related to flood prevention in Centurion, drawing upon insights from primary data collection.

Firstly, the analysis examined the role of LID measures, including the Tshwane Town Planning Scheme, the CoT Disaster Management Plan, the WUL Policy/National Water Act, the City Support Program, the Gauteng City Region Overarching Climate Change Response Strategy and Action Plan, and the Kaalspruit Climate Resilient Catchment Management Plan. A key observation was the interconnectedness of these plans and regulations in safeguarding watercourses and mitigating flood risks within the context of blue infrastructure principles and flood line regulations.

Secondly, the chapter highlighted the significant impact of wetland encroachment, particularly in the upper catchment areas, which adversely affects downstream areas, including Centurion.

Thirdly, the analysis focused on the critical role of effective service delivery, particularly in maintaining the functionality of grey infrastructure such as stormwater drainage systems. The chapter highlighted the challenges posed by the accumulation of debris from the upper catchment areas and the importance of regular maintenance, often undertaken by local non-governmental organisations to prevent urban flooding in Centurion.

Finally, the analysis emphasised the crucial need for inter-municipal collaboration. Recognising that flooding in Centurion is influenced by activities occurring in neighbouring municipalities (Tembisa, CoE; Midrand, CoJ), the Kaalspruit Climate Resilient Catchment Management Plan aims to facilitate regional cooperation in addressing flood risks. However, the political dynamics and varying priorities of different municipal administrations can pose challenges to the effective implementation of such collaborative initiatives.

Therefore, the above findings and analysis were identified during the interviews conducted with the municipality and an expert. The next chapter will provide summary of the key findings, contributions to the research, study limitations, recommendations for future research, and conclusion based on the findings and analysis.

CHAPTER 5: RECOMMENDATIONS AND CONCLUSION

5.1 Introduction

The previous chapter unpacked the primary data collected during the research through semi-structured interviews with four participants, three site visits and a detailed ethical consideration, challenges encountered during data collection, and the strategies implemented to overcome these challenges. The current chapter is the last one for the study and presents a comprehensive summary of the key findings, potential contributions to the research, study limitations, recommendations for future research, and conclusion. Yet, ensuring that the research question aim has been investigated and reviewed. This involved examining the interplay between urban planning, land use management regulations, and disaster risk reduction strategies.

The rest of the chapter is structured as follows: Section 5.2 provides a summary of the key findings that emerged from the data analysis. Section 5.3 discusses the potential contributions of this research to the field of flood risk management. Section 5.4 outlines the study limitations and recommendations for future research to further enhance the understanding and mitigation of urban flooding within Centurion and other similar contexts in Section 5.5. Finally, Section 5.6 offers concluding remarks on the overall research findings and their implications.

5.2 Summary of the Key Findings

Key findings revealed significant limitations in current flood prevention measures within Centurion. Analysis of the CoT Town Planning Scheme, particularly concerning the 100-year flood line, indicated that it may not adequately protect properties along the Hennops River, especially considering the ongoing urbanisation and development within the catchment areas of the CoJ and the CoE.

Despite the existence of a Flood Management Plan and a Maintenance Plan, challenges persist in effectively mitigating flood risks. Research Participant one acknowledged the municipality's efforts, including the development of a Flood Incident Management Plan and the encouragement of regular maintenance of drainage systems. However, Research Participant Two emphasised the need for enhanced proactive maintenance efforts, highlighting the reliance on external support from non-governmental organisations such as Hennops Revival to address the shortcomings of municipal maintenance programs.

Research Participant Two emphasised the critical importance of proactive maintenance activities, stating that "***Preventative maintenance are typically not happening. So, one of the things that we've done to compensate for this is we've signed an MOU*** *(memorandum of understanding)* ***with a non-profit organisation called Hennops Revival... Now she's got a programme called Adopt-a-Warrior... They clean out those stormwater drains. So, we're trying to compensate for the lack of proactive maintenance that's not being done by the region***."

Furthermore, Research Participant two stressed the importance of initiative-taking measures, stating that "***With the floods, so you've got your flood plans you must do your proactive work and your proactive maintenance and then if there's a flood you have to then come in with all your contingency measures***."

Additionally, the Flood Mitigation Plan is implemented internally by the Department of Roads and Transport in the municipality, which should run concurrently with the municipal maintenance plan for disaster. Those are the top five prevention measures from a LID measure currently implemented in the municipality. Encroachment of wetlands in the upper catchment and service delivery for grey infrastructure is lacking in urban areas.

Key findings on the prevention measures is on service delivery for grey infrastructure is lacking in urban areas that were investigated as part of the primary data. Firstly, Pre-Flooding Season Activities that is in reference to cleaning the drainage system before the rainy season. Secondly, de-silting, the purpose of this task is to remove debris that ends up in the Hennops River from the upper catchment of the Kaalspruit. As highlighted during the interviews, from two years ago the municipality has increased the flow of the river by removing debris created from the rubbish created from the upper catchment. This was according to Participant Three who confirmed that de-silting is working for the municipality, *"…**the risk of flooding downstream and eventually it would land up in Harties*** (Hartbeespoort Dam) … ***When I started two years back with de-silting. The year after that the flooding was much less than the previous year because it didn't go into the hotel. The water went under the bridge instead of every time over Because there was no space for the water to flow This lake was totally full."*** This led to a decrease in flooding in the area. Encroachment of wetlands in the upper catchment area would indicate that there are no key prevention measures that the metropolitan can use to prevent flooding in Centurion. Other than addressing service delivery with other municipalities as it is clear that wetlands are not prioritised by government bodies and community members. Hence, this is evident from the responses

of the participants regarding the encroachment of wetlands and Centurion experiences flooding due to activities in the upper catchment. Another prevention measures that was key in the findings is the importance of stakeholder's engagement and partnerships during critical times such as disasters in the municipality. Political support in terms of supporting governance and legislation can transform the way disaster is defined in this day and age, with reference to how political leaders face disaster and implementation of legislation. Solutions in terms of educational programmes focus on educating residents on the dangers of living on a flood-line, wetlands and/or building on any blue infrastructure. Additionally, transboundary municipalities are the greatest institutional barriers that constrain the prevention of flood risk prevention measures. This is in reference to the upper catchment and municipalities are lacking in enforcing town planning schemes and the Water Use Licence policy on blue infrastructure. Whereas, Tshwane Town Planning Scheme speaks on Section 144 of the National Water Act, 1998 (Act 36 of 1998), mentions the implementation of the average of every hundred years flood line in any layout plan produced to the authorities at the municipality. Due to the lack of implementation of the town planning scheme from the City of Johannesburg and the City of Ekurhuleni, this impacts the lower catchment in Centurion and causing silting, debris and stormwater drainage clogging along the Hennops River.

In conclusion, the key findings that were found during the investigation have identified what makes Centurion vulnerable to flooding and the measures currently being used to prevent flooding in the area, and, lastly, any institutional obstacles that hinder the implementation of flood risk prevention measures in Centurion. The analysis has made it possible to further answer the research question and the developmental planning implications in flood-prone areas of Centurion.

5.3 Potential Contributions of this Research

5.3.1 Enhanced understanding of flood risk factors in Centurion

The study provides valuable insights into the specific factors contributing to flood risk within the Centurion area, including the impact of urbanisation, wetland encroachment, inadequate stormwater drainage, and the influence of upstream activities in neighbouring municipalities.

5.3.2 Identification of critical gaps in existing flood management strategies

The study highlights the limitations of current flood prevention measures, such as the potential inadequacy of the 100-year flood line and the challenges associated with maintaining stormwater drainage systems.

5.3.3 Emphasis on the importance of inter-municipal collaboration

The study underscores the critical need for collaboration between the CoT, the CoJ, and the CoE to address flood risks within the shared catchment areas.

5.3.4 Advocacy for the integration of low-impact development (LID) measures

The study emphasises the importance of incorporating LID principles into urban planning and development to enhance flood resilience.

5.3.5 Highlighting the crucial role of wetland protection

The study emphasises the critical role of wetland protection in mitigating flood risks and the need to address the ongoing encroachment of wetlands due to urbanisation and other human activities.

5.3.6 Providing a framework for future research and policy development

The study provides a foundation for future research on flood risk management in Centurion and other urban areas facing similar challenges. The findings and recommendations can inform the development of more effective flood prevention policies and strategies at the local, regional, and national levels

5.4 Limitation of the findings

During the course of the study, various limitations should be acknowledged and disclosed, as this provided insight into the aim of the research. The main two limitations were the delayed availability and the non-responsiveness of participants. These two major limitations influenced the data in terms of having a reduced sample size from fifteen suggested participants to four participants who were interviewed. Despite the limitations, the use of observation methods to gather data from the site-visits did assist in covering some of the gaps in the investigation research. To not report biased research in the findings and recommendations of the study.

Additionally, the study focuses on specific professionals in specific organisations but is not limited to the three spheres of government, universities, NGOs and surrounding businesses. Individuals suggested using the route of ethnography which would have not worked as the research aim was to investigate prevention measures related to urban planning and land use management regulations that prevent flooding through disaster risk reduction that have been adopted in urban flood-prone areas in the CoT, particularly Centurion. Therefore, community interviews would have redirected the investigation into addressing challenges faced by locals in the upper catchment area rather than indicating who should be taking accountability for not implementing prevention measures based on urban planning and land use management regulations through disaster risk reduction

in Centurion. Furthermore, prevention measures should be undertaken by local government with the assistance of various stakeholders.

Even though these limitations occurred, the participants interviewed, and the observation data collected during the site visit painted a picture of where the responsibility lies for the flooding in the Centurion area and the actions that need to be taken from there. In conclusion, more can be done to address these limitations for instance another research design could be used to include statics to the equation or work on time management or explore the sample sizes into planning law. Therefore, by addressing these limitations future researchers can work on deepening the research.

5.5 Recommendations for Future Research

This chapter presents key recommendations arising from the theoretical, methodological, practical, and policy-related aspects of the investigation.

5.5.1 Policy-Related Recommendations

- **Review and Enhance Flood Risk Assessment**

The current Flood Disaster Risk Assessment requires refinement, focusing on a more localised and region-specific approach rather than a blanket assessment across the entire municipality.

- **Strengthen Legislative Framework**

The Disaster Management Act of 2002 should be strengthened to explicitly address disaster resilience and sustainable development within urban areas, particularly in the context of flood risk management.

- **Enhance Inter-Municipal Collaboration**

Stronger collaboration between the CoT, the CoJ, and the CoE is crucial, particularly in the context of the Kaalspruit Climate Resilient Catchment Management Plan. This collaboration should include regular forums and binding agreements to ensure coordinated flood mitigation efforts across municipal boundaries.

- **Reinforce Municipal By-laws and Land Use Management Plans**

The municipality should rigorously enforce existing by-laws and land use management plans, ensuring their alignment with the National Water Act (Act 36 of 1998) and incorporating the principles of LID.

5.5.2 Practical Recommendations

- **Review and Update Building Plans**

The municipality should review and update building plans submitted by developers to ensure compliance with the Tshwane Town Planning Scheme and the provisions of Section 144 of the National Water Act.

- **Enhance Stormwater Drainage Maintenance**

Regular and proactive maintenance of stormwater drainage systems is crucial. This may involve increased municipal resources or continued partnerships with NGOs like Hennops Revival to address the issue of debris accumulation and ensure the efficient functioning of the drainage infrastructure.

- **Prioritise Wetland Protection**

The protection of wetlands, a critical component of blue infrastructure, should be prioritised through measures such as fencing and the implementation of barriers to prevent sedimentation and debris accumulation.

5.5.3 Implications of Inaction

Failure to implement these recommendations and proactively address flood risks through integrated and collaborative approaches will have significant consequences. Continued vulnerability to flooding will result in increased property damage, infrastructure disruption, and environmental degradation within the Centurion area. The potential for widespread damage to property, including residences, government buildings, and businesses, could lead to significant economic and social disruption, including potential population displacement and consequent revenue losses for the municipality.

This chapter underscores the urgent need for a proactive and multi-faceted approach to flood risk management within Centurion, emphasising the importance of inter-municipal collaboration, effective implementation of existing plans and regulations, and the protection of critical natural resources such as wetlands.

5.6 Final Conclusion

Final reflection from a developmental planning context with reference to the conceptual framework, it is important to implement the LID approach as a prevention measure to assist the investigation that aimed at discovering any prevention measures that have been implemented in flood-prone areas of Centurion. LID approach ensures that spatial

planning and land use management regulations are implemented to prevent any runoff during heavy rainfalls. This is key as it will address any critical encroachment to wetlands be it from the upper and low catchment areas. Therefore, it forces local officials to implement planning regulations such as Disaster Management Act, the CoT Disaster Risk Mitigation Plans, CoT Flood Incident Management Plan, the Water Use Licence Policy, Flood Mitigation Plan, and the town planning scheme that already exist on a higher level. Yes, capacity is an issue in developing countries such as South Africa but having policies under LID approaches such as land use management plans will assist institutions to fast-track development planning processes. On the contrary, it is imperative to note that the upper catchment is the main issue in this cycle as it is evident in the literature review, the primary data collection and the images taken on site during the site-visits. One should acknowledge that dealing with transboundary municipalities could be an issue because each municipality has their own development plans, but municipal by-laws and land use management plans focus on one thing when it comes to addressing flooding as the bases come from the Disaster Management Act. Although results from the literature appear to be consistent with prior research, no previous research has investigated the means of integrating municipalities other than in South Africa through provincial SDFs that could hold these municipalities accountable for not implementing the Disaster Management Act and their by-laws and Water Use Licence policies.

Therefore, vulnerabilities do exist from prevention measures, but municipalities need to take account of any hindrances faced by blue and grey infrastructure. Furthermore, municipalities need to take the opportunity to work with other stakeholders as per the Disaster Management Act. In the case of Centurion, this has worked in the municipality whereby internal departments are lacking in providing service delivery and using external stakeholders to assist in the prevention of flooding during off-season to prepare for flooding even though it is not based on prevention measures, but it could fall under stormwater drainage maintenance systems within the municipality for the Centurion area.

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APPENDIX A: ETHICS CLEARANCE CERTIFICATE

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG | SCHOOL OF ARCHITECTURE PLANNING

23 October 2023

Dear Ofentse Kutumela (1351080)

This letter confirms that your clearance/waiver application has been approved. Your protocol/clearance number is: SOAP063/07/2023

Yours sincerely

Lerato Nkosi

Lerato Nkosi

School of Architecture and Planning, Faculty of Engineering and Built Environment, John Moffat Building, Wits, 2050, South Africa
Tel: +27 11 717 7692 Email: lerato.nkosi2@wits.ac.za | **www.wits.ac.za**

APPENDIX B: SUBMISSION OF THESIS/ DISSERTATION/ RESEARCH REPORT FOR EXAMINATION AND ACQUIESCENCE FORM

Faculty of Engineering and the Built Environment

Private Bag 3, Wits 2050, South Africa * Telephone (011) 717 – 7007 * Fax: (011) 717 7009

WITS UNIVERSITY

SUBMISSION OF THESIS/DISSERATIO/RESEARCH REPORT FOR EXAMINATION

1. Name: __Ofentse _____
2. Surname: __Kutumela _____
3. Student No: ___1351080_____
4. Current Residential Address: ___37 Navarino Complex, Eremomela Avenue, Montana Gardens, Pretoria, 0128_____

   _____

   Home Telephone Number: __N/A_____

   Work Telephone Number:____N/A_____

   Mobile Number: ___0839553912_____

   E-mail Address: __1351080@students.wits.ac.za_____

_____

5. I hereby submit my Research Report (delete whichever is not applicable).
6. I have checked all copies of my Research Report and declare that no pages are missing or poorly reproduced.
7. Number of copies: _____1_____ (bound) ____1_____ (pdf)
8. I confirm that my signed declaration in terms of Rule G27 is included in each copy of the Research Report.
9. Title of submitted Dissertation / Research Report / Thesis

   ____Investigating flood prevention measures adopted in flood-prone areas of Centurion, City of Tshwane Metropolitan Municipality_____

   _____

   _____

   _____

10. Did your research involve animal experimentation or human participants as defined in A.4 of the Senate Standing Orders on Higher degrees?

    If YES, please certify that clearance was obtained from the relevant Ethics committee

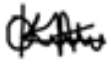
YES	NO
X	

    Clearance Number: __ SOAP063/07/2023_____
11. I understand that I may not graduate unless my University fees have been paid in full and I have no Library holds.
12. Name of Supervisor(s)

    _____Dr. Tsepang Leuta_____ School: _____ School of Architecture and Planning_____

    _____ School: _____
13. Has the work been published in any peer reviewed journals. If yes how many papers?

YES	NO
	X



Signature of Candidate:

Date: ___15 December 2023_____

FACULTY STAMP

Faculty of Engineering and the Built Environment

Private Bag 3, Wits 2050, South Africa * Telephone (011) 717 – 7007 * Fax: (011) 717 7009

WITS UNIVERSITY

ACQUIESCENCE FORM

Name: __Ofentse Kutumela _____ Student Number: __1351080_____

Candidate for the degree of: ____MSc Development Planning_____

has today submitted her research report for examination.

Please answer **ALL** questions below by ticking the appropriate box:

Is this research submitted with your acquiescence? (if no attach/submit a separate report to the Faculty Office)

YES	NO
X	

To the best of your knowledge are you able to verify that the candidate has acknowledged wherever any information used in the thesis or other work have been obtained by him or her while employed by, or working under the aegis of any person or organization other than the University or its associated institutions?

YES	NO
X	

Did the students research involve any animal experimentation of human particiapans as defined in A.4 of the Senate Standing Order on Higher Degrees:

YES	NO
X	

If yes, has clearance been obtained rom the relevant Ethics Committee? Provide ethics clearance form.

YES	NO
X	

Name of Supervisor: Dr Tsepang Lesuta _____

Signature: _____

Date: 29/02/2024 _____

Name of Co-Supervisor: N/A _____

Signature: _____

Date: _____

Name of Head of School: Prof Nnamdi Elleh _____

Signature: _____

Date: _____

FACULTY STAMP

APPENDIX C: CONFIDENTIALITY AGREEMENT BETWEEN THE RESEARCHER AND THE CITY OF TSHWANE MUNICIPALITY

CITY OF TSHWANE
IGNITING EXCELLENCE

City Strategy and Organizational Performance

Room ACE 044 | Ground Floor, West Wing, Block D | Tshwane House | 320 Madiba Street | Pretoria | 0002
PO Box 440 | Pretoria | 0001
Tel: 012 358 2182
Email: ThabisaMb@tshwane.gov.za | www.tshwane.gov.za | www.facebook.com/CityOf Tshwane

My ref: Confidentiality Agreement (V2)
Contact person: Pearl Maponya
Section/Unit: Knowledge Management

Tel: 012 358 4559
Email: PearlMap3@tshwane.gov.za

CONFIDENTIALITY AGREEMENT BETWEEN THE RESEARCHER AND THE CITY OF TSHWANE MUNICIPALITY

(To be completed by researchers who require access to conduct research within the City of Tshwane Municipality)

Name of Researcher	Ofentse Kutumela
Name of Institution	University of the Witwatersrand
Research Topic/Title	Investigating flood mitigation strategies adopted in flood-prone areas of Centurion

I, the undersigned, acknowledge, understand and agree to adhere to the following conditions of access.

(Insert details of dataset fields and other information to be accessed in course of research)

- I will maintain the privacy and confidentiality of all accessible research data and understand that unauthorized disclosure of personal/confidential data is an invasion of privacy and may result in disciplinary, civil, and/or criminal actions against me.
- I will not disclose data or information to anyone other than those to whom I am authorized to do so.
- I will access data only for the purposes for which I am authorized explicitly. On no occasion will I use research data, including personal or confidential information, for my personal interest or advantage, or for any other business purposes.
- I will comply at all times with the City of Tshwane's data/information security policies and confidentiality code of conduct.

- I am informed that the references to personal, confidential and sensitive information in these documents are for my information and research purposes, and are not intended to replace my obligations under the Data Protection and Privacy policies and regulations of Republic of South Africa.

- I understand that where I have been given access to confidential information I am under a duty of confidence and would be liable under common law for any inappropriate breach of confidence in terms of disclosure to third parties and also for invasion of privacy if I were to access more information than that for which I have been given approval or for which consent is in place.

- Should my work in relation to the research discontinue for any reason, I understand that I will continue to be bound by this signed Confidentiality Agreement.

Researcher Signature	27/07/2023 **Date**
City of Tshwane Signature	24/08/2023 **Date**

APPENDIX D: INTERVIEW QUESTIONS

Emergency Services Department - Questions

1. Are wetlands protected along the Hennops River?
2. Are there mitigations in maintaining old drainage infrastructure, especially in low-line areas?
3. What is the best mitigation system that one can use between structural measures and/or non-structural measures?
4. Do you think the Programme of Action for the Implementation of the Sendai Framework for Disaster Risk Reduction 2015–2030 in Africa (PoA) is effectively implemented in South Africa?
5. What causes the sedimentation in the Centurion Lake?
6. Is there capacity in local government to address the prevention of flooding urban such as Centurion?
7. Does the municipality get assistance from the National Disaster Management Centre? And how
8. Is there integration between municipalities, provinces and national and the Disaster Management Act? To provide prevention measures that are core to disasters in South Africa?
9. Also, are policies within these spheres of government aligned to be implemented in local government with the assistance of the Disaster Management Act?
10. What causes flooding in Centurion, especially around the lake?
11. What is and what happened to the Centurion Lake Rehabilitation Plan?
12. Which agendas and agreements from a local and international perspective have been put in place to prevent flooding in the area?
13. What attributes make Centurion vulnerable to flooding?
14. What institutional barriers constrain the uptake of adequate flood risk prevention measures?
15. Do you think concepts such as the Spong-City Program can be used to mitigate flooding in South Africa?

Department of Stormwater Management and Department of City Sustainability

Questions

1. Are wetlands protected along the Hennops River?

2. Are there mitigations in maintaining old drainage infrastructure, especially in low-line areas?

3. What is the best mitigation system that one can use between structural measures and/or non-structural measures?

4. Do you think the Programme of Action for the Implementation of the Sendai Framework for Disaster Risk Reduction 2015–2030 in Africa (PoA) is effectively implemented in South Africa?

5. What causes the sedimentation in the Centurion Lake?

6. Is there capacity in local government and the national disaster management centre to address the prevention of flooding urban such as Centurion?

7. How has the Disaster Management Act 2002 been implemented within local government?

8. Is there integration between municipalities, provinces and national and the Disaster Management Act to provide prevention measures that are core to disasters in South Africa?

9. Also, are policies within these spheres of government aligned to be implemented in local government with the assistance of the Disaster Management Act?

10. What causes flooding in Centurion, especially around the Centurion Lake Hotel?

11. What attributes make this area vulnerable to flooding?

12. And are they sustainable?

13. Are there any constraints to these prevention measures?

14. What is and what happened to the Centurion Lake Rehabilitation Plan?

15. Which departments participate in the Hennops River Forum? Is this forum helpful in resolving flooding along the Hennops River?

16. Which agendas and agreements from a local and international perspective have been put to prevent flooding in the area?

17. What institutional barriers constrain the uptake of adequate flood risk prevention measures?

Academia – Experts - University of South Africa - Questions

1. Are there enough mitigations in maintaining old drainage infrastructure to accommodate disaster, especially in areas affected by flooding?

2. What is the best prevention and mitigation system that one can use between structural measures and/or non-structural measures in a disaster?

3. Do you think non-structural prevention measures work?

4. How can one sustain green-blue-gray infrastructure in areas that are affected by flooding?

5. Do you think the Programme of Action for the Implementation of the Sendai Framework for Disaster Risk Reduction 2015–2030 in Africa (PoA) is effectively implemented in South Africa?

6. Are stakeholders such as NGOs, government departments, and the private sector aligned or willing to combat urban flooding in South Africa?

7. Is there integration between municipalities, provinces and national and the Disaster Management Act to provide prevention measures that are core to disasters in South Africa?

8. Do you think the Disaster Management Act has been fully implemented within the municipality?

9. Has the National Disaster Management Centre been able to ensure that municipalities are legally complying with these acts?

10. Also, are policies within these spheres of government aligned to be implemented in local government with the assistance of the National Disaster Management Center?

11. What makes an area vulnerable to flooding?

12. Are there any constraints to providing prevention measures to local government from your perspective as an academic?

13. Which agendas and agreements from a local and international perspective have been put to prevent flooding locally?

14. What institutional barriers constrain the uptake of adequate flood risk prevention measures?

APPENDIX E: LANGUAGE EDITING CERTIFICATE

22 Osche Street

The Reeds

Centurion

0157

02 February 2024

TO WHOM IT MAY CONCERN

This certificate serves to confirm that I have edited O Kutumela's dissertation entitled, **INVESTIGATING FLOOD MITIGATION STRATEGIES ADOPTED IN FLOOD PRONE AREAS OF CENTURION, CITY OF TSHWANE MUNICIPALITY.**

I found the work easy and intriguing to read. Much of my editing basically dealt with obstructionist technical aspects of language, which could have otherwise compromised smooth reading as well as the sense of the information being conveyed. I hope that the work will be found to be of an acceptable standard. I am a member of Professional Editors' Guild.

Hereunder are my contact details:

Jack Chokwe (PhD)

Contact numbers: 072 214 5489

jackchokwe@gmail.com

Professional EDITORS Guild

APPENDIX F: PROOF OF CORRESPONDENCE

1/17/25, 9:11 AM University of the Witwatersrand, Johannesburg Mail - Permission to conduct an interview with Fresh NGO

WITS UNIVERSITY

Ofentse Kutumela <1351080@students.wits.ac.za>

Permission to conduct an interview with Fresh NGO

3 messages

Ofentse Kutumela <1351080@students.wits.ac.za> 25 August 2023 at 06:02
To: info@fresh.ngo

Good day Ma'am/Sir,

I hope that this email finds you well.

My name is Ofentse Kutumela, and I am a Master's student at the University of the Witwatersrand. I am seeking permission to do an interview with Fresh NGO on the Hennops River within Region 4 at the City of Tshwane Metropolitan Municipality on disaster risk reduction.

Kindly see the attached letter for more information.

Your response will be highly appreciated.

Kind regards
Ofentse Kutumela
0839553912

Letter Requesting Permission - Fresh NGO.pdf
116K

Ofentse Kutumela <1351080@students.wits.ac.za> 30 August 2023 at 04:59
To: info@fresh.ngo

Good morning,

I would like to follow-up on the above email.

Kind regards
Ofentse Kutumela
[Quoted text hidden]

Ofentse Kutumela <1351080@students.wits.ac.za> 1 October 2023 at 20:20
To: info@fresh.ngo

Good day,

I hope that you are well.

I would like to follow-up on the below request.

Your response will be highly appreciated.

Kind regards
Ofentse Kutumela
[Quoted text hidden]

https://mail.google.com/mail/u/0?ik=c4f40238b&view=pt&search=all&permthid=thread-a:r6178071413579164943&simpl=msg-a:r126731452319... 1/1

1/17/25, 9:11 AM University of the Witwatersrand, Johannesburg Mail - Permission to conduct an interview with Hennops Revival

WITS UNIVERSITY

Ofentse Kutumela <1351080@students.wits.ac.za>

Permission to conduct an interview with Hennops Revival

3 messages

Ofentse Kutumela <1351080@students.wits.ac.za> 25 August 2023 at 06:04
To: info@hennopsrevival.co.za
Cc: tarryn@hennopsrevival.co.za

Good day Ma'am/Sir,

I hope that this email finds you well.

My name is Ofentse Kutumela, and I am a Master's student at the University of the Witwatersrand. I am seeking permission to do an interview with Fresh NGO on the Hennops River within Region 4 at the City of Tshwane Metropolitan Municipality on disaster risk reduction.

Kindly see the attached letter for more information.

Your response will be highly appreciated.

Kind regards
Ofentse Kutumela
0839553912

Letter Requesting Permission - Hennops Revival.pdf
115K

Ofentse Kutumela <1351080@students.wits.ac.za> 30 August 2023 at 04:59
To: info@hennopsrevival.co.za

Good morning,

I would like to follow-up on the above email.

Kind regards
Ofentse Kutumela
[Quoted text hidden]

Ofentse Kutumela <1351080@students.wits.ac.za> 1 October 2023 at 20:21
To: info@hennopsrevival.co.za

Good day,

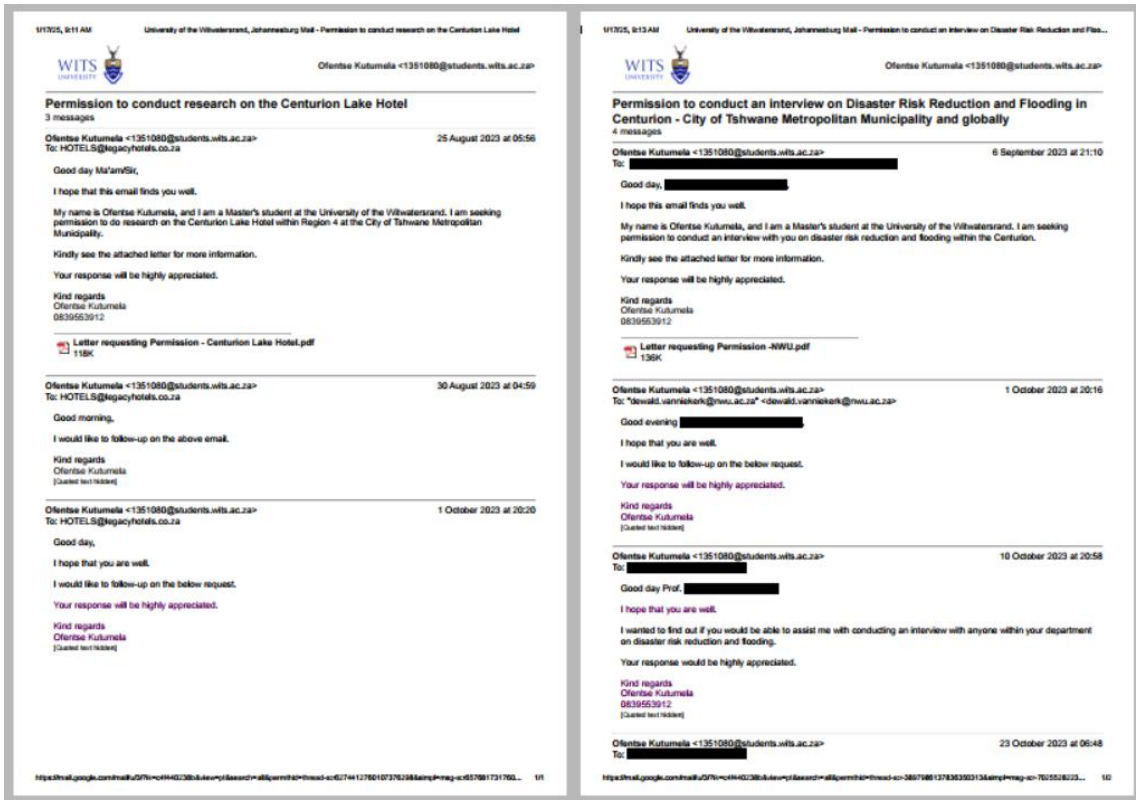
I hope that you are well.

I would like to follow-up on the below request.

Your response will be highly appreciated.

Kind regards
Ofentse Kutumela
[Quoted text hidden]

https://mail.google.com/mail/u/0?ik=c4f40238b&view=pt&search=all&permthid=thread-a:r3645942721810448354&simpl=msg-a:r-3075918875... 1/1



1/17/25, 9:11 AM University of the Witwatersrand, Johannesburg Mail - Permission to conduct research on the Centurion Lake Hotel

WITS UNIVERSITY

Ofentse Kutumela <1351080@students.wits.ac.za>

Permission to conduct research on the Centurion Lake Hotel

3 messages

Ofentse Kutumela <1351080@students.wits.ac.za> 25 August 2023 at 05:56
To: HOTELS@legacyhotels.co.za

Good day Ma'am/Sir,

I hope that this email finds you well.

My name is Ofentse Kutumela, and I am a Master's student at the University of the Witwatersrand. I am seeking permission to do research on the Centurion Lake Hotel within Region 4 at the City of Tshwane Metropolitan Municipality.

Kindly see the attached letter for more information.

Your response will be highly appreciated.

Kind regards
Ofentse Kutumela
0839553912

Letter requesting Permission - Centurion Lake Hotel.pdf
118K

Ofentse Kutumela <1351080@students.wits.ac.za> 30 August 2023 at 04:59
To: HOTELS@legacyhotels.co.za

Good morning,

I would like to follow-up on the above email.

Kind regards
Ofentse Kutumela
[Quoted text hidden]

Ofentse Kutumela <1351080@students.wits.ac.za> 1 October 2023 at 20:20
To: HOTELS@legacyhotels.co.za

Good day,

I hope that you are well.

I would like to follow-up on the below request.

Your response will be highly appreciated.

Kind regards
Ofentse Kutumela
[Quoted text hidden]

https://mail.google.com/mail/u/0?ik=c4f40238b&view=pt&search=all&permthid=thread-a:r6274412760107376288&simpl=msg-a:r6576817317650... 1/1

1/17/25, 9:13 AM University of the Witwatersrand, Johannesburg Mail - Permission to conduct an interview on Disaster Risk Reduction and Flo...

WITS UNIVERSITY

Ofentse Kutumela <1351080@students.wits.ac.za>

Permission to conduct an interview on Disaster Risk Reduction and Flooding in Centurion - City of Tshwane Metropolitan Municipality and globally

4 messages

Ofentse Kutumela <1351080@students.wits.ac.za> 6 September 2023 at 21:10
To: [redacted]

Good day, [redacted]

I hope this email finds you well.

My name is Ofentse Kutumela, and I am a Master's student at the University of the Witwatersrand. I am seeking permission to conduct an interview with you on disaster risk reduction and flooding within the Centurion.

Kindly see the attached letter for more information.

Your response will be highly appreciated.

Kind regards
Ofentse Kutumela
0839553912

Letter requesting Permission -NWU.pdf
136K

Ofentse Kutumela <1351080@students.wits.ac.za> 1 October 2023 at 20:16
To: "dewald.vanniekerk@nwu.ac.za" <dewald.vanniekerk@nwu.ac.za>

Good evening [redacted]

I hope that you are well.

I would like to follow-up on the below request.

Your response will be highly appreciated.

Kind regards
Ofentse Kutumela
[Quoted text hidden]

Ofentse Kutumela <1351080@students.wits.ac.za> 10 October 2023 at 20:58
To: [redacted]

Good day Prof. [redacted]

I hope that you are well.

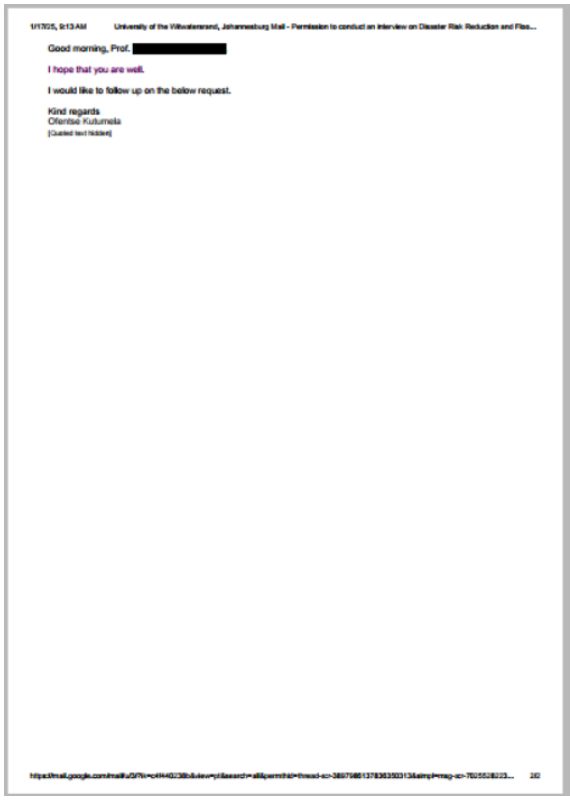
I wanted to find out if you would be able to assist me with conducting an interview with anyone within your department on disaster risk reduction and flooding.

Your response would be highly appreciated.

Kind regards
Ofentse Kutumela
0839553912
[Quoted text hidden]

Ofentse Kutumela <1351080@students.wits.ac.za> 23 October 2023 at 06:48
To: [redacted]

https://mail.google.com/mail/u/0?ik=c4f40238b&view=pt&search=all&permthid=thread-a:r-3697985137836393134&simpl=msg-a:r-7025528223... 1/2

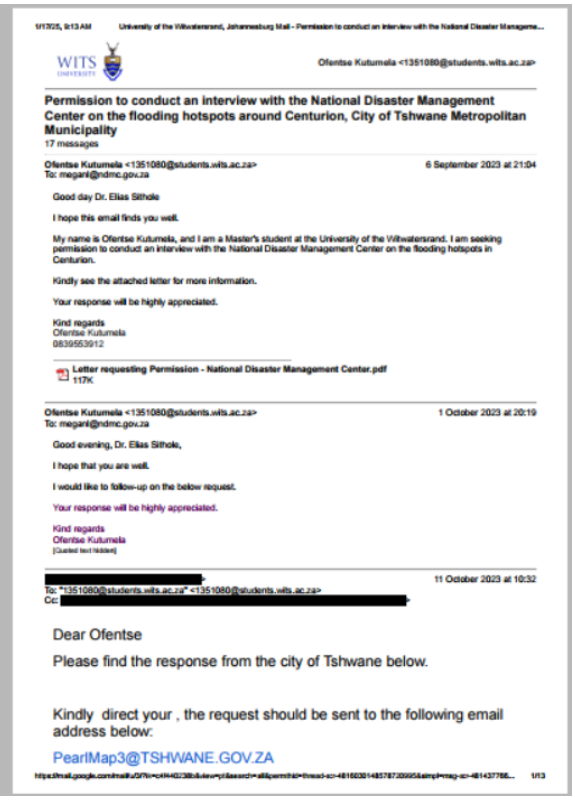


Good morning, Prof. [redacted]

I hope that you are well.

I would like to follow up on the below request.

Kind regards
Ofentse Kutumela
[Quoted text hidden]



WITS UNIVERSITY

Ofentse Kutumela <1351080@students.wits.ac.za>

Permission to conduct an interview with the National Disaster Management Center on the flooding hotspots around Centurion, City of Tshwane Metropolitan Municipality
17 messages

Ofentse Kutumela <1351080@students.wits.ac.za> 6 September 2023 at 21:04
To: megan@ndmc.gov.za

Good day Dr. Elias Sithole

I hope this email finds you well.

My name is Ofentse Kutumela, and I am a Master's student at the University of the Witwatersrand. I am seeking permission to conduct an interview with the National Disaster Management Center on the flooding hotspots in Centurion.

Kindly see the attached letter for more information.

Your response will be highly appreciated.

Kind regards
Ofentse Kutumela
0839563912

Letter requesting Permission - National Disaster Management Center.pdf
117K

Ofentse Kutumela <1351080@students.wits.ac.za> 1 October 2023 at 20:19
To: megan@ndmc.gov.za

Good evening, Dr. Elias Sithole,

I hope that you are well.

I would like to follow-up on the below request.

Your response will be highly appreciated.

Kind regards
Ofentse Kutumela
[Quoted text hidden]

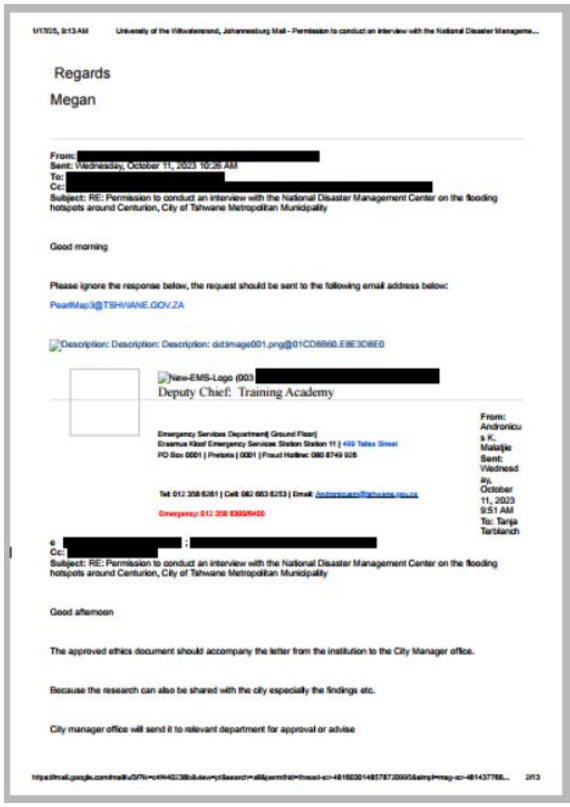
[redacted] 11 October 2023 at 10:32
To: "1351080@students.wits.ac.za" <1351080@students.wits.ac.za>
Cc: [redacted]

Dear Ofentse

Please find the response from the city of Tshwane below.

Kindly direct your , the request should be sent to the following email address below:

PearlMap3@TSHWANE.GOV.ZA



Regards

Megan

From: [redacted]
Sent: Wednesday, October 11, 2023 10:26 AM
To: [redacted]
Cc: [redacted]
Subject: RE: Permission to conduct an interview with the National Disaster Management Center on the flooding hotspots around Centurion, City of Tshwane Metropolitan Municipality

Good morning

Please ignore the response below, the request should be sent to the following email address below:

PearlMap3@TSHWANE.GOV.ZA

Description: Description: Description: did:image001.png@01CD8B60.E8E3D8E0

New-EMS-Logo (003 [redacted]
Deputy Chief: Training Academy

Emergency Services Department| Ground Floor|
Erasmus Kloof Emergency Services Station Station 11 | 499 Tsitsa Street
PO Box 0001 | Pretoria | 0001 | Fraud Hotline: 080 8749 926

Tel: 012 358 6261 | Cell: 082 663 6253 | Email: Andronicus.em@tshwane.gov.za

Emergency: 012 358 6300/6400

From: Andronicus K. Maletjie
Sent: Wednesday, October 11, 2023 9:51 AM
To: Tanja Terblanch

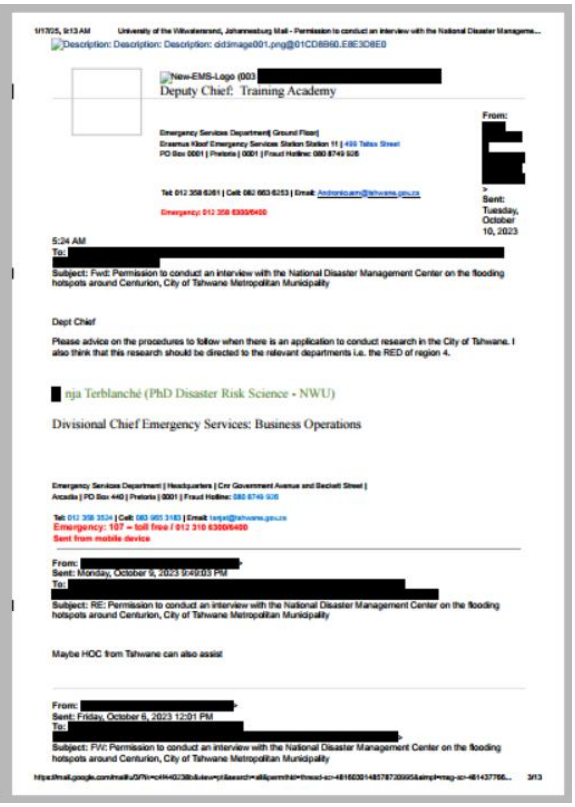
o [redacted] :
Cc: [redacted]
Subject: RE: Permission to conduct an interview with the National Disaster Management Center on the flooding hotspots around Centurion, City of Tshwane Metropolitan Municipality

Good afternoon

The approved ethics document should accompany the letter from the institution to the City Manager office.

Because the research can also be shared with the city especially the findings etc.

City manager office will send it to relevant department for approval or advise



Description: Description: Description: did:image001.png@01CD8B60.E8E3D8E0

New-EMS-Logo (003 [redacted]
Deputy Chief: Training Academy

Emergency Services Department| Ground Floor|
Erasmus Kloof Emergency Services Station Station 11 | 499 Tsitsa Street
PO Box 0001 | Pretoria | 0001 | Fraud Hotline: 080 8749 926

Tel: 012 358 6261 | Cell: 082 663 6253 | Email: Andronicus.em@tshwane.gov.za

Emergency: 012 358 6300/6400

From: [redacted]
Sent: Tuesday, October 10, 2023 5:24 AM
To: [redacted]
Subject: Fwd: Permission to conduct an interview with the National Disaster Management Center on the flooding hotspots around Centurion, City of Tshwane Metropolitan Municipality

Dept Chief

Please advice on the procedures to follow when there is an application to conduct research in the City of Tshwane. I also think that this research should be directed to the relevant departments i.e. the RED of region 4.

[redacted] nja Terblanché (PhD Disaster Risk Science - NWU)

Divisional Chief Emergency Services: Business Operations

Emergency Services Department | Headquarters | Cnr Government Avenue and Beckett Street |
Arcadia | PO Box 440 | Pretoria | 0001 | Fraud Hotline: 080 8749 926

Tel: 012 358 3524 | Cell: 083 965 3183 | Email: tanjat@tshwane.gov.za
Emergency: 107 – toll free / 012 310 6300/6400
Sent from mobile device

From: [redacted]
Sent: Monday, October 9, 2023 9:49:03 PM
To: [redacted]
Subject: RE: Permission to conduct an interview with the National Disaster Management Center on the flooding hotspots around Centurion, City of Tshwane Metropolitan Municipality

Maybe HOC from Tshwane can also assist

From: [redacted]
Sent: Friday, October 6, 2023 12:01 PM
To: [redacted]
Subject: FW: Permission to conduct an interview with the National Disaster Management Center on the flooding hotspots around Centurion, City of Tshwane Metropolitan Municipality

1/17/25, 9:13 AM University of the Witwatersrand, Johannesburg Mail - Permission to conduct an interview with the National Disaster Manageme...

accepted for the proper, complete transmission of the information contained in this email or any files transmitted with it or any delay in its receipt; or arising from or as a result of the use of or reliance on the content of this email or any files transmitted with it. Any views expressed in this email or any files transmitted with it are not necessarily the views of the NDMC. Queries regarding this email or any files transmitted with it should be directed to ITSupport@ndmc.gov.za . This disclaimer forms part of the content of this e-mail for purposes of section 11 of the Electronic Communications and Transactions Act, 2002 (Act No. 25 of 2002)

2 attachments

image002.jpg
26K

image004.jpg
59K

Ofentse Kutumela <1351080@students.wits.ac.za> 12 October 2023 at 05:57
To: [redacted]
Cc: [redacted]

Good morning, [redacted]

I hope that you are well.

Thank you for getting back to me.

Kindly note that I already received approval from the City of Tshwane, see the attached approval letters.

Will this institute me getting an interview from NDMC?

Kind regrads
Ofentse Kutumela
[Quoted text hidden]

3 attachments

~WRD0000.jpg
1K

Permission Letter_Ms Ofentse Kutumela_26July23.pdf
62K

Signed Confidentiality Agreement_CoT and Ofentse Kutumela.pdf
871K

Cynthia Nonjola <CynthiaN@ndmc.gov.za> 12 October 2023 at 08:04

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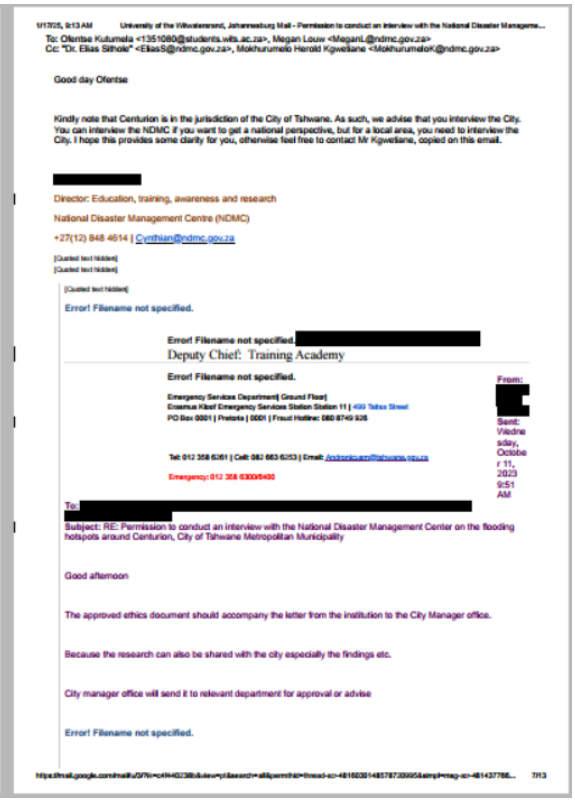

1/17/25, 9:13 AM University of the Witwatersrand, Johannesburg Mail - Permission to conduct an interview with the National Disaster Manageme...

To: Ofentse Kutumela <1351080@students.wits.ac.za>, Megan Louw <MeganL@ndmc.gov.za>
Cc: "Dr. Elias Sithole" <EliasS@ndmc.gov.za>, Mokhurumele Herold Kgwetlane <MokhurumeleK@ndmc.gov.za>

Good day Ofentse

Kindly note that Centurion is in the jurisdiction of the City of Tshwane. As such, we advise that you interview the City. You can interview the NDMC if you want to get a national perspective, but for a local area, you need to interview the City. I hope this provides some clarity for you, otherwise feel free to contact Mr Kgwetlane, copied on this email.

[redacted]
Director: Education, training, awareness and research
National Disaster Management Centre (NDMC)
+27(12) 848 4614 | Cynthian@ndmc.gov.za

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[Quoted text hidden]

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Deputy Chief: Training Academy

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Emergency Services Department| Ground Floor|
Erasmus Kloof Emergency Services Station Station 11 | 499 Tokoa Street
PO Box 0001 | Pretoria | 0001 | Fraud Hotline: 080 8749 926

Tel: 012 358 6261 | Cell: 082 663 6253 | Email: [redacted]

Emergency: 012 358 6300/6400

From: [redacted]
Sent: Wednesday, October 11, 2023 9:51 AM

To: [redacted]

Subject: RE: Permission to conduct an interview with the National Disaster Management Center on the flooding hotspots around Centurion, City of Tshwane Metropolitan Municipality

Good afternoon

The approved ethics document should accompany the letter from the institution to the City Manager office.

Because the research can also be shared with the city especially the findings etc.

City manager office will send it to relevant department for approval or advise

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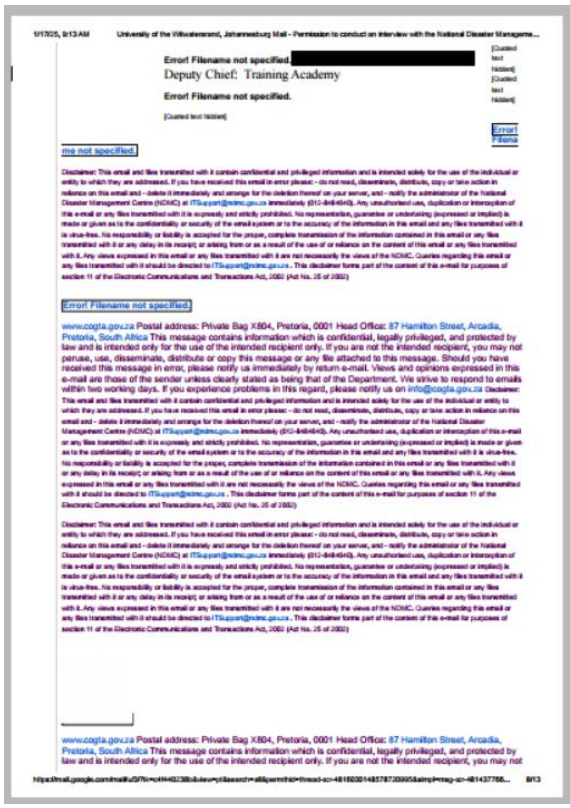
https://mail.google.com/mail/u/0/?ik=c4f402238b&view=pt&search=all&permthid=thread-a:r4816030148578720995&simpl=msg-a:r481437766... 7/13



1/17/25, 9:13 AM University of the Witwatersrand, Johannesburg Mail - Permission to conduct an interview with the National Disaster Manageme...

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Deputy Chief: Training Academy

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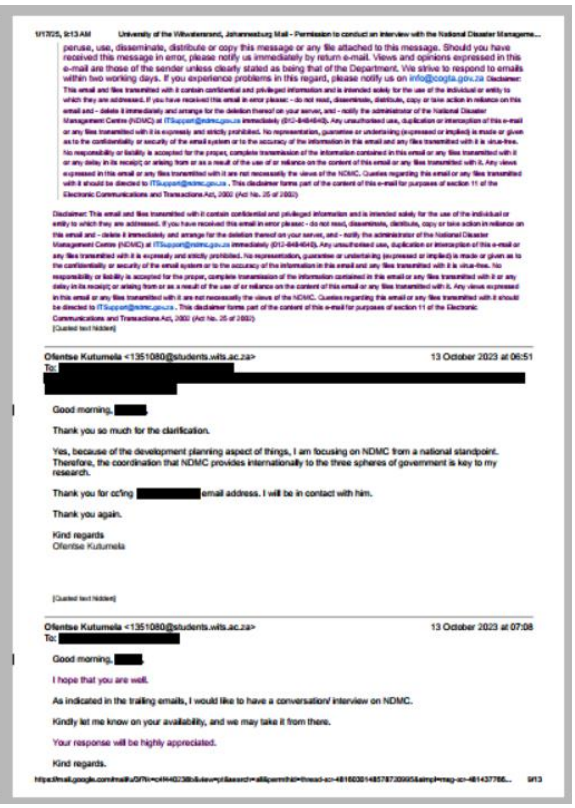

1/17/25, 9:13 AM University of the Witwatersrand, Johannesburg Mail - Permission to conduct an interview with the National Disaster Manageme...

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[Quoted text hidden]

Ofentse Kutumela <1351080@students.wits.ac.za> 13 October 2023 at 06:51
To: [redacted]

Good morning, [redacted].

Thank you so much for the clarification.

Yes, because of the development planning aspect of things, I am focusing on NDMC from a national standpoint. Therefore, the coordination that NDMC provides internationally to the three spheres of government is key to my research.

Thank you for cc'ing [redacted] email address. I will be in contact with him.

Thank you again.

Kind regards
Ofentse Kutumela

[Quoted text hidden]

Ofentse Kutumela <1351080@students.wits.ac.za> 13 October 2023 at 07:08
To: [redacted]

Good morning, [redacted].

I hope that you are well.

As indicated in the trailing emails, I would like to have a conversation/ interview on NDMC.

Kindly let me know on your availability, and we may take it from there.

Your response will be highly appreciated.

Kind regards.

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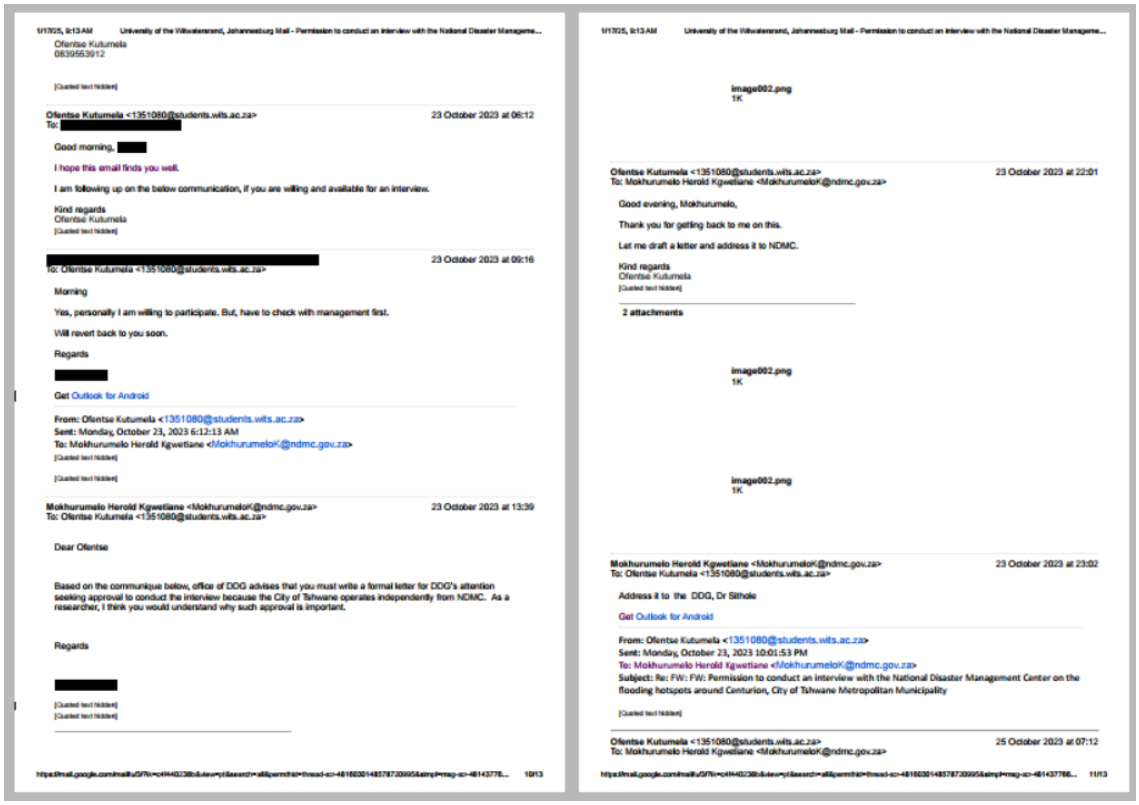

1/17/25, 9:13 AM University of the Witwatersrand, Johannesburg Mail - Permission to conduct an interview with the National Disaster Manageme...

Ofentse Kutumela
0839553912

[Quoted text hidden]

Ofentse Kutumela <1351080@students.wits.ac.za> 23 October 2023 at 06:12
To: [redacted]

Good morning, [redacted]

I hope this email finds you well.

I am following up on the below communication, if you are willing and available for an interview.

Kind regards
Ofentse Kutumela
[Quoted text hidden]

[redacted] 23 October 2023 at 09:16
To: Ofentse Kutumela <1351080@students.wits.ac.za>

Morning

Yes, personally I am willing to participate. But, have to check with management first.

Will revert back to you soon.

Regards

[redacted]

Get Outlook for Android

From: Ofentse Kutumela <1351080@students.wits.ac.za>
Sent: Monday, October 23, 2023 6:12:13 AM
To: Mokhurumelo Herold Kgwetlane <MokhurumeloK@ndmc.gov.za>
[Quoted text hidden]

[Quoted text hidden]

Mokhurumelo Herold Kgwetlane <MokhurumeloK@ndmc.gov.za> 23 October 2023 at 13:39
To: Ofentse Kutumela <1351080@students.wits.ac.za>

Dear Ofentse

Based on the communique below, office of DDG advises that you must write a formal letter for DDG's attention seeking approval to conduct the interview because the City of Tshwane operates independently from NDMC. As a researcher, I think you would understand why such approval is important.

Regards

[redacted]

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[Quoted text hidden]

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Ofentse Kutumela <1351080@students.wits.ac.za> 23 October 2023 at 22:01
To: Mokhurumelo Herold Kgwetlane <MokhurumeloK@ndmc.gov.za>

Good evening, Mokhurumelo,

Thank you for getting back to me on this.

Let me draft a letter and address it to NDMC.

Kind regards
Ofentse Kutumela
[Quoted text hidden]

2 attachments

image002.png
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Mokhurumelo Herold Kgwetlane <MokhurumeloK@ndmc.gov.za> 23 October 2023 at 23:02
To: Ofentse Kutumela <1351080@students.wits.ac.za>

Address it to the DDG, Dr Sithole

Get Outlook for Android

From: Ofentse Kutumela <1351080@students.wits.ac.za>
Sent: Monday, October 23, 2023 10:01:53 PM
To: Mokhurumelo Herold Kgwetlane <MokhurumeloK@ndmc.gov.za>
Subject: Re: FW: FW: Permission to conduct an interview with the National Disaster Management Center on the flooding hotspots around Centurion, City of Tshwane Metropolitan Municipality

[Quoted text hidden]

Ofentse Kutumela <1351080@students.wits.ac.za> 25 October 2023 at 07:12
To: Mokhurumelo Herold Kgwetlane <MokhurumeloK@ndmc.gov.za>

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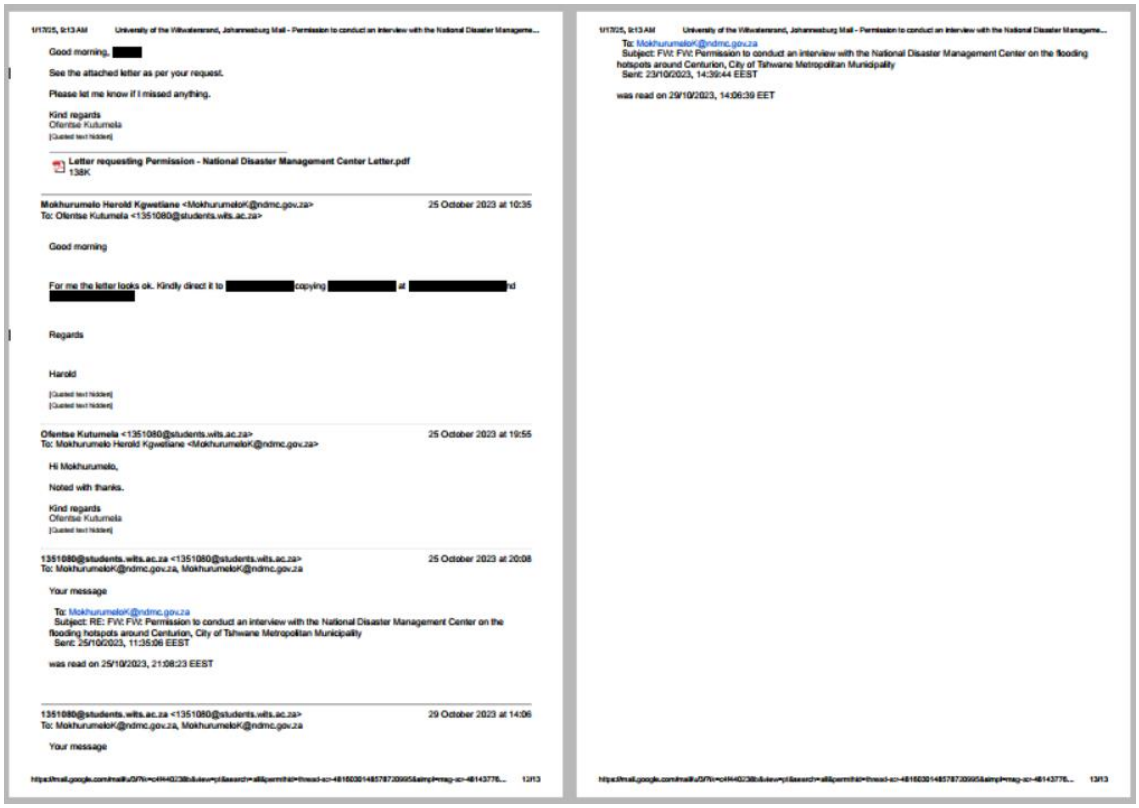

1/17/25, 9:13 AM University of the Witwatersrand, Johannesburg Mail - Permission to conduct an interview with the National Disaster Manageme...

Good morning, [redacted]

See the attached letter as per your request.

Please let me know if I missed anything.

Kind regards
Ofentse Kutumela
[Quoted text hidden]

Letter requesting Permission - National Disaster Management Center Letter.pdf
138K

Mokhurumelo Herold Kgwetlane <MokhurumeloK@ndmc.gov.za> 25 October 2023 at 10:35
To: Ofentse Kutumela <1351080@students.wits.ac.za>

Good morning

For me the letter looks ok. Kindly direct it to [redacted] copying [redacted] at [redacted]nd [redacted]

Regards

Harold

[Quoted text hidden]
[Quoted text hidden]

Ofentse Kutumela <1351080@students.wits.ac.za> 25 October 2023 at 19:55
To: Mokhurumelo Herold Kgwetlane <MokhurumeloK@ndmc.gov.za>

Hi Mokhurumelo,

Noted with thanks.

Kind regards
Ofentse Kutumela
[Quoted text hidden]

1351080@students.wits.ac.za <1351080@students.wits.ac.za> 25 October 2023 at 20:08
To: MokhurumeloK@ndmc.gov.za, MokhurumeloK@ndmc.gov.za

Your message

To: MokhurumeloK@ndmc.gov.za
Subject: RE: FW: FW: Permission to conduct an interview with the National Disaster Management Center on the flooding hotspots around Centurion, City of Tshwane Metropolitan Municipality
Sent: 25/10/2023, 11:35:06 EEST

was read on 25/10/2023, 21:08:23 EEST

1351080@students.wits.ac.za <1351080@students.wits.ac.za> 29 October 2023 at 14:06
To: MokhurumeloK@ndmc.gov.za, MokhurumeloK@ndmc.gov.za

Your message

https://mail.google.com/mail/u/0?ik=c4f40238b8&view=pt&search=all&permthid=thread-a:r4816030148578720995&simpl=msg-a:r48143776... 12/13

1/17/25, 9:13 AM University of the Witwatersrand, Johannesburg Mail - Permission to conduct an interview with the National Disaster Manageme...

To: MokhurumeloK@ndmc.gov.za
Subject: FW: FW: Permission to conduct an interview with the National Disaster Management Center on the flooding hotspots around Centurion, City of Tshwane Metropolitan Municipality
Sent: 23/10/2023, 14:39:44 EEST

was read on 29/10/2023, 14:06:39 EET

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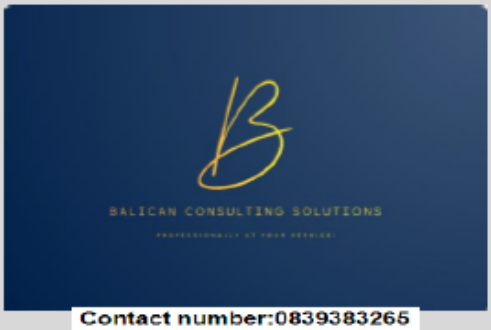
APPENDIX G: LANGUAGE EDITING CERTIFICATE



Contact number:0839383265
Whatsapp:0658888129
Email: rbrtncky@yahoo.com

This serves to confirmthat we'veduly edited a Master of Science in Development Planning *titled*:

Investigating flood prevention measures adopted in flood-prone areas of Centurion, City of Tshwane Metropolitan Municipality

by

OFENTSE KUTUMELA

WITS

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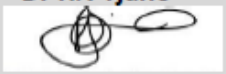
Should there be any queries, please do not hesitate to contact us on the details provided above.

Yours sincerely
Dr RN Tjano



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