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DIFFERENTIATING VULNERABILITY TO CLIMATE CHANGE

A COMPARATIVE CASE STUDY OF THE QUARRY ROAD WEST INFORMAL
SETTLEMENT AND WESTVILLE FORMAL RESIDENTIAL AREA

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Abstract

Climate change affects every ecosystem, country, and individual on this planet. However, its impacts are felt differently across time and space, differentiating between the diverse communities, depending on their vulnerability. The purpose of this comparative case study is to problematize vulnerability to climate change by examining the differences in vulnerability between informal settlements and formal residential areas on the example of Quarry Road West and Westville in eThekweni, Durban, South Africa. Based on the results, it will be discussed how these differences impact the process of climate-proofing cities. The research adopts a mixed-method comparative case study design based on an analysis of secondary data and semi-structured expert interviews. Thereby, the findings answering the research question *how is vulnerability to climate change-related hazards differentiating between informal settlements and formal settlements alongside the Palmiet River in eThekweni, South Africa?* will be placed within the Climate Change Vulnerability Framework. Based on the results, this research argues that vulnerability to climate change differentiates between informal settlements and formal residential areas, highlighting the need for context-specific and localized policy approaches when climate-proofing cities.

Keywords vulnerability • informal settlements • residential areas • climate change • climate-proofing cities • South Africa

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List of Abbreviations

CBD	Central Business District
CC	Climate Change
CCV	Climate Change Vulnerability
CCVF	Climate Change Vulnerability Framework
CFCP	Cities Fit for Climate Change Project
CPC	Climate-Proof Cities
FRA	Formal Residential Area
GHG	Greenhouse Gas Emissions
IPCC	Intergovernmental Panel on Climate Change
IS	Informal Settlement
PCRPP	Palmiet Catchment Rehabilitation Project
PR	Palmiet River
QRW	Quarry Road West
SLF	Sustainable Livelihood Framework
SSA	Sub-Saharan Africa
UEIP	uMngeni Ecological Infrastructure Partnership
UKZN	University of Kwazulu-Natal

1. Introduction

“Once you deal with climate change, you can’t say that one size fits all.” – Bhengu 2021

Climate change (CC) affects every country on every continent and impacts various livelihoods, economies, and ecosystems (UN n.d.). Thereby, climate change is not only an environmental but also a social and economic issue (Frank et al. 2019). In 2018 CC has affected over 39 million people due to the rising severity and frequency of hazardous events, while only 85 countries dispose of disaster risk reduction strategies to cope with the effects (UN n.d.). Especially cities will be exposed to the extreme climatic events, which requires a governmental led transformation to more sustainable and climate-proof cities (CPC) with strategies countering the negative impacts of CC such as droughts, sea-level rise, floods, and the urban heat-island effect (Rosenzweig et al. 2015; Williams et al. 2018; Frank et al. 2019).

Although impacts of CC are felt in cities across the globe, their consequences and vulnerability are highly dependent on the resilience of the affected community. Hence, local governments play a crucial role in creating sustainable, climate-proof, and resilient cities by implementing holistic and new-thinking adaption and mitigation strategies in their urban development plans. Based on the need for local adaption strategies, this study will address the differences between informal and formal settlements and highlight how vulnerability to CC differentiates, reflecting on the human, social, economic, biophysical, and institutional capital of two communities in Durban, South Africa. By evaluating the differences, the necessity of localized and distinctive approaches for the development of CPC will be demonstrated.

1.1. Specific Aims and Research Question

Understanding vulnerability in its complexity is relevant to combat the effects of climate change in cities. This study highlights the individuality in vulnerability when cities are exposed to CC. Thereby, this study aims to shine light on the differences in vulnerability to CC-related hazards within the city by focusing on the differences between informal and formal settlements. Hence, the following research question will be proposed:

RQ: How is vulnerability to climate change related hazards differentiating between informal settlements and formal settlements alongside the Palmiet River in eThekweni, South Africa?

The research is conducted as a comparative case study. The cases are located along the Palmiet River, eThekweni in South Africa. The region experiences heavy rainfall due to CC, making

flooding the focused hazard of this study (Okem 2019). The cases of the informal settlement Quarry Road West (QRW) and the formal residential area Westville were chosen due to their high level of comparability based on their similar location and exposure to the same hazard. By excluding different time periods, different legal systems, and other external factors, the likelihood of finding the correct explanatory variable gets increased (Kaarbo et al.1999).

This study hopes to inspire future research on climate-proofing cities by analysing vulnerability in a holistic and transdisciplinary manner, highlighting the need to address context-specific factors based on identified differences in vulnerability.

1.2. Delimitations

The effects of CC on urban areas are enormous and concern a broad spectrum of issues. Therefore, this study is delimited to the impact of CC on the vulnerability of specific forms of settlement. Moreover, the research limits on two particular cases which are impacted by the specific climate-related hazard of flooding and storms due to heavy rainfall. By narrowing the study down and choosing a specific angle, I feel confident in exploring my research questions within the limited scope of this bachelor thesis. The data collection for this study has been limited to the Quarry Road West informal settlement (IS) and the Westville formal residential area (FRA) since multiple comparisons of more communities along the Palmiet River would have been beyond the scope of the study.

1.3. Structure

The thesis began with an introduction to the relevance of assessing vulnerability for the creation of climate-proof cities. The second chapter provides a review of previous literature on the topics of CC in South African cities and climate-proofing cities, followed by an evaluation of the concept of vulnerability to CC. Chapter three presents the case and the background of both areas. This part is followed by the theory in chapter four, in which the Climate Change Vulnerability Framework (CCVF) will be displayed to provide an understanding of how the vulnerability to climate change of both areas will be examined within this study. The fifth chapter will present the research methodology and will elaborate on the data collection, analysis, and limitations faced during the research. Moreover, a reflection on ethical considerations during the research process will be provided. Chapter six will present the findings of the research, which will be discussed in chapter seven of this thesis, placing the findings within the theoretical background and in context to the research question. Finally, the eighth chapter will draw conclusions and will provide considerations for future studies.

2. Literature Review

This chapter will first outline the existing literature on the impact of CC in South African cities, including FRA and IS within these. Secondly, the concept of climate-proofing cities will be presented as an approach to counter climate change in cities. Thirdly, the concept of vulnerability and its relation to climate change will be displayed, which will provide the foundation for the developed working definition of vulnerability for this study, presented in chapter four.

2.1. Climate Change in South African Cities

The global phenomenon of CC has a significant impact on urban life and poses an enormous challenge for sustainable urban development (UN n.d.; Wamsler et al. 2013). Otto et al. (2017) state that especially developing countries are vulnerable to CC since the economic resources are limited and social safety nets are often insufficient.

Cities in Sub-Saharan Africa (SSA) are particularly vulnerable to the effects of CC (Jagarnath et al. 2020). CC reinforces social and spatial inequalities, worsening poverty and inequality in African cities (Jagarnath et al. 2017; Ogwu 2019). The vulnerability of African cities to CC is intensified by fast and unplanned urbanization (Addaney et al. 2019). CC intensifies the already existing push and pull effects, where economic opportunities pull the rural population in the cities, and low agricultural activity pushes migrants in the urban areas (Ogwu 2019; Nkrumah 2019). Therefore, African cities are experiencing the world's highest urbanization, with an annual rate of 4.0% (Addaney et al. 2019; Ogwu 2019; Jagarnath et al. 2020). By 2050, 31 countries in SSA are expected to double their populations, amounting to 60.0% of the total population living in urban areas (Ogwu 2019).

The climatic risks for African cities range from an increase in temperature to rising sea levels, heavy rainfall, and draughts (Jagarnath et al. 2020; Addaney et al. 2019; Ogwu 2019). These risks are related to increased mortality, child undernourishment, and lung diseases (Jagarnath et al. 2020). Moreover, the extreme weather events destroy the biodiversity and infrastructure of African cities, threatening access to water, electricity, and other vital services (Addaney et al. 2019; Ogwu 2019). Due to the hazardous events, African cities suffer from lower incentives of the government to invest in education, health, and other services. Thereby the effects and impacts of CC are felt from residents of FRA, just as from IS (Addaney et al. 2019). Besides the effects mentioned above, IS in cities are, according to previous studies, particularly prone to climate-related risks and suffer more from the effects than other settlements. They are located in areas prone to more diseases, pollution, or flooding and are characterized by the lack of access to water and sanitation facilities, limited access and

provision of resources, social safety nets, essential services, and infrastructure, and fragile housing (Adger 2006; Bai 2018; World Bank 2011; UN-Habitat 2016; Jean-Baptiste et al. 2018; Mazeka et al. 2019).

2.2. Climate-Proofing Cities

The pressure on social and natural systems of African cities requires the development of adaption strategies to climate-proof urban areas (Jagarnath et al. 2017; Martel et al. 2019). Despite global policy actions such as the Paris Agreement or the New Urban Agenda, cities must start implementing effective strategies on the ground in which context, history, and geography need to be considered (UN-Habitat 2020; Martel et al. 2019; Frank et al. 2019). Thereby, studies have shown that it is crucial to mainstream climate measures into urban development, since challenges like rising energy consumption, urban sprawl, the demand for housing and safety, and urbanization are heavily impacted by climate change and the other way around (Frank et al. 2019; Döpp et al. 2011; Papa 2021; Maragno et al. 2020; Brown et al. 2011).

The approach of climate-proofing cities aims for a holistic assessment of climate adaption and mitigation strategies to tackle these challenges (Brown et al. 2011). This comprehensive approach requires coordinated action amongst relevant stakeholders and recognizing transdisciplinary urban development processes (Frank et al. 2019; Papa 2021). Frank et al. (2019) stress that cities must develop a shared vision that meets their geography, social, environmental, and economic contexts to become climate-proof. Since urban areas vary in their urban form and are shaped by different political, historical, and legal contexts, no single concept of mitigation and adaption can be implemented globally but instead requires considering local factors (Frank et al. 2019; Albers et al. 2015). This involves integrating local stakeholders and opinions and raising awareness of CC as ownership highly affects the effectiveness of local policies (Albers et al. 2015; Chigwada 2005; Elias 2011).

In the Netherlands, the Climate Proof Cities program established in 2010 attempted to follow these guidelines and strengthen the adaptive capacity and reduce vulnerability to CC in cities (Albers et al. 2015). However, the programs' results have been focusing on cities in the Netherlands, which demands more research on climate-proofing cities, especially in developing countries. This is also supported by Ngoc Le et al. (2021), stressing that the linkages between climate change and adaption are rarely explored in developing countries.

2.3. Vulnerability to Climate Change a Contested Concept

Vulnerability is a multidimensional and dynamic concept that includes various stressors, and is associated to concepts like risk, exposure, susceptibility, coping capacity, and resilience (Rehman et al. 2019; Adger 2006, O'Brien et al. 2005; Liverman 1990; Kasperson et al. 2012; Thomas et al. 2018). Scientifically, the concept has its origin in geography, where it has been used descriptively, whereas social scientists tend to use it in an explanatory context (Füssel 2006).

CC is a significant- and multi-scale global issue, influenced by various actors, scales, and agents. Determining the impacts of CC depends not only on the nature of climate changes but the vulnerability of the places and people that experience those changes (CSIR 2017). Research states that the impacts of climate change will increase the burden on those who are already more vulnerable in society (Adger 2006). Therefore, concerning CC, vulnerability is defined as the state of susceptibility derived from exposure to external stresses such as environmental and social change with the capacity to adapt to these changes (Adger 2006; Proag 2014; Cutter 2003; Jabareen 2012). Thereby, Adger (2006) stresses that the coping capacity is highly dependent on institutional circumstances, including the equal distribution of natural and social resources. Moreover, Eizenberg et al. (2017) state that vulnerability is dependent on prior stresses, social networks, the society's development path, physical exposures, and governance. Based on previous studies, vulnerability is highly variable and depends on critical factors such as exposure, system sensitivity, and adaptive capacity (Adger 2006; Joakim et al. 2015). Füssel (2005) developed a general framework in which he identified four crucial determinants for vulnerability: the system, hazard, consequences, and a temporal reference. He distinguishes between internal and external vulnerability factors, by which internal refers to the assets of the vulnerable system and the external to factors outside the vulnerable system.

Within the academic field, the concept of vulnerability has been heavily contested due to its use by a great variety of disciplines and traditions (Rehman et al. 2019; Adger 2006; Füssel 2006; Joakim et al. 2015). Especially in the interdisciplinary research on CC, its multidimensional use has proposed enormous challenges to the development of an appropriate definition (Füssel 2006). O'Brien et al. (2005) stress that these diverging conceptions have confused governance and policymaking. However, Adger (2006) argues that the diversity of the concept is not necessarily a weakness but rather a strength when conceptualised clearly. Kasperson et al. (2005) conclude that there is no one-size-fits-all conceptualization, but instead, that vulnerability needs to be fitted to its specific context.

2.3.1. Integrated Approaches

Previously scholars have distinguished between socio-economic and biophysical vulnerability (Füssel 2006; Soares et al. 2012). According to Füssel (2006), socio-economic factors for vulnerability are concerned with the distribution of power, cultural circumstances, and normative institutions, whereas biophysical factors accounting for vulnerability relate to the hazard literature. Another significant difference between the two approaches is their perspective on vulnerability. Biophysical approaches consider vulnerability as an end-point, in which vulnerability is the outcome of the impacts of climate change minus adaptation (Soares et al. 2012.; O'Brien et al. 2007). Socio-economic approaches consider vulnerability as a starting point. Here, vulnerability is defined by the damage a priori and by the existing state of the system. It centres around the socio-economic and political context to address the needs in policy adaptation that cause the vulnerability in the first place (Kelly et al. 2000; Füssel 2006; Adger 2006; O'Brien et al. 2007). Scholar work acknowledged that there is a synergy between biophysical processes and social systems (Adger 2006). This synergy created a need for integrated approaches in the field of vulnerability, especially in the context of CC (Adger 2006; Füssel 2006). Since vulnerability is impacted by socio-economic as well as by biophysical factors, integrated approaches aim to combine the two perspectives equally to facilitate a holistic perspective on vulnerability (O'Brien et al. 2007; Soares et al. 2012; Füssel et al. 2006).

2.4. Evaluation of Climate Change Vulnerability in Cities

Reviewing the present literature has shown the impacts of climate change on cities' formal residential areas and informal settlements. Evaluating the concept of vulnerability has shown that the integrated perspective provides a multidimensional and broad analytical conceptualization of vulnerability and hence is the most influential paradigm in analysing climate change vulnerability (Soares et al. 2012). However, reviewing the present literature has revealed that the concept of vulnerability to climate change has yet failed to be evaluated distinctively within cities and how it differentiates across its diverse spaces. Previous studies tend to stress the importance of vulnerability of IS to climate change rather than the vulnerability of FRA and fail to examine factors that account for vulnerability in the two different types of settlement. Thus, previous literature fails to highlight context-specific dimensions and factors accounting for vulnerability to climate change, which will be the gap addressed with this research.

Adger (2006) stresses that developing a framework that incorporates both human and natural perspectives is crucial for assessing the complexity of vulnerability. Hence this study developed a consistent framework, reflecting the integrated perspective. Since this study hopes

to inspire future research by assessing different kinds of vulnerability within the same city and eventually highlighting the importance of localized approaches for future studies on the issue, a framework was developed that allows for an assessment from distinctive perspectives aiming to evaluate vulnerability to CC in a context-specific setting, as localized as possible. In order to draw meaningful conclusions, a clear and transparent specification of the applied concept is necessary, which will be provided in chapter four of this study (Füssel 2005, 2006).

3. Background

The following chapter will describe the background of Westville and QRW concerning climate change vulnerability, presenting their relevance and suitability for addressing the current gap in the present literature. The context of eThekweni and the two cases will be presented, followed by an introduction of the Palmiet Catchment Rehabilitation Project (PCRP) since its work has had a substantial impact on climate change vulnerability (CCV) of QRW.

3.1. eThekweni Municipality and Durban

eThekweni municipality is a metropolitan area in the KwaZulu Natal Province, located on the east coast of South Africa (Okem 2019; Parikh et al. 2020; Jagarnath et al. 2020).

Durban is part of the eThekweni municipality and forms with 3.8 million inhabitants, the third-largest city in South Africa (Williams et al. 2018; Parikh et al. 2020). Due to its large port, the municipality is an essential contributor to the South African economy, accounting for 44.0% of the municipal employment and 57.1% of the provincial GDP (Padayachee et al. 2019; Okem 2019). Durban faces high rates of urbanization, resulting in urban poverty. Moreover, historical preconditions such as colonialism and the apartheid regime have led to high levels of inequality in the city (Williams et al. 2019; Georgiada et al. 2021). Durban's history caused a strong spatial fragmentation in the city, which is also impacted by the bisected topography of eThekweni municipality: 45.0% is considered rural, 30.0% peri-urban, and 25.0% urban (Parikh et al. 2020; Jagarnath et al. 2017). The peri-urban areas are the most disadvantaged neighbourhoods in the city with little access to basic services, while the urban core with neighbourhoods like Westville belongs to the most privileged areas (Jagarnath et al. 2017). In Durban, the unemployment rate amounts to 16.6%. 41.8% of the population lives in poverty and is provided with state-subsidised housing (Williams et al. 2018). Moreover, 27.0% of the inhabitants live in informal settlements. However, the city has a more progressive attitude towards informality, which is reflected in the provision of basic services such as water points and electricity to these settlements. eThekweni encourages in-situ upgrading projects, which

implies the formalisation of IS in its original location (Georgiada et al. 2021; Mazeka et al. 2019). However, some settlements are categorized as deferred relocations since their local risks limit the opportunities to upgrade the settlement, one of which is the QRW (Mazeka et al. 2019; Sutherland et al. 2019).

3.1.1. eThekweni Municipality and Climate Change

eThekweni has a subtropical climate and is experiencing high climate variability. Due to climate change, it is expected that by 2065 the mean annual temperature will increase between 1.5 and 2.5 C. The municipality experiences the effects of climate change and is also a contributor with high GHG (Okem 2019). Hence, climate change mitigation and adaptation became an essential part of the municipal agenda in which the strategy focused on water, sea-level rise, biodiversity, food security, health, energy, transport, waste and pollution, economic development, and knowledge generation and understanding (Martel et al. 2019).

The municipality expects an annual sea-level rise of 2.7 mm and increased rainfall up to 100% by the end of the century due to climate change. Furthermore, rainfall will become more extreme, increasing by 22.0 mm by 2050 (eThekweni municipality n.d.; Okem 2019; Williams et al. 2018; Martel et al. 2019). Higher runoff and river flow will lead to an increased risk of flooding in flood-prone areas (Constable et al. 2009). Its location alongside the Palmiet River intensifies the risks of flood events in the city since the river peaks quickly after heavy rainfall (Williams et al. 2019; Mazeka et al. 2019). The events of flooding impact not only the access to safe water but the drainage and waste collection, the supply of sanitation, healthcare, and emergency services and lead to disruptions of the transport, electricity, and sewerage infrastructure, resulting in limited mobility and economic activity (Williams et al. 2018; Constable et al. 2009). Pluvial floods will affect eThekweni's natural, economic capital, and social capital (eThekweni municipality n.d.).

3.2. Westville

Westville is a formal residential area located in the West of Durban's Central Business District (CBD) (Fig. 3.1.). It was founded in 1847 by German immigrants, which is also reflected in the architecture. The formerly independent town is now a suburb of Durban and part of eThekweni. Westville is characterized by gated communities, several schools, and higher-education institutions like the University of Kwazulu-Natal (South Africa Info n.d.). It is located close to the Palmiet River, encompassing 30.76 km² and home to 30,508 residents (Census 2011).

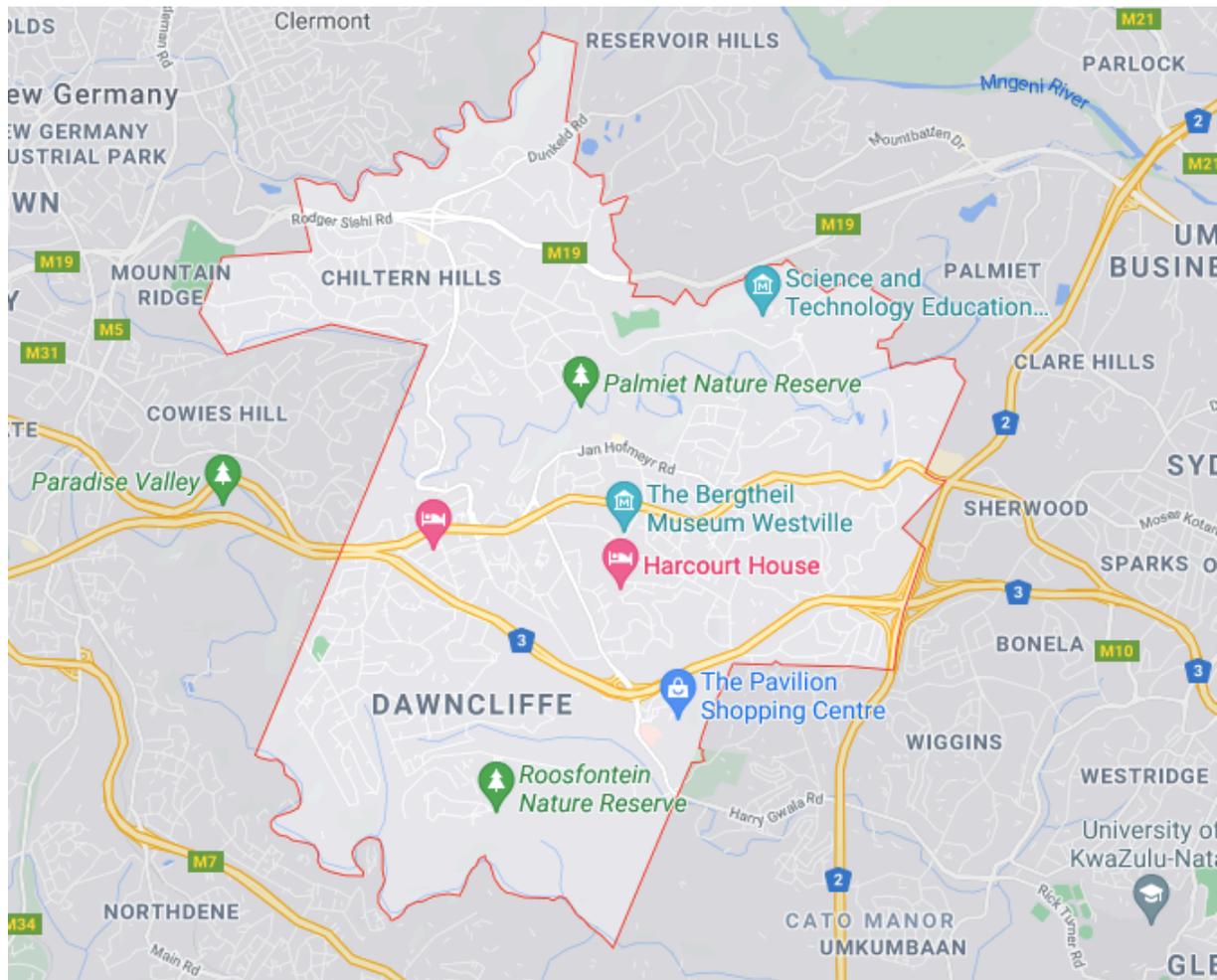


Figure 3.1. Location of Westville: GoogleMaps 2021

3.3. Quarry Road West Informal Settlement

The settlement was founded in 1984. It is located in the urban core of Durban on the flood plain of the Palmiet River, as shown in Fig. 3.2. (Williams et al. 2018; Mazeka et al. 2019). Based on a community mapping project in 2017, the settlement inhabits c.a. 2400 residents in around 931 households (Williams et al. 2018). The area is socially well organized with high levels of social cohesion (Sutherland et al. 2019). Its relationship with the government has been conflictual in the past with low trust between the parties (Martel et al. 2019). The settlement exists of four sections MamSuthu, MCondo I, MCondo II, and eMampondweni (Mazeka et al. 2019). Its proximity to the urban centre and residential suburbs is the most crucial resource for the residents (Williams et al. 2018). The river serves as another vital resource for waste disposal, the washing of goods, and some spiritual practices (Williams et al. 2019).

The settlement has a long history of flooding due to its risk-exposed location alongside the PR, and the unmanaged stormwater flows originating from the roads close to QRW (Williams et al. 2018; 2019). The area lacks access to basic services and infrastructure, has low housing standards, and is characterized by high levels of poverty which makes the settlement

vulnerable to hazardous events like the flood in 2019 where 240 homes were lost (Sutherland et al. 2019; UNEP 2020). However, Williams et al. (2019) state that residents are willing to trade-off that risk for the settlements' urban opportunities.

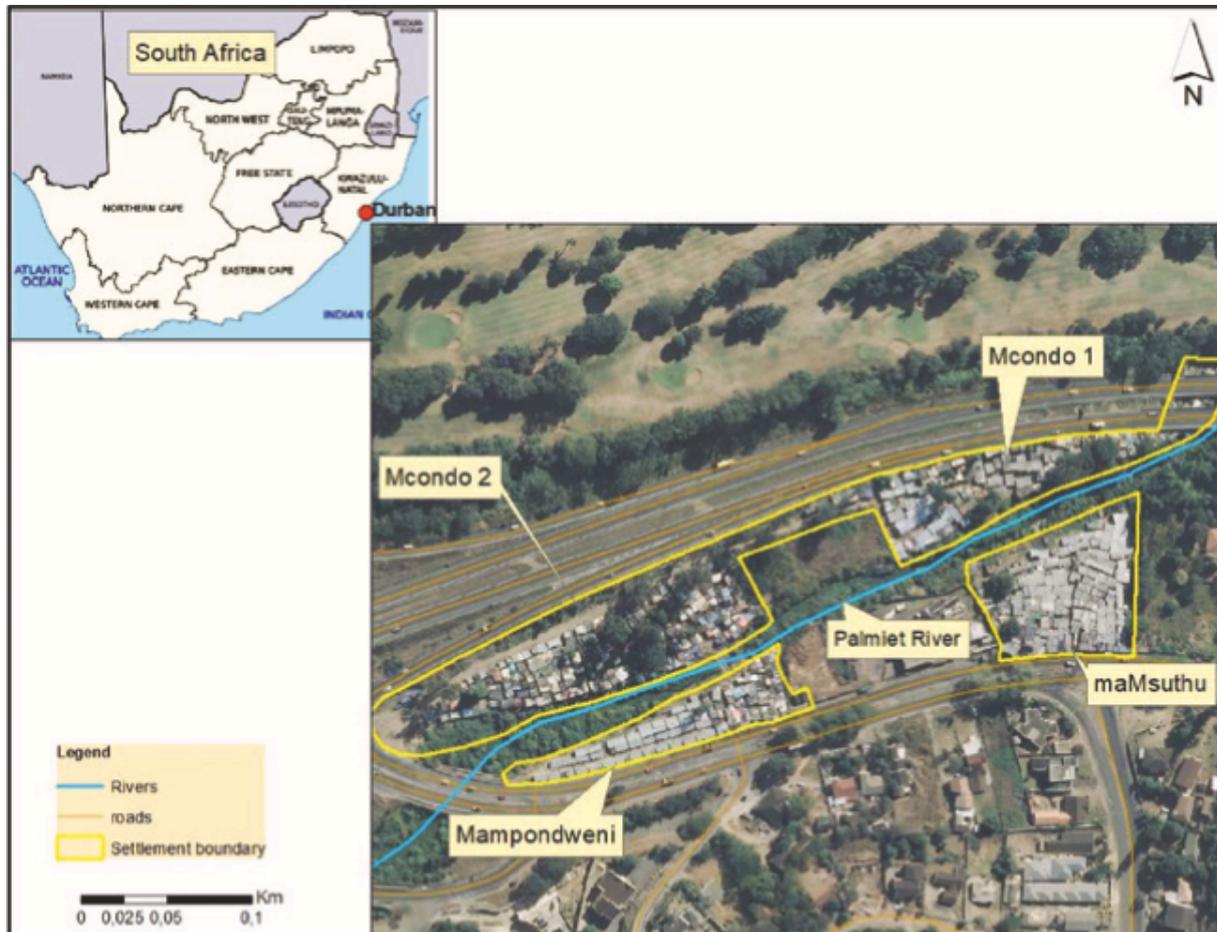


Figure 3.2. Location of Quarry Road West: Bahle Mazeka 2019

3.3.1. Palmiet Catchment Rehabilitation Project

Due to the settlements' risk exposed location, past projects have attempted to increase the community's resilience to CC. The PCRP is a partnership of the municipality, research institutions, and community organizations (Williams et al.2018). It is part of the uMngeni Ecological Infrastructure Partnership (UEIP) pilot project, which aims to improve the water security in the uMngeni Catchment (Sutherland et al. 2019). The PCRP goal is to improve the ecological infrastructure of the river and, by that, enhance the community's resilience to CC (Martel et al. 2019). The project followed a shared-governance approach, focusing on climate change adaption through infrastructure management and the conservation, rehabilitation, and restoration of the environment (Frank et al. 2019).

In 2015 the University of KwaZulu-Natal (UKZN) entered a partnership with the project. Students and researchers focused on community engagement through a participatory

action research approach (Sutherland et al. 2019; Frank et al. 2019). This collaboration aimed to co-produce data collection on the settlement and the residents' relationship with the river to improve resilience (Sutherland et al. 2019). An outcome has been the creation of a risk map produced by the residents in which they identified the location of places most prone to future hazards. Furthermore, the location of solid waste disposal or eroding river banks got determined. The project created a handbook, serving as a guide on how people can make their homes climate-proof (Mazeka et al. 2019; Frank et al. 2019). Additionally, a WhatsApp group was created to warn one another about river water rise (UNEP 2020).

The project also intended to address the lack of trust between the government and the settlement. This step was crucial for the technical implementation of environmental resilience measures, as only through an inclusive approach would residents feel equally represented in the process (Martel et al. 2019; UNEP 2020).

4. Theoretical Framework

The following chapter will present the study's theoretical framework, which will direct the analysis of the research. First, the Climate Change Vulnerability Framework will be displayed to analyse the data collection results within this selected frame of the study. Secondly, critics and difficulties in measuring vulnerability will be examined to show the limitations of the research. This chapter seeks to provide an understanding of how the vulnerability to climate change of both areas will be examined within this study.

4.1. Climate Change Vulnerability Framework

The brought about changes of climate change propose several consequences to the livelihood of people and the environment and are thereby dependent on various socio-economic and biophysical processes (Iyalohme 2011). In support of the aim of this research, it is crucial to display the determinants and impacts of external factors on vulnerability to understand how their interplay affects the vulnerability to climate change of a community. Hence the CCVF serves as a theoretical framework, presenting relevant indicators for vulnerability, allowing for a meaningful comparison between IS and FRA based on these factors. The CCVF considers human, socio-economic, biophysical, and institutional indicators accounting for differences in vulnerability (Iyalohme 2011; European Commission 2011). The framework allows for an integrated vulnerability assessment, including all aspects of vulnerability, placed within the complex dynamics of the institutional system (Adger 2006). Moreover, the CCVF provides qualitative just as quantitative insights that complement one another and allow for insights into

perceptions of vulnerability. Thereby, the qualitative narratives of stakeholders are complemented by quantitative measures in their particular places and contexts (Adger 2006).

The author developed the CCVF, based on the Theoretical Framework for a Holistic Approach to Disaster Risk Assessment and Management proposed by the European Commission and the Sustainable Livelihood Framework (SLF) developed by the British Department for International Development (1997). The author adopted the interactions of hazard and society and the scale, resilience, and adaption determents from the European Commission (2011) (Fig. 4.1.) and complemented it with the interplay of the capital assets from the SLF (1997) (Fig 4.2.). To address the qualitative component of vulnerability, the author added personal perceptions, experiences, and opinions shaping vulnerability to the CCVF (Fig. 4.3.).

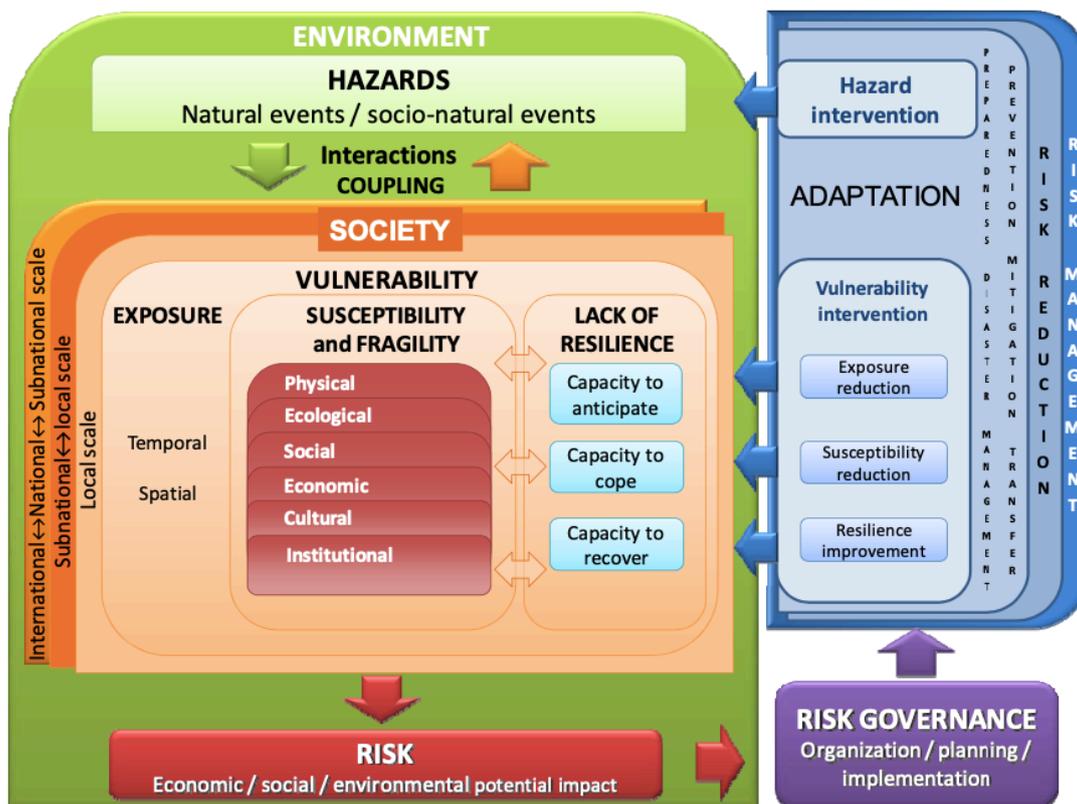


Figure 4.1. Theoretical Framework for a Holistic Approach to Disaster Risk Assessment and Management: European Commission 2011

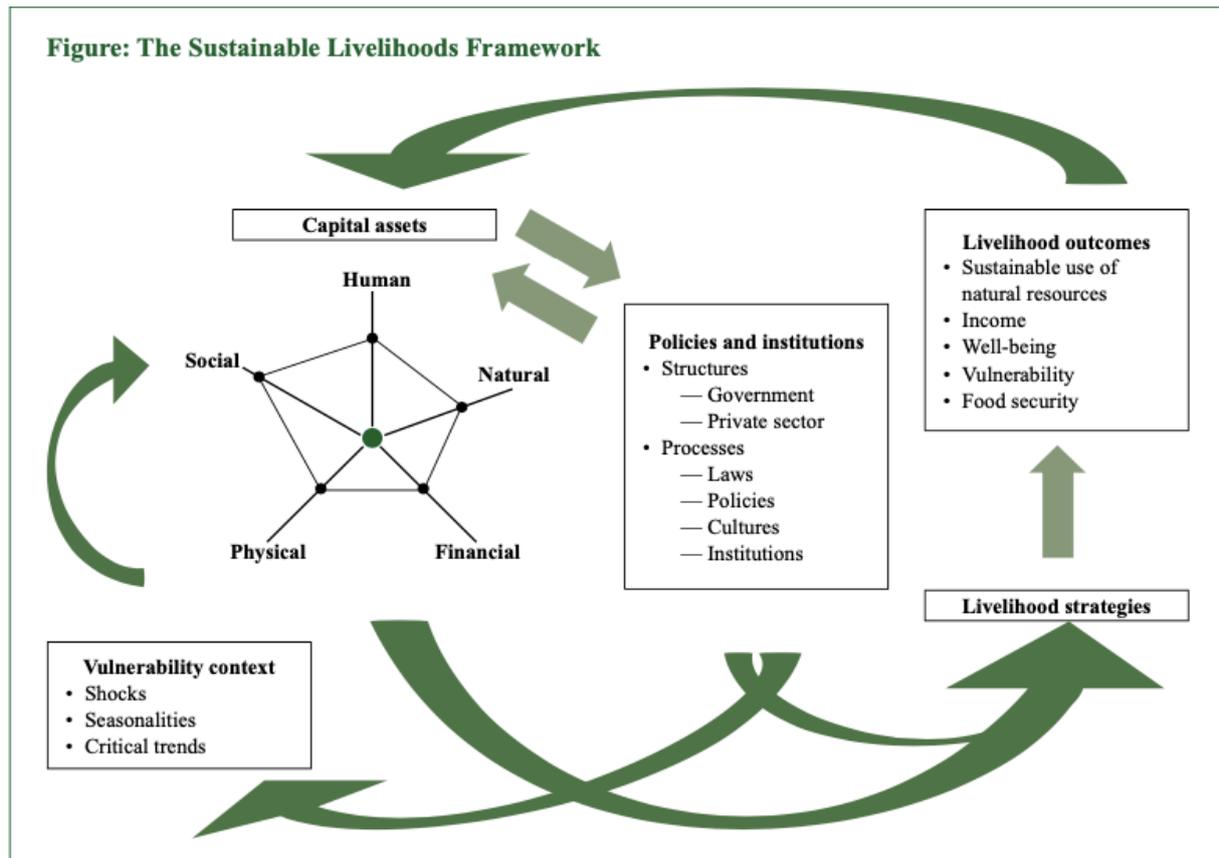


Figure 4.2. Sustainable Livelihood Framework: Department for International Development of the United Kingdom 1997

The developed CCVF (Fig.4.3.) recognizes the coexistence and interactions of the society and hazards, which is described as coupling and allows to address vulnerability from a multidimensional perspective (European Commission 2011). Since this study addresses the vulnerability in two specific areas, the framework focuses on the local scale. Concerning the hazard, the research will focus on the impact of heavy rainfall, including flooding and storm events, as those have the most significant effect on the selected communities. The CCVF displays vulnerability in the interrelated human, social, economic, biophysical, and institutional dimensions (European Commission 2011). Vulnerability is defined as *the degree to which a system is susceptible to and unable to cope with the adverse effects of climate change, including climate variability and extremes. The degree of vulnerability is impacted by society's human, social, economic, physical, environmental, and institutional capital. Vulnerability varies across stakeholders and depends on personal perceptions, experiences and opinions* (working definition of vulnerability developed by the author based on the IPCC (1996) definition of vulnerability). Susceptibility hereby refers to the disposition of the community to suffer harm based on different capital levels of human, social, economic, biophysical, and institutional factors (Serrat 2008). The framework displays the interconnectedness of susceptibility and lack of resilience, which includes the capacity to anticipate, cope and recover by accessing the

necessary resources (European Commission 2011). Since adaption strategies impact climate change vulnerability, the framework also includes this factor and its impact on the community's vulnerability. To include qualitative dimensions of vulnerability and how they expose a community to risk, personal perceptions, experiences, and opinions are included in the framework.

Applying the CCVF will provide the study with the necessary theoretical foundation to display the impact of external processes and structures on vulnerability and the interplay between the human, social, economic, biophysical, and institutional capital of both communities. Evaluating these linkages will be essential for assessing the differences in vulnerability of the two cases since only by understanding the relationships between the different concepts, the study will be able to draw meaningful conclusions on the differences in vulnerability.

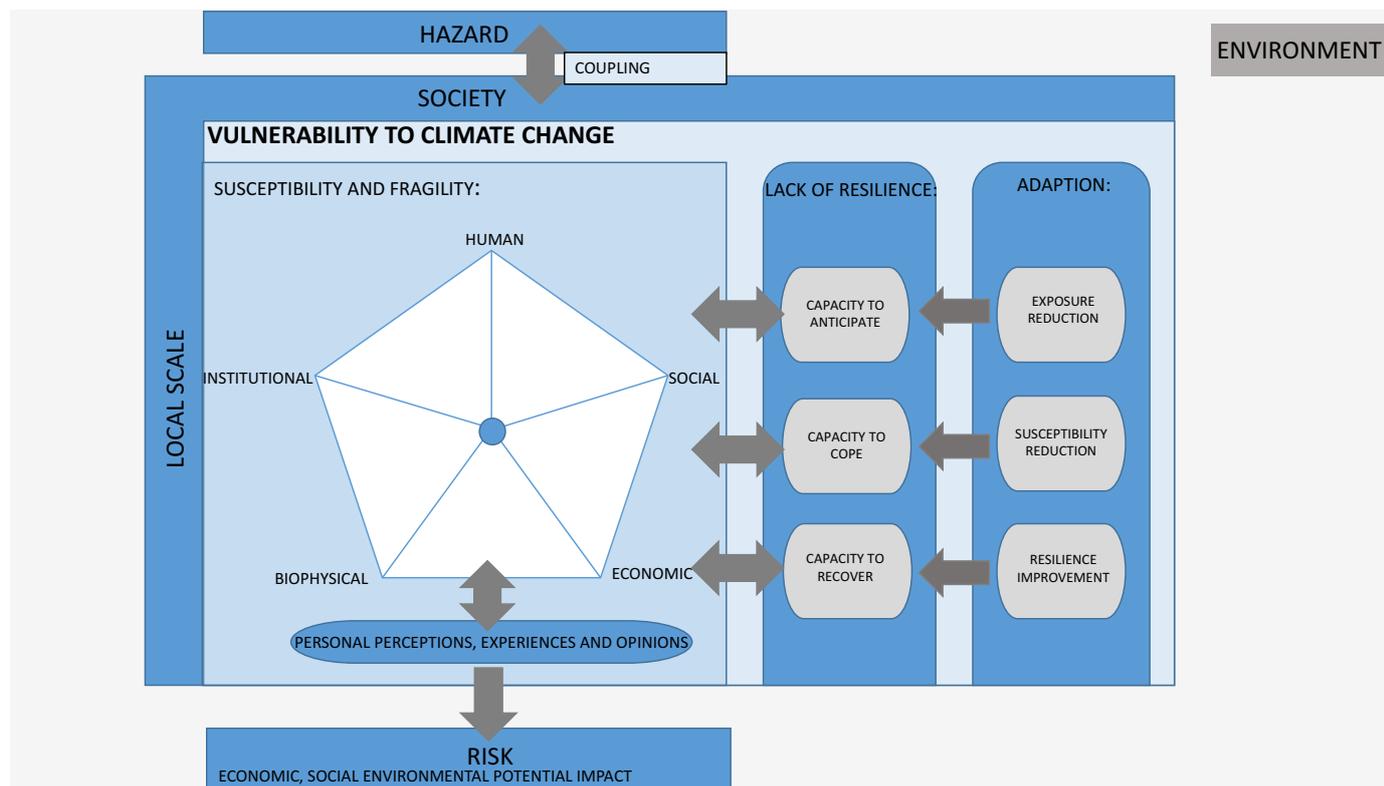


Figure 4.3. Climate Change Vulnerability Framework: developed by the author

4.1.1. Critics and Difficulties

Since CC is a highly complex issue that interacts with various kinds of stressors, problems, and variables, it affects communities differently. Measuring the vulnerability of communities can lead to misunderstandings when conceptualized in different ways (Füssel 2010; Zhang et al. 2019). Even when defined clearly, the complexity of the interplay of socio-economic and

biophysical systems requires large sets of variables and indicators (Zhang et al. 2019). However, this complex set of variables leads to the controversial challenge of practical and straightforward information related to vulnerability and the complexity of the concept (Zhang et al. 2019). Consequently, Adger (2006) stresses that vulnerability is not easily quantifiable due to its complexity. Therefore, this study is not only aiming to capture the areas quantitative vulnerability. Moreover, the research aspires to capture the multidimensional understanding of vulnerability by including voices from stakeholders and experts.

Difficulties in measuring vulnerability arise from the lack and quality of available data and the integration of various sources (Füssel 2010; Zhang et al. 2019). By aligning the variables with the available data of the communities, the framework tries to counter the issue.

A study by Füssel (2010) highlighted the issue of weighing the relevant variables. Although there are reasonable arguments for the weighting of indicators, such as the emphasis of priority issues, critics have stressed that this is a subjective process based on personal perceptions of affected residents and does not follow a precise mathematical relationship (Zhang et al. 2019).

Another issue consists of the uncertainty of future events of CC and how they might affect the proposed variables of vulnerability (Füssel 2010). Therefore, the theoretical framework applied in this study excludes future events from its metric and focuses on the assessment of recent vulnerability.

5. Methodology

The following chapter will first present the overall research strategy of this study. Secondly, the selected indicators will be presented, followed by an elaboration on the data collection. After that, the analytical approach will be explained, and the limitations faced will be explored. This chapter will finish with a reflection on ethical considerations from the author during the research process.

5.1. Overall Research Strategy

The research strategy will be based on the developed Climate Change Vulnerability Framework since the study intends to identify how vulnerability to climate change-related hazards is differentiating between informal and formal settlements. To facilitate a holistic assessment of the issue, an instrumental case study approach will be applied to provide the study with in-depth insights in a natural setting (Punch 2005, p.144). Since vulnerability is a complex issue, it cannot be easily reduced to a single form of analysis (Adger 2006). Therefore, the study will

use a mixed-method approach to combine the representativeness from quantitative research with the detailed understanding of qualitative research (Chambers 2008; de Vaus 2001, p.230). By that, it will be ensured that the quantitative findings of the secondary data will be combined with the qualitative insights of perceptions from stakeholders (Adger 2006; Cresswell 2018, p.264). When performing vulnerability assessments, it is crucial to complement traditional analyse approaches with qualitative measures since parts of vulnerability are constructed by the residents and their individual experiences (Sutherland et al. 2010).

The study will start with an identification of indicators for vulnerability. Secondly, a collection of secondary data of both areas based on the indicators will be performed to generate a quantitative picture. Thirdly, the study will move to qualitative data collection to generate a greater in-depth picture of the communities by conducting semi-structured interviews with experts of the municipality, university, and relevant stakeholders of local projects such as the PCRCP. A descriptive-correlational survey (Appendix A.2.) was developed to assess residents' perception of their vulnerability in both communities. Due to geographical distance and no initial or personal contacts with residents in Durban, it was challenging to generate response rates. I contacted Catherine Sutherland, a professor at the UKZN, who became my gatekeeper and offered to distribute the survey via two WhatsApp groups. We revised the questionnaire together that I developed based on Bryman (2015) and Krosnick and Presser (2009) guidelines and tailored it to the residents of both areas. However, because my gatekeeper did not distribute the survey within the limited time of this thesis, I only generated one response. Due to their insignificance, the results will not be listed and included in the study. The response can be found in Appendix A.3.

5.2. Selection of Indicators

Measuring a theoretical concept such as vulnerability requires the creation of variables, yet there is no agreement on how many are needed for effective measurement. Rather than the number, it is crucial to identify the context-relevant elements (Hinkel 2011; Zhang et al. 2019). The proposed set aims for a comprehensive understanding while not being exhaustive (Füssel 2010). However, since the vulnerability to CC consists of the relationship between human, social and biophysical, and institutional factors as displayed in the theoretical framework of this study, it is crucial to identify indicators that recognize the multiscale of the issue. Therefore, it is crucial to consider quantitative factors when assessing vulnerability, just as qualitative measures (Debortoli et al. 2018). The selection of variables in this study is motivated by the working definition of vulnerability to climate change and based on an extensive literature review. Therefore, the following syntaxes were inserted in google scholar during a 1990-2021

period: climate change vulnerability, vulnerability indicators, assessing vulnerability, and risk and vulnerability assessment. In alignment with research question, variables were identified that include a range of human, socio-economic, biophysical, and institutional factors (Tab. 5.1.) and are based on the following authors (Debortoli et al. 2018; Cutter 2003; Pandey et al. 2017; Adger et al. 2005; Adger 1999; Rosenzweig et al. 2015; Sverdlik et al. 2019; World Bank 2011; GIZ 2014; Tedim et al. 2014; Kienberger et al. 2014; Serrat 2008; Füssel 2005, 2006; Miola et al. 2015; Khajuria et al. 2012; Williams et al. 2018, 2019; Martel et al. 2019; Soares et al. 2012; Otto et al. 2017; Proag 2014; Thomas et al. 2018; Rehman et al. 2019; Downing et al. 2005; Aribi et al. 2020; Jean-Baptiste et al. 2018; Eizenberg et al. 2017).

Table 5.1. Set of Indicators Vulnerability to Climate Change: developed by the Author

Human	Social	Economic	Biophysical	Institutional
Age	Social Networks	Income	Infrastructure <ul style="list-style-type: none"> - Roads and Transport Network - Energy, Water, Sanitation, Telecommunication Availability - Emergency Services 	Provision of Basic Services <ul style="list-style-type: none"> - Water - Electricity - Health
Gender	Sense of Community	Occupation	Built Environment <ul style="list-style-type: none"> - Quality of Housing - Public Space - Drainage System 	Provision of Public Services
Ethnicity	Community Attachment	Unemployment	Density <ul style="list-style-type: none"> - People - Buildings 	Political Action
Education	Integration	Social Status	Topography	Political Stability
Household Composition	Violence and Crime	Insurance	Flood Frequency	Engagement Environmental Conservation
Coping Skills		Savings	Precipitation	Social Security Networks
Risk Awareness			Pollution	Relationship with Citizens
			Water Quality	
			Biodiversity	
			Waste Management	

5.3. Data Collection

5.3.1. Secondary Data

To generate an overall picture of both areas, secondary data was collected. This method aims to portray the vulnerability of both communities concerning the selected variables. Although there was only little literature available, the documents were carefully chosen. Attention was

paid to the quality and reliability of the documents. The sampling process followed a combination of purposive and probability sampling, tightly connected to the research question (Bryman 2015, p.416,424). Concerning the sample size, attention was paid that it was not too extensive but still large enough to provide valid findings and compare the results of the cases (Bryman 2015, p.425). The data was collected from governmental reports, the official statistics of South Africa, and studies on the two cases. An overview of these documents, including their relevance, can be found below (Tab.5.2.).

Table 5.2. Sampled Documents: developed by the author

Name	Source	Sampling	Content	Relevance
Document I. Official Statistical Data Base of South Africa (online)	Available at: http://www.statssa.gov.za/?page_id=4286&id=10411 (last access 18.05.2021)	The data base was sampled by inserting “Westville” in the search bar.	Statistics on human, social, economic, and biophysical capital of Westville.	The statistics are relevant since they generate an overview of the different forms of capital present in Westville, which affect the vulnerability of the area.
Document II. Land use impacts on the water quality of the Palmiet River, Durban, KwaZulu-Natal, South Africa	Moodley, K., Pillay, S., Patha, K., Ballabh, H., (2016) Land use impacts on the water quality of the Palmiet River, Durban, KwaZulu-Natal, South Africa, <i>international Journal of Scientific Engineering and Applied Science</i> ,2(1)	The article was sampled based on specific searches for the impact of water quality on residents of Westville and QRW.	The article presents land use and seasonality impacts of the physic-chemical, nutrient and microbiological properties of the Palmiet River.	The document is relevant because it places the impact of waste disposal and other environmental impacts on the Palmiet River in a broader social context.
Document III. eThekweni Integrated Development Plan 2020/2021	eThekweni Municipality (2021) Available at: http://www.durban.gov.za/City_Government/City_Vision/IDP/Documents/eThekweni_	The report was sampled based on specific searches in the document with	The municipal Integrated Development Plan serves as a tool for	The plan contains relevant information for this study

	IntegratedDevelopmentPlan_IDP 2020_2021.pdf (last access 17.05.2021)	the words: - Quarry Road West - Westville	transforming local governments towards facilitation and management of development within their areas of jurisdiction.	since it gives comprehensive presentation and explanation of the overall planning objectives and strategies of the municipality.
Document IV. eThekwini Municipality Spatial Development Framework (SDF) 2018	eThekwini Municipality (2018) Available at: http://www.durban.gov.za/City_Services/development_planning_management/Documents/SDF%202018%202019%20MAY%202018.pdf (last access 18.05.2021)	The report was sampled based on specific searches in the document with the words: - Quarry Road West - Westville	The SDF is an integral component of the Integrated Development Plan (IDP) and a key spatial transformation tool. The SDF guides the spatial distribution of land uses within a Municipality in order to give effect not only to the spatial vision, goals and objectives of the Municipality but by directing where the city should intervene in space to achieve its transformational objective.	The report highlights the goals and objectives of the municipality in terms of spatial development and presents current development stages of the Westville and QRW which makes it able to draw conclusions of the vulnerability level to climate change of both areas.
Document V. eThekwini Municipality and Living Conditions Survey 2015-2016	eThekwini Municipality (2016) Available at: http://www.durban.gov.za/Resource_Centre/quality_life/Documents/MSLCS_Trend_Report_2011_12to2015_16.pdf (last access 15.05.2021)	The survey was sampled based on specific searches in the document with the words: - Quarry Road West	The survey supplies Municipal decision-makers with information relating to the residents' living conditions, their perceptions of	The survey gives reflections and comments on specific questions concerning the living conditions. This makes this

		- Westville	the eThekweni Municipality, the satisfaction with their lives and neighbourhoods and the quality of their lives, amongst other questions.	document relevant since one can draw conclusions on the vulnerability levels of Westville and QRW.
Document VI. eThekweni Municipality Annual Report 2018/2019	eThekweni Municipality (2019) Available at: http://www.durban.gov.za/City_Government/Administration/city_manager/performance_management_unit/reports/Pages/AnnualReports.aspx (last access 15.05.2021)	The report was sampled based on specific searches in the document with the words: - Quarry Road West - Westville	The annual report of eThekweni Municipality contains information on city governance, service delivery, organisational development performance, financial performance, auditor-general statement and management response, and annual financial statements.	The report is relevant since it provides comprehensive statements, on current projects and planning objectives of the municipality, which gives insight into the apparent capital levels of Westville and QRW.
Document VII. Palmiet Action Plan Process	Palmiet Action Plan Process (2018) Available at: file:///Users/paulinewedepohl/Documents/UNI/Bachelor%20Thesis/Data%20Collection/Data%20on%20Westville%20and%20Quarry%20Road%20West/20180413-Palmiet-Action-Plan-Progress%20Kopie.htm	The Document was sampled based on the vulnerability indicators identified in Tab.5.1.	Action Plan that provides quarterly updated to all stakeholders of the PCRPs on the governmental, biophysical and social process of the project.	The report is important since it shows the levels of social, biophysical and institutional capital of QRW.
Document VIII. eThekweni Municipality Palmiet Rehabilitation Project: A research perspective, Power Point	Sutherland, C., Sim, V., Buthelezi, S., Khumalo, M., Scott, D., Saharan, T., Brouwer, B., Ntini, N., Buckley, C., Friedrichs, E., Stenstrom T., Braathen, E., Vedeld, T., University of Kwazulu-Natal (2015) Palmiet Rehabilitation Project: A research perspective	The presentation was sampled based on the vulnerability indicators identified in Tab.5.1.	Review of Research Process of the Palmiet Rehabilitation Project.	The document is significant since it gives insight into the process of the PCRPs and thereby displays information

Presentation (online)				on the vulnerability to climate change of QRW.
Document IX. Vulnerability of Informal Settlements in the Context of Rapid Urbanization and Climate Change	Williams, D.S., Máñez Costa, M., Sutherland, C., Celliers, L., Scheffran, J., (2019) Vulnerability of Informal Settlements in the Context of Rapid Urbanization and Climate Change. <i>International Institute for Environment and Development</i> , 31(1), pp. 157-176	The article was sampled based on the impacts of climate change on QRW informal settlement.	The article highlights how detailed empirical research can facilitate the broader theoretical knowledge on urban vulnerability in the face of climate change and urbanization by applying participatory modelling techniques.	The article balances the more technical reports by the government and gives a picture of what perceptions and narratives are apparent in the settlement of QRW.
Document X. Informal Settlements and Flooding: Identifying Strengths and Weaknesses in Local Governance for Water Management.	Williams, D.S., Máñez Costa, M., Celliers, L., Sutherland, C., (2018) Informal Settlements and Flooding: Identifying Strengths and Weaknesses in Local Governance for Water Management. <i>Water</i> , 10	The article was sampled based on the impacts of flooding on QRW informal settlement.	The article presents a governance assessment for QRW in relation to flood risk by applying the Capital Approach Framework.	The article serves as an addition to the governmental reports by the government by presenting local perceptions and information of the impacts of flooding in QRW.
Document XI. Governing River Rehabilitation for Climate Adaptation and Water Security in Durban, South Africa	Martel, P., Sutherland, C., (2019) Governing River Rehabilitation for Climate Adaptation and Water Security in Durban, South Africa. In: Cobbinah P., Addaney M. (Eds.) <i>The Geography of Climate Change Adaption in Urban Africa</i> . Palgrave Macmillan Cham.	The article was sampled based on the impacts of the PCRP on QRW informal settlement.	The article adopts a case study approach, examining two river rehabilitation projects in Durban analysing different forms	Since the article presents the impacts of the PCRP on the vulnerability level of QRW it is highly relevant for this study.

			of governance at local scale and how their policies affect water security and climate change adaption in Durban.	
Document XII. SYNTHESIZING ARCHITECTURE & INFORMALITY: The influence of Informality in Creating a Responsive Architecture	Shaikjee, M., (2018) SYNTHESIZING ARCHITECTURE & INFORMALITY: The influence of Informality in Creating a Responsive Architecture, Dissertation submitted to the School of Built Environment and Development Studies, University of KwaZulu-Natal	The dissertation was sampled based on specific searches in the document with the word: <ul style="list-style-type: none"> - Quarry Road West 	Dissertation about how informal settlements can inform architecture as a means of creating better and more responsive architectural interventions to the issues faced by communities within the settlements.	The document is significant for the purpose of this study since it displays many indicators for the biophysical capital of QRW.
Document XIII. Constraints and Opportunities in the Implementation of the Slims Clearance Programme in eThekweni Metropolitan Area: The cases of Webadagt West and Parkgate Relocation Areas and Quarry Road West Informal Settlement	Tyida, S., (2003) Constraints and Opportunities in the Implementation of the Slims Clearance Programme in eThekweni Metropolitan Area: The cases of Webadagt West and Parkgate Relocation Areas and Quarry Road West Informal Settlement, Dissertation submitted to the University of KwaZulu-Natal	The dissertation was sampled based on specific searches in the document with the word: <ul style="list-style-type: none"> - Quarry Road West 	Dissertation about the constraints and opportunities in the implementation of the Slums Clearance Programme in the eThekweni Metropolitan Area. With a case study on Quarry Road West Informal Settlement, Welbadagt West and Urnzomuhle Parkgate Relocation Areas	The document is suitable for the purpose of this research since it presents voices of residents in QRW regarding the socio-economic and biophysical capital of the area.

5.3.2. Semi-Structured Interviews

The qualitative semi-structured interviews aim to understand how vulnerability to climate change differentiates between informal and formal settlements. The interviews aim to assess the opinions and perceptions of experts in the field.

The choice for this method was based on its flexibility and unfolding nature that allows for a natural conversation between the participants and the researcher. Moreover, semi-structured interviews allow for personal storytelling of the participants and therefore provide the study with various and different angles on the subject (Punch 2005, p.169; Cresswell 2018, p.240). To guide the interview, a general interview template was created with pre-designed questions (Appendix B.3.), which was later on adapted to the individual participants. The interview guide should allow for an evolving conversation while at the same provide the researcher with a strong focus to not obliterate important issues. The template questions were based on the guidelines of Krosnick and Presser (2009) and Bryman (2015). The questions were tailored to the research question and aim of the study.

The interviews were conducted over Zoom, accessible through a private meeting link sent out to every participant via mail beforehand. Before starting with the questions, the interviewees' consent for participation was confirmed (Appendix B.2.). Aiming for high levels of comparability, every meeting lasted for around 30 minutes.

The choice for participants was based on relevant actors identified in the literature review and work on the conceptual background. The study aims to represent voices from various groups with different backgrounds to the issue to provide the research with the most multidimensional and holistic perspective possible. The three identified groups include employees of the municipality involved in either climate-proofing and planning activities or projects with the selected communities. Secondly, researchers and professors of the School of Built Environment and Development Studies of the UKZN engaged in the PCRCP or research on informal settlements or climate change vulnerability. Thirdly, stakeholders engaged in the Cities Fit for Climate Change Project (CFCP) and the PCRCP. Since I could not establish contacts in persona, I contacted relevant stakeholders from all groups via email and LinkedIn, following a process of stratified random sampling, which evolved to snowballing since people forwarded me to other actors (Appendix B.1.). Four stakeholders expressed their willingness to participate in the study. I acknowledge the limited number of interviews. However, since all participants represent one of the previously identified groups and are experts in their field, it will still serve the purpose of the study.

The first interview was conducted with Elizabeth Dubbeld, an experienced Urban Planner who worked in the local government of eThekweni municipality until 2016. Moreover,

she has been the national advisor for South Africa and Durban in the CFCCP. Secondly, Catherine Sutherland was interviewed, a geographer working on the interface between social and environmental systems, focusing on sustainable development, and teaching development at the UKZN. She works on risk and vulnerability assessments to CC and has conducted many projects with the QRW settlement. The third participant was Smiso Bhengu, a climate protection scientist at eThekweni municipality. Moreover, he is the primary contact for the PCRCP in eThekweni and project manager of Durban Research Action Partnership between the municipality and the UKZN. Lastly, an interview was conducted with a participant who wishes to stay anonymous but is relevant for this study since he has done research on QRW and works as a city planner for the municipality. Tab.5.3. provides a short introduction of the participants and why their expert knowledge is relevant for the cases

Table 5.3. List of Participants

Participant	Name	Position	Interview
A	Elizabeth Dubbeld	Urban Planner and National Advisor for South Africa in the Cities Fit for Climate Change Project	Zoom, 17.04.2021
B	Catherine Sutherland	Associate Professor at the University of Kwazulu-Natal, teaching Development Studies Research centres around informal settlements with a special focus on QRW	Zoom, 19.04.2021
C	Smiso Bhengu	Climate Protection Scientist and the Main Contact for the Palmiet River Catchment Rehabilitation Project in eThekweni Municipality.	Zoom, 21.04.2021
D	Anonymus		Zoom, 30.04.2021

5.4. Analytical Approach

5.4.1. Secondary Data

The collected secondary data will be described and placed within the context of vulnerability. Both community data will be analysed individually to determine their vulnerability by placing the generated data thematically in the developed variables for vulnerability.

5.4.2. Semi-Structured Interviews

The generated data of the semi-structured interviews will be analysed following the guidelines of content analysis. The content analysis will identify relevant themes, emerged in the conversation and allows for a comprehensive analysis without losing the focus of the research (Punch 2005, p.170). It will focus on the different forms of capital which relate to the purpose of the thesis. First, data will be reduced based on my aim of the study. Secondly, the responses will be organized and categorized by colour coding manually into the different forms of capitals. Finally, the data will be analysed based on differentiating vulnerability between formal and informal settlements and placing the findings thematically within the CCVF.

5.5. Limitations

5.5.1. Secondary Data

Since Westville and QRW are both areas within the city, this requires localized and specific data, which is difficult to generate. Especially the collection of statistical data QRW, as an IS, was highly difficult. I had to rely on different sources for both areas, limiting the comparability between them. It was also noted that much more data on the vulnerability to climate change was available on QRW than Westville, which represents the current focus in research on vulnerability to climate change and complicates a balanced comparison. Nevertheless, I found it essential to generate an overall picture of both areas that display quantitative measures for vulnerability to allow for data triangulation in the study and facilitate a holistic understanding of the issue.

5.5.2. Semi-Structured Interviews

Since only four people participated in the interviews, their responses can lead to biased results since not all the opinions and perceptions of every stakeholder affected by climate change are represented in the study. Hence, the responses do not accurately represent all voices of the identified groups, such as residents of the areas. Nevertheless, more interviews would have been beyond the scope and time frame of this thesis, and although the number of interviews is

limited, all groups are still represented and serve the answering of the proposed research question as it is about the personal and expert knowledge and the study does not intend to generalize their opinions.

In terms of practicability, the research faced minor limitations due to a few internet disruptions during the interviews. However, this does not affect the general content and quality of the generated responses.

Since the interviews were conducted personally, the research faces the social desirability and researcher bias. However, this will not negatively modify the results, as long as patterns are recognized and attention to these two biases is paid when analysing the results.

5.6. Ethical Considerations

The main aim of the researcher should be to protect the participants and promote their integrity. Particularly, attention should be paid to the protection of personal information and voluntary and anonymous participation (Cresswell 2014, p.258). By providing the participants with an information sheet containing a detailed explanation of the purpose of the study and all their fundamental rights, a safe research process guided by the code of ethics will be attained (Scheyvans 2014, p.185). For both survey and interviews, a consent form (Appendix A.1.; B.2.) was developed, presenting the aim of the thesis and the researcher. The form stated the voluntary and, if wished, anonymous participation in the research process and reflected on the data handling process. Throughout the research process, I attained to follow the code of ethics and was highly concerned with the protection of the participants through a clear and transparent communication with them.

6. Findings

The following section presents the quantitative and qualitative findings of the differentiating vulnerability of Westville and QRW. To provide a coherent base of analysis for the following discussion in chapter 7, the findings of the secondary data and interviews will be placed within the previously identified variable categories; human, social, economic, biophysical, and institutional capital.

6.1. Secondary Data

6.1.1. Human Capital

According to the official statistical database of South Africa (n.d.), Westville is home to 30.508 people, living in 8.814 households with an average household size of three people. 94.0% of

the residents live in formal dwellings. Concerning the population groups, 42.0% are white, 32.5% are black Africans, 22.1% are Indian and Asian, and 2.6% are coloured. The most spoken language is English with 72.2%. 17.3% speak IsiZulu, and 5.4% Afrikaans. 48.2% of the population received higher education. 14.2% received some secondary education, and only 1.0% of the residents did not attend any schooling, which shows that residents have attained high levels of education (Official Statistics South Africa, n.d.) Overall, the educational background of residents, the demography of the area, the access to health care, and the ethnic backgrounds based on South Africa's apartheid history indicate strong presence of human capital in the area.

QRW is home to 2400 residents in 931 households with an average household size of 2.6 people (Williams et al. 2018). According to Professor Sutherland, the primary language spoken is Zulu. Based on a survey by Tyida (2003), 33.3% of the residents in QRW have received 0-5 years of education and 66.7% 6-10 years of education. There are low health standards in the settlement, which is further affected by the low access to medical service (Williams et al. 2019). However, the community has high levels of risk awareness due to community workshops organized within the PCRFP. A risk map was produced, residents actively participated in Durban's Resilience Strategy and created an early flood warning system (Palmiet Action Plan Process 2018). In summary, compared to Westville, the community's presence of human capital is relatively low. However, through external support, capital towards risk awareness and access to environmental knowledge was raised.

The findings show that the human capital differentiates most in the type of education and knowledge present in the communities. Residents of Westville have attained more years of higher academic education, which indicates higher-income jobs that provide the residents with the necessary financial assets to recover from a hazard. Residents of QRW, on the other hand, dispose of high levels of risk awareness and environmental knowledge, which reduces the vulnerability of QRW since they can actively implement adaption measures to increase their resilience.

6.1.2. Social Capital

Based on the integrated development plan of eThekweni municipality (2020/2021), it can be stated that Westville has high crime rates. The crime rate is also displayed in Fig. 6.1. showing the total crime rate per area in which Westville is part of the third-highest group. The high levels of crime harm the social capital of the area. However, due to the lack of other available variables for social capital in the consulted data, no absolute statements can be made.

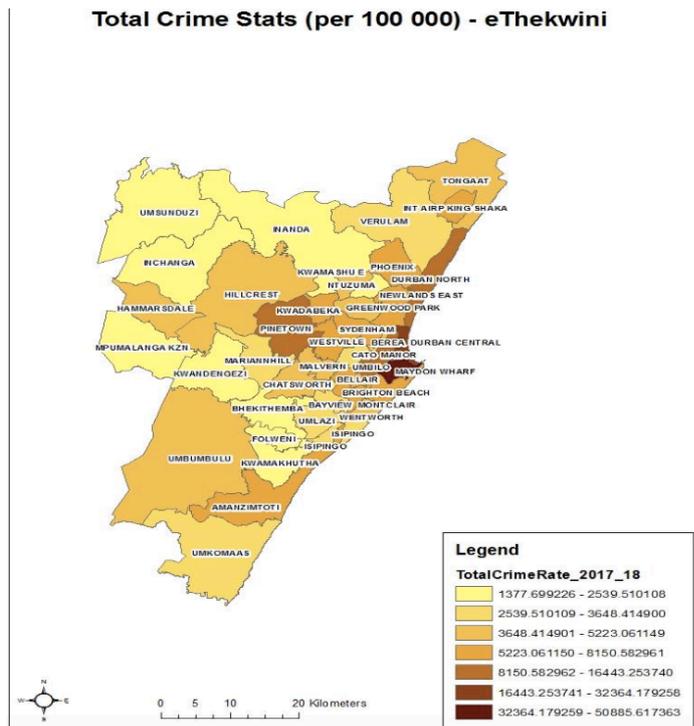


Figure 6.1. Total crime rate in Westville: eThekweni municipality IDP 2020/2021

QRW is a highly organized community with an executive branch committee (Sutherland et al. 2015). Observations by Shaikjee (2018) have shown that the community gathers at many places, which shapes the public space of the settlement. This interaction is impacted by the density and proximity of community members. Often, the choice for the settlement is affected by associates or friends already living there (Shaikjee 2018). Hence, one can state that high community interaction and internal organization lead to strong social capital in the area.

Comparing the social capital of both areas is difficult since they rely on different indicators. However, the findings show that social capital in QRW increases their capacity to adapt and bounce back after a disaster, as community members support one another in implementing adaption measures such as improving the resilience of their built infrastructure and sharing their knowledge and experience amongst each other. The high community interaction differentiates to Westville, where high crime rates impact the social capital.

6.1.3. Economic Capital

Moodley et al. (2016) state that Westville mainly comprises high to middle-income groups. This is also supported by the official statistical database of South Africa (n.d.). Only 7.9% of Westville's residents have no income. The largest share of residents, with 22.4%, has an average monthly income of R307.601-R614.400. The second-largest share amounts to R153.801-R307.600, with 17.8%, of the residents. 15.4% of the population have an average

monthly income between R614.401-R1.228.800 (Official statistical database of South Africa n.d.). Hence, it can be stated that the area disposes of high financial resources.

Based on the results of a survey by Tyida (2003), residents of QRW earn from R0-R500 per month. Moreover, the survey shows that 52.4% of the population is employed part-time, and 47.6% are unemployed. Many of those employed are engaged in informal sector activities.

The findings show that the economic capital in the areas differs, with residents in Westville having a larger income than residents of QRW. The different availability of financial resources results in differentiating levels of susceptibility between the areas since residents of QRW lack the economic resources to protect themselves from the impacts of climate change. In contrast, residents in Westville have the financial resources to combat the impacts of hazardous events.

6.1.4. Biophysical Capital

Westville belongs to the areas with the lowest density in Durban, with less than 15du/ha, which allows for public and green spaces. Westville has a strong physical infrastructure (eThekweni Spatial Development Framework (SDF) 2018). According to the SDF (2018), the area has a wide range of land uses and services, including shops, a community centre, clinics and hospitals, public spaces and facilities, restaurants, banks, and offices. Moreover, its road and transport network enhance the community's accessibility level. The Westville node provides residents with everyday commercial and social needs, transport interchanges, and public transport (SDF 2018). The area also has access to basic services, which is supported by the official statistical database of South Africa (n.d.) 98.3% of the households are attached to the regional and local water scheme, 71.1% have a flush toilet that is connected to the sewerage system, only 0.3% of the residents have no toilet. At least once a week, the waste is removed by a local authority in 96.4% of the households. Electricity is the primary source of energy for heating and lighting, with 85.3%. Houses in the neighbourhood are mainly robust, formal houses (ibid). The availability of public and basic services leads to strong physical capital in Westville, which is also supported by the high levels of residents' satisfaction with their area (eThekweni Municipality and Living Conditions Survey 2015-2016). Due to climate change, the community has experienced extreme storms and heavy rainfall. In March and April 2019, Westville was part of the worst-hit areas hit by a hazard that brought 136 mm of rain within a 24h period (eThekweni Municipality Annual Report 2018/2019). Hence, it can be stated that the community is highly affected by the events of flooding, extreme storms, and heavy rainfall. A study has shown that the Palmiet River along Westville contains high levels of E. coli, which can cause illness and death (Moodley et al. 2016). However, these extreme events only seldom

impact the delivery of basic services since every household has individual access to resources and does not rely on the river as a source of water or other services.

QRW built environment is marked by high density and dwellings that are compromised by a mixture of various materials. Their lack of financial capital leads to more temporary building materials, including corrugated iron, plastic sheeting, or wood (Shaikjee 2018). To adapt their basic housing to the effects of climate change, residents have raised their buildings on platforms or placed carpets around their houses to absorb the flood water (Shaikjee 2018). Access to basic services is limited, and most residents rely on illegal electricity. Only one part of QRW has access to formal electricity (Williams et al. 2019). Members of the community have free access to water from communal standpoints. The municipality provided the settlement with four Community Ablution Blocks including showers, washbasins and toilets (Williams et al. 2018). However, the lack of adequate sanitation facilities increases the community's health risk (Williams et al. 2019). Waste management is an enormous challenge for the community. Only through the support of a UKZW research team in 2016, the issue was addressed. The initiation of a recycling program, which also employs ten community women, improved their waste management. Furthermore, since 2017 the Durban Solid Waste Unit removes waste in QRW (Palmiet Action Plan Process 2018). Although the community is located very central at the intersection of two major transport arteries, the M19 and N2 highway, the access to the settlement is limited due to the lack of roads within (Shaikjee 2018; Williams et al. 2019). However, this proximity to the centre of Durban provides residents with economic opportunities and access to urban resources (Williams et al. 2019). QRW is highly affected by flooding, extreme storms, and heavy rainfall (Williams et al. 2018). Being located right at the bottom of the river, where all the water is concentrated, the government identified the settlement as being prone to risk and hence pushes for relocation (SDF 2018). The flood events lead to the collapse of dwellings and flooded pathways affecting the residents' mobility and access to public and basic services. Heavy rains also increase the dispersion of waste and greywater, increasing the pollution of the river (Shaikjee 2018; Williams et al. 2019). Besides climate impacts, the river water quality is low due to pollution of industrial waste and littering. The polluted water spreads around the settlement, through flood events, increasing mosquitos' prevalence and increasing the risk for diseases (Williams et al. 2019). Overall, the environmental capital of the settlement is affected by its exposure to floods based on its location, the characteristics of the river, climate change, and pollution of the river water by industry and residents (Williams et al. 2019).

The findings show that the two areas differ in their density (Fig. 6.2., 6.3.) and the quality of their housing, highlighted by Fig.6.4. and Fig.6.5. Their access to basic services also

differentiates since residents in Westville dispose of personal sanitation, water, and electricity, whereas the QRW community shares access to basic services. Both communities are located centrally in proximity to essential infrastructural facilities but differ in their accessibility. Although both areas are exposed to the same environmental hazard, they differ in their proximity to the river, which leads to different degrees of impact in case of flooding, visualized by Fig.6.6. and Fig.6.7. Moreover, the communities are differently dependent on the polluted river, exposing them to different degrees of susceptibility.



Figure 6.2. Density of Westville: GoogleMaps 2021



Figure 6.3. Density of QRW: Shaikjee 2018

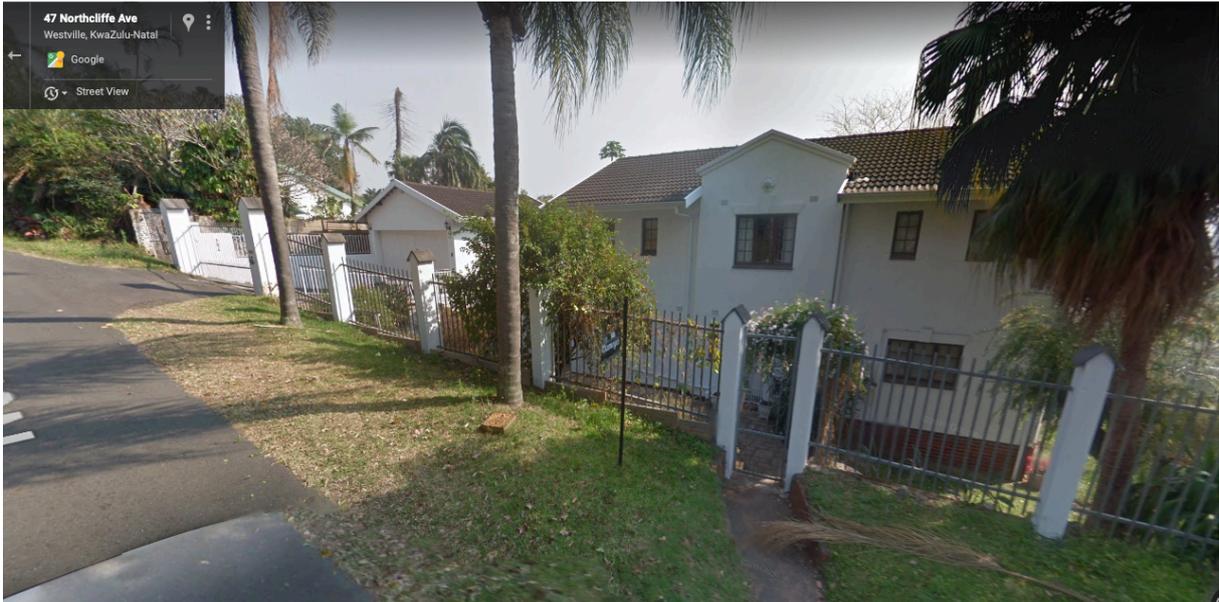


Figure 6.4. Quality of Housing in Westville: GoogleMaps 2021



Figure 6.5. Quality of Housing in QRW: Shaikjee 2018



Figure 6.6. Impact Flooding in Westville: eThekweni Municipality Annual Report 2018/ 2019



Figure 6.7. Impact Flooding in QRW: Sutherland 2019

6.1.5. Institutional Capital

A study by Williams et al. (2019) revealed that residents see governance as the primary influence on flood risk and vulnerability since they provide the community with basic infrastructure and public services, impacting inequality, health standards and educational levels. Previously, the relationship between the government and residents of QRW has been marked by mistrust and conflict. Community members stated that political agendas drive the underdevelopment of the settlement as politicians personally benefit from controlling resources that are meant to be redistributed to the settlement. Instead of collectively searching for solutions, stakeholders have worked in isolation (Williams et al. 2019). Through the PCRCP, the lack of trust between the government and settlement has been addressed by the involvement of the UKZN as a mediating agent (Martel et al. 2019). Moreover, the settlements' institutional capital is increased by their membership of a network of informal settlements located along the Umgeni Road and the M19 highway, which allows them to join together and make their voices heard by governmental authorities (Shaikjee 2018).

For Westville, the sources did not reveal any relevant data on the institutional capital, which does not allow for a comparison of the areas.

6.2. Interviews

6.2.1. Human Capital

Regarding the human capital of both areas, it is essential to highlight that the interviewees distinguished between academic education and the awareness and knowledge around climate change that impact the human capital.

Concerning IS, Dubbeld stated that it is essential to raise awareness towards the impacts of climate change amongst residents to decrease their vulnerability. Mindfully understanding the impacts of climate change is essential for the people before they can physically adapt to the impacts and increase their resilience in physical adaptation measures. Bhengu stresses that once that awareness is established, the community understands their structures and environment much better than any outsider, so it is essential to work with the people on the ground and listen to their understanding of climate change impacts. However, Sutherland points out that it is essential to build capacity in a holistic context. Otherwise, people could perform adaptation measures in their household, making things worse for neighbours around them. She concludes that for raising awareness, it is important to include local capacities and then use context-specific variables to explain the impacts of climate change to residents and thereby improve the human capital. QRW managed to attain high levels of awareness inter alia due to collaborations

with the PCRP in which the support from outside helped make sense of their local knowledge in context with climate change. In line with that, risk maps were produced which identified potential hazards. Additionally, the community created a climate-smart booklet, which centres around their understanding of what kind of adaption measures would help them to decrease their vulnerability. Sutherland states that residents can now respond to hazards very quickly based on their local knowledge since they own a capacity other people do not have. Participant D agrees and stresses that this high local adaptive capacity decreases the community's vulnerability and helps them bounce back since they have developed the necessary skills and tools to cope with the harsh environments. He relates his statement to residential areas and declares that this awareness is an advantage QRW residents have.

Example Box: Environmental Knowledge and Human Capital

Sutherland and Participant D initiated a participatory mapping project with the QRW community within the PCRP in which potential risks and risk areas were identified by the residents. When I asked Participant D of what surprised him the most in this process he told me the following story:

“So because the community is on a flood plain the municipality cannot give them formal electricity, then they have their own ways of pulling electricity from different areas so that they can power their homes. No what is interesting is, they use trees as one of those meeting points where all the cables are going around. And what was interesting was that one of the trees was identified as a potential hazard because most of the illegal wires somehow go to that tree. And I think maybe a week or two after we had mapped that tree and others, then there was a fire in that tree and it damaged a couple of structures maybe three to four homes. And I mean that was, Jesus, it was so powerful. It was so powerful in the sense that it showed that you can't replace local knowledge when attempting to reduce vulnerability to climate change in informal communities.”

Example Box 6.2.1.1. Environmental knowledge and human capital

Residents of FRA instead dispose of academic education, which is also shown in the findings of section 6.1.1. The participants individually agree that local knowledge of the environment is not as present in Westville, mainly because they are not as affected by the physical consequences due to their more substantial economic capacity to bounce back.

Overall, the findings indicate that the level of vulnerability measured in human capital mainly differentiates between the two areas in their academic education and environmental awareness of climate change. All participants agreed that while QRW has high local knowledge and awareness, the community lacks the academic education to make sense of it concerning climate change, which is why projects like the PCRP are essential to combine the local with academic knowledge to decrease their vulnerability to climate change. On the other hand, as a formal residential area, Westville disposes of human capital due to their educational

background and is furthermore less vulnerable since they dispose of the financial assets to bounce back after the disaster.

6.2.2. Social Capital

The participants' answers relating to the social capital and its effect on the communities' vulnerability to climate change covered a broad spectrum from crime to social networks.

Informal settlements tend to function in a very communal way states Participant D. He claims that after a disaster, people come together and help one another. Moreover, the produced knowledge and experience are shared with each. Sutherland also points out that QRW also obtains of high levels of organization indicating a strong sense of community and hence strong social capital, she claims.

According to Participant D, formal residential areas are more anonymous and marked by high levels of individuality leading to a state in which neighbours do not even know each other. Another issue Westville is facing is the high crime rate, Dubbeld stresses. She explains that residents see areas of wilderness as places where criminals can hide. Residents of Westville perceive the greening as a threat that has enormous consequences for the biodiversity since people destroy the vegetation in the area. She concludes that this increases the residents' vulnerability to climate change since it worsens the biophysical conditions, elaborated on in section 6.3.4.

The findings highlight that vulnerability measured in social capital is highly different between QRW and Westville. While QRW disposes of strong communal sense, Westville is instead an area with a low sense of community and social networks. Furthermore, high levels of crime increase the residents' biophysical vulnerability to climate change.

6.2.3. Economic Capital

Participants' responses concerning the economic capital and its effect on the communities' vulnerability to climate change referred to it as a means of prevention, just as the ability to bounce back after the disaster.

Bhengu states that most QRW residents rely on informal employment leading to an unstable economic situation. Participant D stresses that informal communities such as QRW are relatively poor, making it difficult for them to recover after flooding. Often they rely on assistance from the state for material to rebuild their structures which takes much time. Dubbeld highlights that poverty makes residents of QRW most vulnerable to climate change since they

lack insurance and other resources to adapt to the effects of climate change. She states that people living in informal settlements and poverty suffer most from climate change events.

Formal residential areas such as Westville are financially more privileged, according to Participant D. He claims that when peoples' properties get destroyed due to the event of flooding, they have the financial means to quickly bounce back and have the necessary resources such as insurance and financial capital which provides them with greater flexibility. Bhengu indicates that the houses are more resilient towards flooding, considering the building material of their residences. Dubbeld argues that the economic situation of residents in Westville also contributes to a process of environmental injustice. She criticizes that many middle-class people do not want to make changes in their higher lifestyle that are more environmentally friendly, although they have largest share of the carbon footprint of all inhabitants.

Dubbeld stresses, "you cannot separate the socio-economic capital from climate change in South Africa when trying to reduce vulnerability," which summarizes the findings of this section. The statements of Participant D and Dubbeld have shown that the economic capital of the two areas is highly different and hence impacts their vulnerability in different degrees. According to the interviewees, residents of QRW have limited financial resources, which makes it difficult for them to bounce back and hence increases their vulnerability to climate change. In comparison, residents of Westville can cope with the direct effects of climate change due to their financial resources.

6.2.4. Biophysical Capital

Concerning the biophysical capital of both areas, interviewees differentiated between location, the environment, infrastructure, and basic services.

Dubbeld stresses that informal structures are most commonly located in areas where the environmental capital is low since people have to settle in leftover land where nobody else wants to live because it is not safe to build on, often floodplains in South Africa. QRW is located within such a floodplain close to the Palmiet River. Once it overflows the informal settlement is highly exposed to the water masses, according to Participant D, which makes the settlement vulnerable to climate change. Bhengu follows a similar argumentation line claiming that the nature of their localities makes QRW more vulnerable than a planned settlement. Sutherland points out that the high density within the settlement also limits the biophysical capital of the area and increases their vulnerability. She also describes that with every flood this density increases since people lose their land and occupy other tiny spaces of land within the already dense settlement, which then increases their vulnerability. Trees also place risks for residents

in QRW. Although they have ecological benefits such as providing the area with shade, they also create risk for residents since they are prone to storms, mentions Participant D. To improve the biophysical capital of QRW, Bhengu explains that within PCRP, several adaptation measures were performed to increase the communities' resilience towards climate change (Box 6.2.4.1.).

Example Box: Enhancing Environmental Capital of Informal Settlements

Within the PCRP several adaptation measures were performed to improve the bio-physical capital of QRW. Bhengu mentions that just recently an early flood warning system was launched to alert the residents via WhatsApp in case a big storm would come in. Another project centres around increasing the safety of the river itself by planting universal species along the River to strengthen the ecological infrastructure and thus enhance the communities' resilience.

Example Box 6.2.4.1. Enhancing environmental capital of informal settlements

QRW is located in a very strategic area close to various basic services. Participant D states that people do not even need public transport to access schools, places of employment and health, decreasing their vulnerability concerning exposure to biophysical factors. Bhengu argues that this proximity makes it difficult for the government to provide alternative cheap housing since these are often in locations far distant to these services.

According to Participant D, the inadequate basic infrastructure in QRW is another factor increasing the communities' vulnerability as through an upgrade of living conditions, the community's resilience would be improved. Bhengu identifies the installation of basic infrastructure as crucial to reduce the residents' vulnerability to climate change since it minimizes risk exposure to, e.g. fires due to illegal electricity that gets disrupted with floods, storms, or heavy rainfall. He claims that only by "formalizing the informality" the community's resilience will be increased. However, Participant D argues that the municipality will only upgrade the settlement once its physical location has been improved. Thereby, he refers to a current governmental program that aims to make the river along QRW safer. Furthermore, Bhengu highlights accessibility as another factor increasing the vulnerability of the QRW community. He stresses that it is difficult to access the area which hampers the installation of proper sanitation, electricity and water. Moreover, the absence of proper road infrastructure and pathways within the settlement also creates vulnerability by hampering the residents' mobility, as Sutherland points out (Box 6.2.4.2.).

Example Box: Accessibility and Vulnerability

When I talked to Catherine Sutherland on her perception of how climate change affects accessibility and increases vulnerability in QRW, she told me the following stories:

“I’ve gone and it has rained hard and we were walking around you know, hanging on to the side of houses to try not to fall and one of my students was walking with me and he was trying to help me so I didn’t slip and then he slipped and he cut himself on a nail on one of the houses which was of course rusty and then I had to take him for a tetanus shot. Luckily we could do that but at the same time imagine if you like a little kid and you’re running along there and if you slip the things that you grab onto is like rusty metal and rusty nails, those are like the indirect effects impacting the residents’ vulnerability. Because oftentimes they do not have the same access to the resources as we had now. So when these pathways get flooded it not only affects their accessibility but also their health in terms of accidental risks. But in terms of accessibility it also limits them because e.g. kids will not go to schools when it rains because it is so difficult to get out of the settlement. So I guess what I want to show is that climate change impacts the vulnerability in so many ways, like how it just limits the mobility and access to basic services even though they might be provided under normal circumstances.”

Example Box 6.2.4.2. Accessibility and vulnerability

Westville is also located along the Palmiet River. However, Participant D stresses that since these residential areas were appropriately planned, there is a sufficient buffer zone between the homes and the river. Furthermore, Bhengu claims that the location of planned settlements like Westville will need to be approved by planners beforehand and that when houses are constructed, attention is paid to resilience enhancing systems such as a proper drainage system. Therefore, he argues that as much as climate change affects everyone’s vulnerability within formal areas, its impact is way less compared to informal settlements. However, Sutherland argues that although they might have these drainage systems they are still not free from the impacts of climate change since through litter and pollution the drainage systems get blocked, leading to an overflow of stormwater.

Nevertheless, as mentioned in the section of social capital, Westville has low levels of biodiversity and is marked by high levels of hardened surface, which increases the surface water flow and hence makes the community vulnerable in case of heavy rainfalls, which are also an effect of climate change, Dubbeld stresses.

Overall, interviewees’ findings suggest that although both areas are located along the same river their vulnerability to flooding and other climate change-related hazards such as storms and heavy rainfalls vastly differentiates. First, they differ in their proximity to the river. Secondly, Westville’s basic infrastructure is advanced compared to QRW since the area and houses in Westville were adequately planned limiting biophysical exposure and decreasing their vulnerability. Nevertheless, all participants agreed that Westville is not free from the impacts

of climate change and that other biophysical factors such as low biodiversity place the area at risk and make residents vulnerable to climate change.

6.2.5. Institutional Capital

The participants distinguished the institutional capital of both areas between the community and the government's interpersonal relationship and the provision of services by the government.

QRW's interpersonal relationship with the municipality had gotten better primarily due to the PCRPP, states Participant D. Before, trust was lacking due to unredeemed promises by politicians. This trust was enhanced through the active inclusion of residents in the program and listening to their thoughts and perceptions on how to reduce their vulnerability. Nevertheless, he claims that not everyone wants the municipality to be involved in the settlements' development. Concerning the provision of services, Bhengu states that while ten years ago, the municipality's strategy was fighting informal settlements, they shifted their approach towards an upgrading these settlements. He claims that it is the crucial function of the government to provide them with the necessary basic infrastructure and thereby assist them to become more resilient towards climate change-related hazards.

Example Box: Provision of Services to QRW by the Municipality

The following statement by Catherine Sutherland figuratively describes the difficulties in the provision of services to QRW by eThekweni municipality in case of a disaster event. It shows how the community's lacking institutional capital increases their vulnerability in case of hazardous events:

“If a tree falls down in QRW, I know if I phone during the day I will not get that problem sorted. Because the parks department will tell me that it's on private land and they don't cut trees down in informal settlements only if it's damaging city infrastructure so luckily if it falls like on one of the toilet blocks, then I can actually say well, it has actually fallen on your infrastructure, otherwise they will not assist me. If I phone after six o'clock and the municipality is closed and it's the disaster risk management line I get, they'll go and cut the tree and they'll deal with all the electricity wires. So you learn like which systems of the municipality to use. So we just have to wait until it's like after hours. “

Example Box 6.2.5.1. Provision of services to QRW by the municipality

Concerning Westville, Bhengu and Dubbeld both independently stressed that for the municipality, it is more important to focus on the vulnerability of informal instead of formal communities as this is where the most significant damage happens. Dubbeld also mentions that Westville disposes of higher institutional capital, based on their official status. Sutherland criticizes the politics of Westville and argues that representatives from Westville actively work

against the upgrading of QRW since they believe that informality should not be allowed in the city.

In summary, it can be stated that Westville, as a formal area, has a different starting point when it comes to institutional capital since they have legal rights based on their official status. QRW differentiates in that status which makes them face challenges such as lacking provision of services and support by the government.

7. Discussion

The following section will discuss the previously presented findings in relation to the research question. The results of QRW and Westville will be contrasted and placed within the theoretical framework of the study. Thereby, it will be discussed how the available capitals in the districts impact their vulnerability to climate change. Additionally, the findings will be discussed in the broader context of climate-proofing cities.

7.1. Differences in Vulnerability of QRW and Westville

Considering the evaluation of the human capital between the two areas, it can be stated that it differentiates most in the type of education and knowledge present in the communities. The availability of risk awareness reduces the vulnerability of QRW since they can actively implement adaptation measures to increase their resilience. Higher academic education levels of residents in Westville decrease their vulnerability as these frequently correlate with higher income jobs which then makes the community more resilient because they have the economic resources to bounce back after a disaster. Hence, findings of this study present that vulnerability to climate change is impacted by human capital. It interacts with the resilience and the adaptive capacity of the community, as displayed in the CCVF. For QRW, the increased risk awareness leads to a higher adaptive capacity, reducing their susceptibility, improving their resilience in case of a hazardous event. The availability of human capital for Westville, on the other hand, increases their resilience since financial resources improve their capacity to cope and recover from the impacts of climate change. Overall, the evaluation of the human capital shows that the present human capital in both areas decreases their vulnerability to climate change through different educational means. This result contradicts Adger (2006), who stresses that the adaptive capacity is limited for those who are already more vulnerable to climate change. It shows that vulnerability to climate change can be reduced in different ways, e.g. different educational approaches and that there is not one single way to go. Academic education is no safeguard for climate change, and resilience can be enhanced through creative bottom-up

approaches. Involving stakeholders' experiences from different backgrounds in policymaking could lead to approaches that reduce vulnerability in a holistic sense.

The findings suggest that social capital impacts vulnerability to climate change for IS and FRA in different ways. For QRW, the high social capital, composed of strong social networks and levels of organization, serves as an asset towards reducing vulnerability. These results counter previous research on IS, in which Jabareen (2012) and Eizenberg et al. (2017) describe them as unplanned and chaotic spaces. A sense of community is relatively absent in Westville but even more trivial for their vulnerability is the issue of crime. Residents destroy their ecological infrastructure in exchange for security and, by that, increase their vulnerability to climate change as hardened surfaces increase surface water flow during heavy rainfalls. This study reveals that vulnerability to climate change is impacted by unapparent factors that only get visible when locally investigating the phenomenon. The findings of Westville show the importance of addressing vulnerability in a holistic sense by mainstreaming climate change adaptation into politics since the impacts of climate change are evident at the various departments and can only be addressed when considered simultaneously. The findings also expose that CC does not only impact the poorest in society but affects every resident in a city, highlighting the importance of placing vulnerability in a broader context than just economic capital and considering the interplay of the different susceptibility determinants as displayed in the CCVF. It implies that vulnerability to climate change is exposed in different dimensions of society and depends on individuals' various lifestyles and livelihoods. Vulnerability does not draw a line on whom climate change affects. It is just expressing its effects differently across society. While IS's might feel the direct impacts of climate change more due to their poor pre-conditions, FRA's are still exposed to the same hazard and experience the impacts indirectly, e.g. through crime. For a sustainable society, everyone must be included when creating inclusive, safe, and resilient cities as only by acknowledging the interrelatedness of actions, climate-proof cities for everyone will be created.

Analysing the economic capital of both areas reveals that residents of Westville, compared to QRW, tend to be in a better financial situation, which decreases their vulnerability. Residents in QRW lack the economic resources to protect themselves from the impacts of climate change which increases their vulnerability to climate change. On the one side, their poverty affects the built quality of their houses and, on the other side, hampers their capacity to bounce back after a disaster since they do not dispose of the financial capital to cope with the damages and lack insurance. Placing these findings in the CCVF shows that financial resources affect a community's resilience and adaptive capacity and hence their vulnerability. Again, this

emphasizes that society and its institutional circumstances impact vulnerability to climate change. This study shows that reducing vulnerability requires a government that addresses inequality in its society so that every resident disposes of the financial resources to counter the effects of climate change. So that the differences and economic inequalities, as apparent between Westville and QRW, are addressed, regardless and despite of CC.

Although both areas are prone to flooding and are located in the same city, at the same river, they differ in their proximity to the river, which leads to a varying vulnerability between them. The built structure is denser in QRW than in Westville, which in case of flooding increases their vulnerability as there is less surface for the water to flow. The areas also differ in the building material of their houses. QRW residents use more temporary building materials, whereas houses in Westville are more resilient to hazards. Tying into that, every household in Westville is provided with the essential basic services, while QRW relies on communal standpoints and illegal electricity. These findings align with previous research on the impacts of climate change on IS made by Jean-Baptiste et al. (2018) and Mazeka et al. (2019). Thus Sverdlik et al. (2019) stress that climate risk reduction cannot be assessed without upgrading these basic services in IS. However, since eThekweni municipality marked QRW as a deferred relocation project, it seems like this process will not be followed (Williams et al. 2019). The pollution of the PR does not differentiate between the communities. However, their use and dependence on the river make them differently vulnerable to the hazard. The findings present that vulnerability to climate change can differ in the slightest forms. Even when communities in the same city are exposed to the same hazard, their vulnerability is contrasting based on other external circumstances. Concerning the biophysical capital, the study shows that it is dependent on the hazard and influenced by economic resources to build resilient houses, the availability of space, and the institutional provision of basic services and infrastructure. As the CCVF displays, it is the interrelatedness of the capitals that impact the resilience and adaptive capacity of the community and lead to differentiating vulnerability to climate change, which the study demonstrates on the examples of QRW and Westville. Moreover, it shows that generalized policy actions on a city level are likely to be ineffective. The cases of QRW and Westville show that even when two areas with a similar location are affected by the same hazard, their vulnerability differs because of other external factors, which will exist in every case, city, country, and continent.

Evaluating the institutional capital shows that the government plays a key role in shaping the vulnerability to climate change of the communities, which is supported by the research of Godschalk (2003) and Jabareen (2012), stressing that an equal distribution of

resources and access to services and political power is crucial for reducing vulnerability. This is also supported by studies of Eizenberg et al. (2017) and Adger (2006), mentioning that vulnerability to climate change depends strongly on the institutional circumstances. QRW is more dependent on their provision of services, infrastructure, and resources by the government, whereas residents in Westville dispose of the resources themselves and only additionally relying on governmental support. This dissimilarity leads to a differentiating susceptibility of their community system since the availability of these services impacts the resilience and adaptive capacity, as identified in the findings of the biophysical capital. Placing this within a broader development frame, institutional capital determines the pre-conditions for vulnerability by shaping the city's political, economic, social, and environmental circumstances. This connection is also highlighted by the CCVF, stressing that the linkages between the external processes and structures have a high impact on vulnerability to climate change. A city with low levels of poverty and inequality, satisfying infrastructure provision, basic services, and education will tend to limit vulnerability to climate change for its residents. This finding is also supported by the World Cities Report 2020 (UN-Habitat 2020), stating that approaching root causes like inequity in a city is crucial for climate-proofing cities. However, since high levels of inequality mark Durban, the vulnerability varies highly across its residents. Hence, as Schlosberg (2013) stresses, the system in which the injustice is present needs to be transformed and aligned with the notions of sovereignty, equality, human rights, self-determination, and inclusivity. Although Dubbeld stresses that Durban performs highly in addressing climate change, the results show that the city has not managed to holistically implement climate-proofing solutions that go beyond mitigation strategies but address social inequality and poverty issues.

Evaluating the different capitals present in the areas revealed their impact on vulnerability to CC for QRW and Westville and how they differ in their impacts on the communities. The comparison has shown that vulnerability is impacted by various stressors that impact one another, depending on external influences and pre-conditions. The discussion highlights the interconnectedness of all forms of capital and how their availability impacts resilience and adaptive capacity. It prevailed that addressing vulnerability to climate change requires the mainstreaming of CC into policy action, more of which is discussed in the following section.

7.2. Addressing Differences in Vulnerability in Climate-Proofing Cities

This discussion has shown that it is not only poverty and the economic capital of areas that impacts residents' vulnerability. Having access to economic resources is no guarantee for high

resilience, nor is academic education a guarantor for environmental awareness. It is also problematic to generalize that the poorest are also the most vulnerable to climate change, although previous studies by Adger (2006) and Jean-Baptiste et al. (2012) have generalized on such statements. By adopting this kind of thought, innovative local solutions of IS are disregarded that could also help decrease vulnerability for FRA, such as creative, simple building constructions. This ties into the theory of the CCVF, stressing that vulnerability depends on personal perceptions, experiences, and opinions and hence differentiates not only on the susceptibility of a community but their perception and subjective measures of adapting to the changes. This study shows that vulnerability is a multidimensional concept, shaped by various forms of capital and highly dependent on local factors, preconditions, and circumstances, which is supported by studies of Rehman et al. (2019); Adger (2006); O'Brien et al. (2004), Liverman (1990), Kasperson et al. (2012) and Thomas et al. (2018). The discussion has revealed that the various forms of capital are mutually dependent and impact each other, reflected in the CCVF. Hence, policies need to be tailored as narrow as possible when applying climate-proof adaption and mitigation measures. This study highlights that even if areas such as Westville and QRW are exposed to the same hazard, they differentiate highly in their local preconditions and capital assets which complicates general policy measures for the whole city of Durban. Füssels (2005) developed framework on vulnerability supports the findings by stressing that vulnerability is impacted by the interrelation of the system, hazard, consequences, and specific time frame. Universal solutions for climate-proofing cities are inefficient since they miss out on local constraints and opportunities. The study's findings demonstrate that there is no one-size-fits-all approach in climate-proofing cities, which is supported by Kasperson et al. (2005). This is also displayed in the CCVF, highlighting the interconnectedness of vulnerability to climate change, being impacted by the capacity to anticipate, cope and recover from hazards based on the access to necessary resources and human, social, economic, biophysical, and institutional capital.

This study did not intend to draw conclusions on who is the most vulnerable. Instead by problematizing vulnerability to climate change and examining the differences in vulnerability shaped by local preconditions, contexts and assets of capital, the research intended to highlight that climate-proofing cities requires local and context-specific approaches. Vulnerability to climate change is a complex interplay of various dynamics and cannot easily be simplified. Hence, climate-proofing cities faces the enormous challenge of finding the fine line of what measures can be applied universally and what requires context-specific instruments since the vulnerability is different from place to place and community to community impacted by

external stressors, pre-conditions, and institutional circumstances. Only when finding that fine line vulnerability to climate change will be reduced for everyone in the city, not only addressing the needs of the poor but equally paying attention to FRA and by that synthesise CC policies with local development.

8. Conclusion

This comparative case study aimed at identifying differences in vulnerability to climate change between QRW IS and Westville FRA by placing the cases within the developed CCVF. To conclude on the vulnerability of the two areas, the available capitals were examined based on secondary data and expert interviews. Later on, the findings were compared, and the issue of vulnerability to climate change was problematized in the context of climate-proofing cities to inspire future research. The research explored that vulnerability differentiates between the two areas and is dependent on external influences and pre-conditions that impact the available capitals, which affect the community's resilience and adaptive capacity.

The findings have shown significant divergence in vulnerability in all forms of capital between QRW and Westville. It was demonstrated that one could not make causal statements of which area is more vulnerable to climate change since both communities dispose of certain capital assets that either de – or increase their vulnerability to climate change. The findings for QRW have shown that their physical location, weak basic infrastructure, and dependence on the river as a natural resource places them at higher risk of climate change. In contrast, their adaption measures, environmental awareness, and high levels of social capital decrease their vulnerability since they creatively adapt to the impacts of climate change. Westville, on the other hand, is physically less exposed to the impacts of climate change and has a more significant financial capacity to bounce back in case of a disaster event. Nevertheless, the community increases their vulnerability to climate change by destroying their biophysical infrastructure in exchange for security. Despite their higher academic education levels, residents tend to be less aware of climate change and its effects, increasing their vulnerability.

The study revealed, on the examples of QRW and Westville, that it is the interrelatedness of the available capitals that impact the resilience and adaptive capacity of the communities and lead to differentiating vulnerability to climate change. Thereby, the government plays a key role by shaping the city's political, economic, social, and environmental circumstances that impact the vulnerability. Hence, reducing vulnerability requires recognizing the concepts' multidimensionality and the placement of the concept in a broader context that includes all stakeholders and does not limit vulnerability to climate change to the poorest in a society. Instead, the study shows that it is crucial to recognize that

vulnerability to climate change impacts everyone in a society differently and has to be addressed based on the local circumstances. The results contradict previous research in which vulnerability assessments have focused on the most marginalized in a society and neglected the impacts and consequences on all residents in the city.

8.1. Future Considerations

This study identified that vulnerability to climate change differentiates within cities and across settlements. This finding is highly relevant for future policy approaches for climate-proofing cities since it shows that there is no one-size-fits-all approach that can be implemented to reduce climate change vulnerability on a city or national level. The results have shown that vulnerability to climate change is a flexible and broad concept that needs to be examined within the specific context of a place. Thereby, it is essential to recognize the impact of external factors and systems in place and consider the voices of stakeholders in policymaking. The comparison has shown that through stakeholder consultation, different departments and residents can learn from one another when vulnerability is approached from a bottom-up perspective. Future policies must be based on balanced vulnerability assessments that acknowledge the differences in vulnerability within cities and communities, include the voices of stakeholders, and are aligned with local, national, and global development.

Since this study could not draw conclusions on which factors impact and decrease vulnerability the most, future research could start to weigh vulnerability levels of different communities to identify the most effective policy measures to increase resilience to climate change.

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Appendices

Appendix A

Appendix A.1. Consent Form Survey

Welcome and thank you for your willingness to participate in this survey!

First, I want to introduce myself: my name is Pauline Wedepohl and I study Development and Human Geography at Lund University in Sweden. I am currently in the preparations for my Bachelor thesis, which will be about climate-proofing cities and aims to identify how vulnerability to climate change-related hazards differentiates between formal and informal settlements. Thereby, I chose to focus on Westville and Quarry Road West. This survey seeks to assess the level of vulnerability to climate change in your area based on different indicators.

As residents of the district, your personal opinion is very important to me since it will point out what you think is most needed when climate-proofing cities and will help to include your voices in future policy making. Do not worry about right or wrong and simply answer the questions based on your perception. I would like to ask you for five minutes of your time in to complete this questionnaire by the 02. May 2021, if possible.

Your participation in this survey is of course voluntarily and there will be no negative consequences for you in case you decide not to participate or at any time later decide that you do not want your results to be included in the study. The evaluation of the questionnaire will be treated as confidential and anonymous. Your data will not be passed to third parties and will serve merely my research at Lund University. The data will be personally evaluated by me and will be published exclusively as distilled group statistics so that it will not be possible to conclude from individual responses.

In case you have any questions or wish for responses regarding your results, you are more than welcome to contact me (pa5550we-s@student.lu.se).

Thank you very much for your support!

Kind regards,
Pauline Wedepohl

Vulnerability to Climate Change

Survey about Vulnerability to Climate Change

Welcome and thank you for your willingness to participate in this survey!

First, I want to introduce myself: my name is Pauline Wedepohl and I study Development and Human Geography at Lund University in Sweden. I am currently in the preparations for my Bachelor thesis, which will be about climate-proofing cities and aims to identify how vulnerability to climate change-related hazards differentiates between formal and informal settlements. Thereby, I chose to focus on Westville and Quarry Road West. This survey seeks to assess the level of vulnerability to climate change in your area based on different indicators.

As residents of the district, your personal opinion is very important to me since it will point out what you think is most needed when climate-proofing cities and will help to include your voices in future policy making. Do not worry about right or wrong and simply answer the questions based on your perception. I would like to ask you for five minutes of your time in to complete this questionnaire by the 10. May 2021, if possible.

Your participation in this survey is of course voluntarily and there will be no negative consequences for you in case you decide not to participate or at any time later decide that you do not want your results to be included in the study. The evaluation of the questionnaire will be treated as confidential and anonymous. Your data will not be passed to third parties and will serve merely my research at Lund University. The data will be personally evaluated by me and will be published exclusively as distilled group statistics so that it will not be possible to conclude from individual responses.

In case you have any questions or wish for responses regarding your results, you are more than welcome to contact me (pa5550we-s@student.lu.se).

Thank you very much for your support!

Kind regards,
Pauline Wedepohl

0 of 17 answered 

Vulnerability to Climate Change

1. I live in

- Westville
- Quarry Road West

2. How many people are living in your household?
(Please write the number in the textbox)

3. What kind of housing do you live in?
(Please tick where applicable)

- Informal Structure, Umjondolo
- Block of Flats
- Formal House

4. How could your housing be made more resilient towards climate change-related hazards?
 (Please write your ideas in the textbox)

5. What is your main water source?
 (Please tick where applicable)

- Piped water own household
- Piped water communal tap
- Rainwater tank
- River/ stream/
- Other

6. What is your main source of energy?
 (Please tick where applicable)

- Electricity
- Coal
- Solar
- Paraffin
- Wood
- Illegal electricity
- Other

7. Please indicate your level of satisfaction for the following statements. Thereby, you can choose between very satisfied, satisfied, somewhat satisfied, unsatisfied, not satisfied at all.
 (Please tick where applicable)

	very satisfied	satisfied	somewhat satisfied	unsatisfied	not satisfied at all
Water supply	<input type="radio"/>				
Electricity supply	<input type="radio"/>				
Refuse disposal supply	<input type="radio"/>				
Sanitation supply	<input type="radio"/>				
Access to public transport and road infrastructure	<input type="radio"/>				
Access to health care services	<input type="radio"/>				
Access to schools	<input type="radio"/>				
Access to emergency plans	<input type="radio"/>				
Access to information on the environment	<input type="radio"/>				

8. Please indicate your level of agreement for the following statements. Thereby, you can choose between agree, somewhat agree, somewhat disagree, disagree.
(Please tick where applicable)

	agree	somewhat agree	somewhat disagree	disagree
I feel safe in the area	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel a sense of belonging to my community	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am attached to my community	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel a strong sense of community	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

9. Please indicate your level of agreement for the following statements. Thereby, you can choose between agree, somewhat agree, somewhat disagree, disagree.
(Please tick where applicable)

	agree	somewhat agree	somewhat disagree	disagree
The eThekweni municipality has a just management of informal settlements	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The eThekweni municipality is addressing the needs of the area	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I trust the government	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The government provides the district with all necessary basic services	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The government provides me with social security and economic well-being	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The government addresses environmental conservation in my district	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

10. Have you noticed any effects of climate changes?
(Please tick where applicable)

- I have not notices any drastic changes
- I have noticed more droughts
- I have noticed more floods
- Other

11. The effects of climate change impacted ...
(Please tick where applicable)

- ... me not at all
- ... my health
- ... my livelihood
- ... my housing
- Other
- ... my food production
- ... my access to basic services
- ... the infrastructure in my community

12. What are the biggest environmental problems in your area?
(Please tick where applicable)

- Dumping/ littering
- Pollution (noise, air, water, soil)
- Animals
- Loss of biodiversity
- Other

13. How do these environmental problems impact your vulnerability to climate change?
(Please write your answer in the textbox)

14. How old are you?
(Please write your age in the textbox)

15. What is the gender that was assigned to you at birth?
(Please tick where applicable)

- Female
- Male
- Other

16. What is your highest education level attained?
(Please tick where applicable)

- No schooling
- Primary
- High School
- University

17. What is your average gross income a month?
(Please tick where applicable)

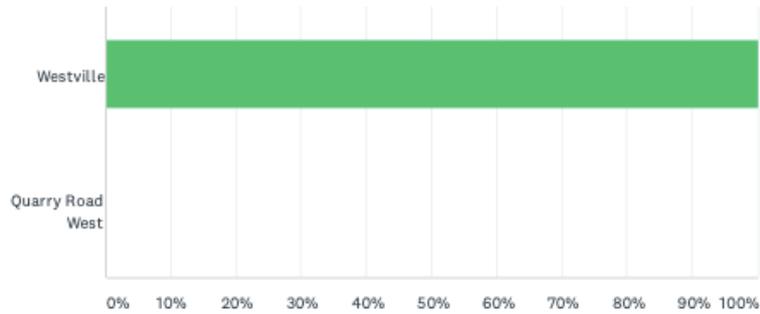
- | | |
|--|---|
| <input type="checkbox"/> informal income | <input type="checkbox"/> R10.001-R15.000 |
| <input type="checkbox"/> no income | <input type="checkbox"/> R15.001-R20.000 |
| <input type="checkbox"/> R1-R1000 | <input type="checkbox"/> above R20.0001 |
| <input type="checkbox"/> R1001-R5000 | <input type="checkbox"/> I wish to not make a statement about my income |
| <input type="checkbox"/> R5001-R10.000 | |

PREV DONE

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F1 I live in

Beantwortet: 1 Übersprungen: 0



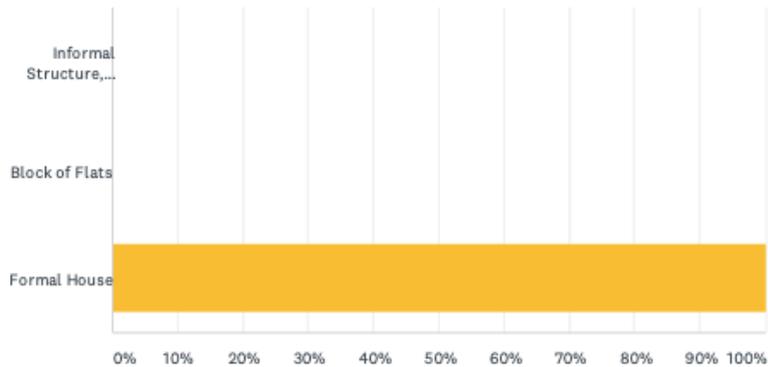
F2

How many people are living in your household?(Please write the number in the textbox)

2

F3 What kind of housing do you live in?(Please tick where applicable)

Beantwortet: 1 Übersprungen: 0



F4

How could your housing be made more resilient towards climate change-related hazards?(Please write your ideas in the textbox)

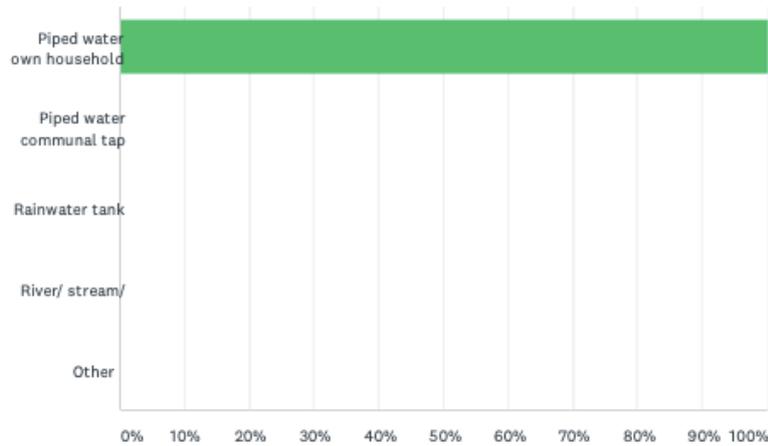
In terms of hard (Built) infrastructure, I would say that formal housing structures in my area are resilient to climate change hazards. In urban, it is forecasted that we will receive more intense rainfall over shorter periods of time (hence flooding is a climate change impact). Although I do know of some properties in Westville being damaged from floods, and some residents access is adversely affected.

Another element to look at would be how wastewater treatment works are adversely affected by flooding events (although this does not affect our housing per se, but rather the quality of the river adjacent to properties). The same can be said about the management of general waste (e.g. plastic packets - which are always in the riparian zone following heavy rainfall).

From a catchment perspective (i.e. greater than just Westville), further climate-proofing could be improved by reducing the flow of surface water from impervious properties into the Palmiet River (so as to lower the flood hydrograph). This could be achieved through stormwater-related policy.

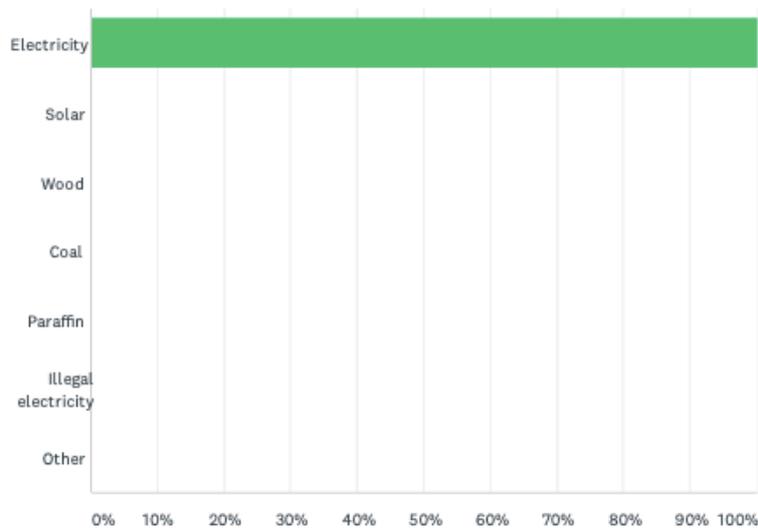
F5 What is your main water source?(Please tick where applicable)

Beantwortet: 1 Übersprungen: 0



F6 What is your main source of energy?(Please tick where applicable)

Beantwortet: 1 Übersprungen: 0



F7

Please indicate your level of satisfaction for the following statements. Thereby, you can choose between very satisfied, satisfied, somewhat satisfied, unsatisfied, not satisfied at all.(Please tick where applicable)

Water supply	very satisfied
Electricity supply	somewhat satisfied
Refuse disposal supply	satisfied
Sanitation supply	very satisfied
Access to public transport and road infrastructure	very satisfied
Access to health care services	very satisfied
Access to schools	very satisfied
Access to emergency plans	satisfied
Access to information on the environment	very satisfied

F8

Please indicate your level of agreement for the following statements. Thereby, you can choose between agree, somewhat agree, somewhat disagree, disagree.(Please tick where applicable)

I feel safe in the area	agree
I feel a sense of belonging to my community	somewhat agree
I am attached to my community	somewhat agree
I feel a strong sense of community	somewhat agree

F9

Please indicate your level of agreement for the following statements. Thereby, you can choose between agree, somewhat agree, somewhat disagree, disagree.(Please tick where applicable)

The eThekweni municipality has a just management of informal settlements	somewhat agree
The eThekweni municipality is addressing the needs of the area	somewhat agree
I trust the government	somewhat disagree
The government provides the district with all necessary basic services	somewhat agree
The government provides me with social security and economic well-being	somewhat disagree
The government addresses environmental conservation in my district	somewhat disagree

F10

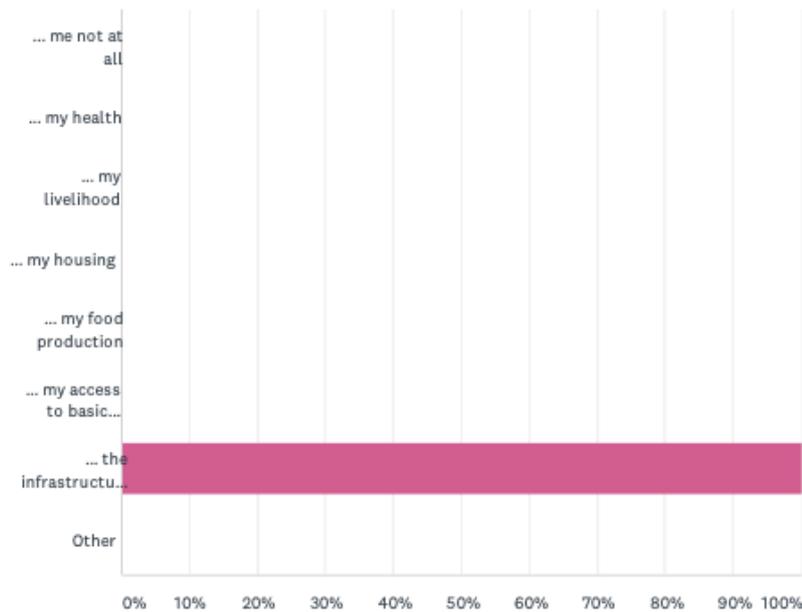
Have you noticed any effects of climate changes?(Please tick where applicable)

Other:

I have noticed more intense droughts and floods - but whether that is directly attributed to climate change or cyclical climatic variations is debatable.

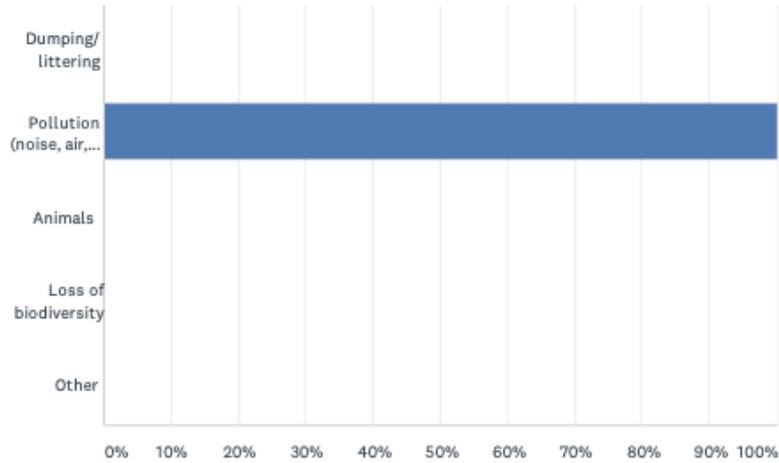
F11 The effects of climate change impacted ...(Please tick where applicable)

Beantwortet: 1 Übersprungen: 0



F12 What are the biggest environmental problems in your area?(Please tick where applicable)

Beantwortet: 1 Übersprungen: 0



F13

How do these environmental problems impact your vulnerability to climate change?(Please write your answer in the textbox)

Dumping - more flood events carry litter from upstream (e.g. Pinetown) to downstream (Westville and below). This reduces environmental quality, and consequently environmental services.

Pollution - I live along the Palmiet River - which is loaded with industrial pollution (illegal) and then upstream there is often dysfunctional infrastructure (sewage - which overflow into the Palmiet River). More intense rainfall will exacerbate these impacts.

Animals - Adverserley affected by the poor quality of environment, and polluted drinking water

Loss of biodiversity - related to above.

To me, these environmental problems are all interconnected and are exacerbated by climate change (so they are not independent)

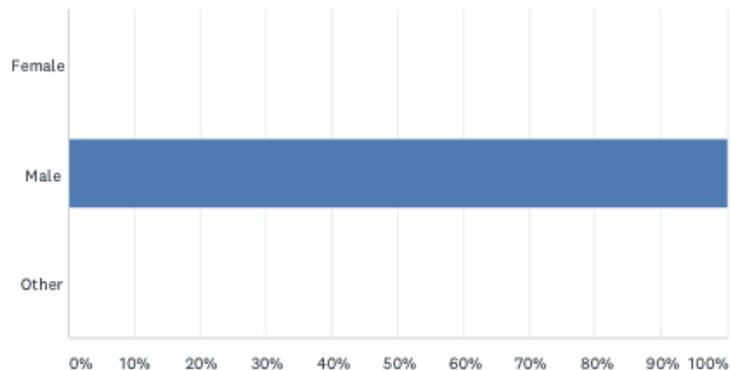
F14

How old are you?(Please write your age in the textbox)

35

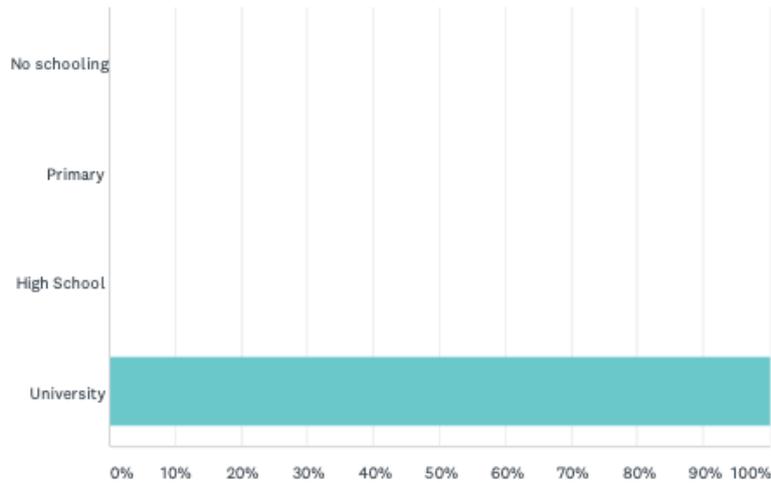
F15 What is the gender that was assigned to you at birth?(Please tick where applicable)

Beantwortet: 1 Übersprungen: 0



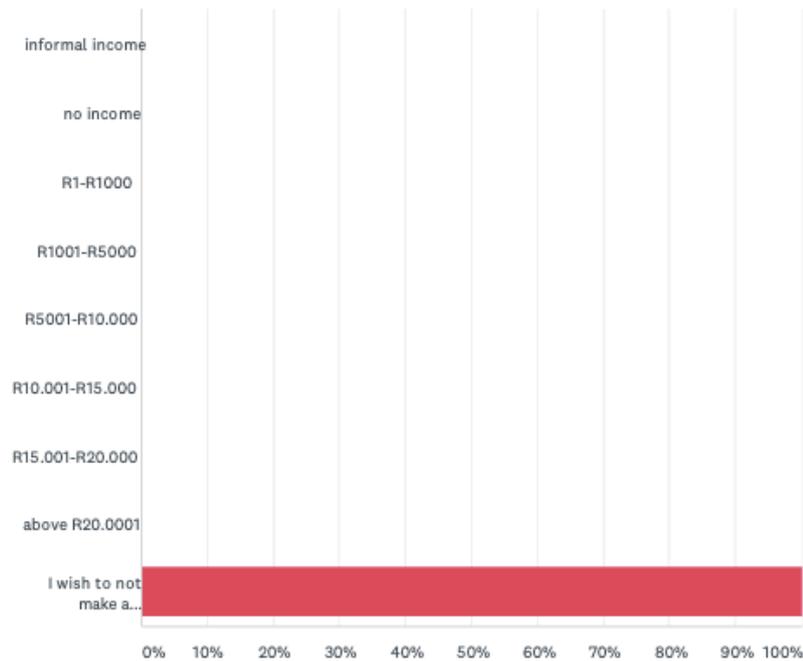
F16 What is your highest education level attained?(Please tick where applicable)

Beantwortet: 1 Übersprungen: 0



F17 What is your average gross income a month?(Please tick where applicable)

Beantwortet: 1 Übersprungen: 0



Appendix B

Appendix B.1. Contact Documentation for Interviews

Name	Date	Position	Reply	Contact
Anonymous	09.04	Executive Assistant eThekweni	X	
Catherine Sutherland	09.04	Professor BEDS and Researcher	√	Scheduled zoom interview Monday 19 th 16:30 SA
Anonymous	12.04	Manager Biodiversity Impact Assessment	X	Forwarded by X on LinkedIn
Anonymous	09.04	Cities Fit for Climate Change GIZ	X	
Anonymous	09.04	Post-doctoral Fellow at BEDS research on poverty and housing	√	Forwarded by X
Elizabeth Dubbeld	09.04 12.04	Cities Fit for Climate Change GIZ	√	Scheduled Zoom Interview Saturday 17 th at 11:00
Anonymous	09.04	spatial strategic development and planning, Climate Change	X	
Anonymous	09.04	Cities Fit for Climate Change GIZ	X	
Anonymous	09.04	climate change mitigation, energy sector	X	
Anonymous	09.04	Student Enquiries	X	

		Community Development		
Anonymous	09.04	Assistant dean of BEDS	X	
Anonymous	09.04 12.04	Student Administrator BEDS	X	Forwarded by X
Anonymous	09.04	Lecturer BEDS Architecture	Referred me to X and X	
Anonymous	09.04	Community Manager eThekweni	X	
Anonymous	09.04	Student Administration BEDS	Referred me to X	
Anonymous	09.04	Senior Lecturer BEDS Development, Population	X	
Anonymous	09.04	Senior Lecturer BEDS	X	
Anonymous	09.04	Lecturer BEDS Planning	X	
Anonymous	09.04	Lecturer BEDS Architecture	X	Forwarded by X
Anonymous	09.04	Lecturer BEDS Development	Referred me to Catherine Sutherland	
Anonymous	09.04	Senior Lecturer BEDS Development	Referred me to Catherine Sutherland	
Anonymous	09.04	Lecturer BEDS Architecture	X	
Anonymous	09.04	Dean of BEDS	Referred me to X and Catherine Sutherland	
Anonymous	09.04	Senior Lecturer BEDS Architecture	X	
Anonymous	09.04	Academic Leader Community	X	

		Development BEDS		
Anonymous	09.04	Lecturer BEDS	X	
Anonymous	09.04	Senior Lecturer BEDS	X	
Anonymous	09.04	Director Civil Society BEDS Lecturer Development	X	
Anonymous	09.04	Developmental Lecturer BEDS	X	
Anonymous	09.04 12.04	Academic Leader BEDS Lecturer Population	X	Forwarded by X
Anonymous	09.04	Associate Professor BEDS Planning	X	
Anonymous	09.04	strategic urban planner, Cities Fit for Climate Change	X	
Anonymous	09.04	School administrator BEDS	Referred me to X Student Administrator, X Academic Leader	
Anonymous	09.04	Lecturer BEDS Population	X	
Anonymous	09.04	Lecturer BEDS Population	Referred me to Catherine Sutherland	
Anonymous	09.04	Lecturer BEDS Community Development	X	
Anonymous	09.04	strategic spatial planning	X	
Anonymous	09.04	Student Administration BEDS	X	

Anonymous	09.04	Durban municipality	Referred me to safer cities	
Anonymous	09.04	climate protection scientist, Cities Fit for Climate Change	X	
Anonymous	09.04	Associate Professor BEDS Development	Referred me to Catherine Sutherland	
Anonymous	09.04	coordinator for the Durban Epic Project	X	
Anonymous	09.04	Professor BEDS Population	Referred me to Catherine Sutherland and X	
Anonymous	09.04	Durban Municipality	X	
Anonymous	09.04	Manager School Operations BEDS	X	
Smiso Bhengu	08.04	climate protection scientist, Palmiet River Catchment Rehabilitation	Referred me to X and told me that he currently limits interviews with residents	Scheduled Zoom Interview Wednesday 21 st at 14:00 SA
Anonymous	09.04	Lecturer BEDS Architecture	X	
Anonymous	13.04	PhD working on Quarry Road	X	Forwarded by Smiso Bhengu

Welcome and thank you for your willingness to participate in this Interview.

First, I want to introduce myself: my name is Pauline Wedepohl and I study Development and Human Geography at Lund University in Sweden. I am currently in the preparations for my Bachelor thesis, which will be about climate-proofing cities and aims to identify how vulnerability to climate change-related hazards differentiates between formal and informal settlements. Thereby, I chose to focus on Westville and Quarry Road West. This survey seeks to assess the level of vulnerability to climate change in your area based on different indicators.

As experts in the field, your personal opinion is very important to me since it will point out what you think is most needed when climate-proofing cities and where the differences in vulnerability between QRW and Westville lay.

Your participation in this interview is of course voluntarily and there will be no negative consequences for you in case you decide not to participate or at any time later decide that you do not want your results to be included in the study. The evaluation of the interviews will be treated as confidential and anonymous if you wish so. Your data will not be passed to third parties and will serve merely my research at Lund University. The data will be personally evaluated by me.

In case you have any questions or wish for responses regarding your results, you are more than welcome to contact me (pa5550we-s@student.lu.se).

Thank you very much for your support!

Kind regards, Pauline Wedepohl

General Interview Template

Hey, thank you for taking the time today. Just before we start I wanted to ask you again if it is okay for you that I am recording the interview? As I already stated in the email, the interview material would be used safely and only within the scope of this thesis project at the university and if you wish you can review your contribution at any time. I also want to mention that this is completely voluntary and if you wish to leave this interview at any time you can do that. Also if you decide at any point that you do not want your answers to be included in the thesis, I will respect your decision and remove your material. Moreover, would you rather like your responses to be displayed anonymously or can I use your name in the thesis?

Before we start, can you just quickly introduce yourself and tell me a bit more about your work in context with climate change?

So based on your experience, what do you consider to be the factors that make communities most vulnerable to climate change?

Where are the biggest differences between informal and formal settlements in their vulnerability to climate change?

What makes formal settlements vulnerable to climate change?

What makes informal settlements vulnerable to climate change?

What are the biggest differences in vulnerability that you have noticed when working with Quarry Road West and then reflecting and comparing it to the vulnerability of Westville?

Do you think that there needs to be special attention paid to informal settlements when adapting cities to climate change?

- If so, why?

Do you think Durban is paying enough attention to that?

- If not, what would be needed?
- What should the government address?

What did you consider the main difficulties in making Quarry Road West fit for climate change?

The report states that you want to use the lessons learned in the project for future studies – what were those biggest lessons learned?

Do you think that with this project the settlement now qualifies for an in situ upgrading or still needs to be replaced as proposed by the municipality?

Would you say that Projects like the PCRPP managed to adapt the principles on environmental justice?