

**Understanding multiple health risks for low-income communities
in Cape Town: water stress, COVID-19, and climate change**

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Declaration

‘I know the meaning of plagiarism and declare that all of the work in the thesis, save for that which is properly acknowledged, is my own’.

Signed:

Signed by candidate

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Abstract

Climatic hazards, such as flooding and drought, are expected to increase in frequency as a result of climate change. Growing evidence suggests that climate-induced water challenges will interact with health concerns, compounding pre-existing challenges for vulnerable populations in low-and middle-income contexts. Due to the novel nature of COVID-19, limited research has focused on the combined impact of the climate crisis and COVID-19 on human health, particularly in South Africa. Thus, there is an urgent need to enhance understanding of the adverse health impacts linked to climate-related water stressors.

Using a mixed-methods approach, this study drew upon multiple datasets to explore water-related health risks prevalent during the Cape Town drought, and in the subsequent period up to and including the current COVID-19 pandemic. Data sources include qualitative stories from a community resilience project, video interviews from the drought response in Cape Town, quantitative COVID-19 water service delivery data from informal settlements, and a document analysis of the Cape Town Water Strategy. Data was analysed using inductive and deductive research approaches to piece together different perspectives on how the pandemic interacts with pre-existing hazards.

The study uses the climate-water-health nexus framing to investigate some of the critical health risks present during and after the drought. The study also explores how the COVID-19 pandemic interacted with health and water issues, providing a snapshot of the lived experience of the urban poor during an emerging public health crisis. The study subsequently considers the implications for the Cape Town water sector in view of the drought and ongoing COVID-19 pandemic.

Results from this study show that inadequate sanitation and exposure to wastewater are the most commonly cited health risks for low-income households in the study sites. The COVID-19 pandemic has amplified existing water-associated health risks by indirectly widening health inequalities and increasing poverty levels. Moreover, compound risks have limited the ability of low-income households to cope with additional shocks and stressors. The findings of this study contribute to a critical research gap and expand the evidence base on the relationship between climate change, water, health, and compound risks in the South African context. The study calls for the adoption of a cross-sectoral, integrated approach to address health threats at the climate-water-health nexus.

Table of contents

Copyright.....	1
Declaration.....	2
Acknowledgements.....	3
Abstract.....	4
1. Introduction.....	7
1.1 Aim and objectives.....	9
2. Literature review.....	10
2.1 Climate change, water and health: the need for a nexus approach.....	10
2.2. Climate-sensitive health risks: the global evidence.....	11
2.2.1 Climate-sensitive health risks in South Africa.....	13
2.3 Vulnerability, water shocks and stressors, and health.....	15
2.4 Multiple health risk factors: climate change, urbanisation and inadequate infrastructure.....	15
2.4.1 Multiple health risk factors: COVID-19, climate change, and compound risks.....	16
2.5 Poverty in South Africa: a health risk multiplier.....	18
2.6 A call for localised responses to hazards at the climate-water-health nexus.....	18
2.7 External risk factors for COVID-19 in South Africa.....	19
3. Methodology.....	20
3.1 Study site.....	21
3.2 Data sources.....	21
3.2.1 Qualitative stories: community resilience project data (SenseMaker).....	22
3.2.1.2 Community resilience project workshops (SenseMaker.....	23
3.2.2 Drought Learning interviews.....	24
3.2.3 COVID-19 informal settlement service delivery data.....	25
3.2.4 Cape Town Water Strategy.....	25
3.2.5 Semi-structured interviews.....	26
3.3 Data analysis.....	27
3.3.1 Community resilience project data and Drought Learning interviews (data analysis.....	28

3.3.2 COVID-19 informal settlement service delivery data (data analysis).....	29
3.3.3 Cape Town Water Strategy (data analysis).....	29
4. Results	29
4.1 Section one: Water-associated health risks during and after the Cape Town drought.....	29
4.1.2 Inadequate sanitation or wastewater exposure.....	31
4.1.3 Psychological stress.....	32
4.1.3.1 Psychological stress, disability and gender.....	33
4.1.4 Direct water-induced disease.....	34
4.1.5 Pre-existing health conditions.....	34
4.1.6 Unclean drinking water.....	35
4.2 Section two: Water-associated health risks during the COVID-19 pandemic.....	35
4.2.1 Asivikelane data results.....	36
4.2.2 Semi-structured interview results.....	38
4.2.2.1 Food security.....	38
4.2.2.2 Psychological stress.....	39
4.2.2.3 Pre-existing health conditions.....	39
4.2.2.4 Inadequate access to water and sanitation services.....	40
4.2.2.5 Compound risks and informal housing during the COVID-19 pandemic.....	41
4.3 Section three: Implications for the water sector in light of COVID-19 and prevailing water-related health risks.....	41
5. Discussion	43
5.1 Section one: Water-associated health risks during and after the Cape Town drought.....	46
5.2 Section two: Water-associated health risks during the COVID-19 pandemic.....	48
5.3 Implications for the water section in light of COVID-19 and prevailing water-related health risks.....	51
5.4 Opportunities for further research.....	53
5.5 Limitations.....	53
5.6 Final synthesis of findings.....	54
6. Conclusion	55

1. Introduction

The adverse health effects of climate change are extensive and multifaceted. They range from malnutrition and mental ill-health to increased prevalence of vector-borne and water-borne disease (Ebi, 2008; Khedun and Singh, 2014; Godsmark et al., 2019). Climate-driven health impacts can result from extreme weather events such as floods or droughts, or factors such as food insecurity or decreased water quality and availability. Mental ill-health can occur during and after extreme climatic events and lead to post-traumatic stress disorder and anxiety. Inadequate water quality or water availability can increase water-borne disease risk, disproportionately affecting populations in resource-constrained contexts (Chersich et al., 2018; Godsmark et al., 2019). Existing research has examined the complex interrelations between climate-driven stressors and shocks, and health and wellbeing (Chersich and Wright, 2019; Levy et al., 2016; Brown and Murray, 2013). Nevertheless, there is an urgent need to explore this topic in further detail given the devastating health impact of the COVID-19 pandemic in contexts already facing significant climate-exacerbated shocks and stressors.

Evidence suggests that sub-Saharan Africa is one of the region's most vulnerable to climate change and variability, due to low adaptive capacity and the burden of multiple stressors (Intergovernmental Panel on Climate Change [IPCC], 2007). Climate change will likely exacerbate pre-existing health risks and social inequalities in resource-poor contexts, thus widening current health disparities (Friel, 2011). The increasing disease burden is of particular concern in urban areas where the physical infrastructure is inadequate to cope with shocks such as flooding and heavy rainfall events (Friel, 2011).

Rapid urbanisation, coupled with demographic change, and governance inadequacies, have contributed to the growth of informal settlements in the Global South. In urban settings, poverty and environmental hazards exacerbate the adverse effects of climate-driven water challenges on human health (Adams, Stoller and Adams, 2020). Water is vital to maintaining human and environmental health, yet evidence suggests that climate change is negatively impacting water quality and availability across the globe (Yu, 2016). Recently, scholars have begun to examine the interactions between water insecurity, urban poverty and health outcomes in the Global South (Adams, Stoler and Adams, 2020). Yet, in-depth case studies exploring these interactions in the sub-Saharan African context are lacking (Adams, Stoler and Adams, 2020).

Given the complex, negative interplay between water, climate change and health, the urban poor are not well-placed to cope with additional crises or hazards. The impact of the COVID-19 pandemic on low-income communities has been severe, exacerbating existing inequalities (Bambra, Riordan, Ford and Matthews, 2020). Often living in dense settlements and working in the informal economy, the urban poor are at a heightened risk of infection and disproportionately affected by lockdown measures and curtailments on economic activity enforced by governments around the world (Madhav et al., 2017; Corburn et al., 2020). COVID-19 has negatively affected the resilience of low-income groups in developing countries, hampering their ability to manage pre-existing health challenges (Wilkinson, 2020; Shadmi et al., 2020). For example, social stigma and marginalisation has been reported in low-income settings after receiving a positive COVID-19 result (Wilkinson, 2020). This type of challenge may in turn exacerbate existing mental health challenges. Reported negative coping mechanisms during the COVID-19 crisis include reducing food consumption and an inability to buy essential medicines (Tyson, 2020).

The global impacts of the COVID-19 pandemic are unprecedented, with over 185 countries affected by the virus. The pandemic has rapidly evolved into a health, geopolitical and economic catastrophe,

topping policy agendas worldwide (Djalante, Shaw and DeWit, 2020). Emerging evidence suggests that there will be significant morbidity and mortality from the COVID-19 pandemic in low-and middle-income countries (Walker et al., 2020). In 2020, the commitment to strengthen global collective action to achieve the 2030 sustainability agenda was overridden by the need to mitigate the harmful effects of the COVID-19 crisis (Djalante, Shaw and DeWit, 2020). Still, some scholars suggest that 2020 can, and must, be the year of tackling both climate change *and* the current global health pandemic caused by the novel Coronavirus (Djalante, Shaw and DeWit, 2020; Phillips et al., 2020). Cross-sectoral, integrated policy initiatives are urgently required to tackle COVID-19 and the climate crisis. Initiatives should be informed by a better understanding of the combined impact of the COVID-19 virus and climate change crises on human health (Leal-Filho, Nagy and Ayal, 2020; Salas et al., 2020). Understanding that climate change is multifaceted and complex, this thesis will predominantly focus on the direct risk factors of increased drought and intensification of rainfall, and the indirect risk factors of water quality and availability.

This thesis contributes to the aforementioned knowledge gap by synthesising the multiple risks to health caused by water challenges such as flooding and droughts in the context of Cape Town, South Africa. It explores how health and water risks interact with the COVID-19 crisis and are exacerbated by underlying social mediating factors such as poverty. While the thesis directly references the current COVID-19 health crisis, its findings also have implications for future pandemics. The study's findings may also be relevant to other water-scarce, resource-constrained contexts in low-and middle-income countries, where similar environmental factors mean that climate change will disproportionately impact human health.

As recently cited by the World Health Organization (WHO, 2020), 'COVID-19 will not be the world's last health emergency'. Ahead of future pandemics, there is a critical need to adopt a whole-of-society approach to build resilience against future shocks and stressors (WHO, 2020). Altered land-use, expanding global population, and globalisation increase the risk of zoonotic diseases shifting into global pandemics (Jowell and Barry, 2020). Actions are urgently required to stabilise the climate, halt biodiversity loss, and preserve human health and wellbeing (Andersen and Rockstrom, 2020). A shared governance approach, which understands the deeply intertwined nature of human health, natural systems and a changing climate, is critical to tackle the current pandemic and reduce future disease risks (Jowell and Barry, 2020).

This study uses the climate-water-health nexus as a conceptual framework to investigate the relationship between these three variables. Within the nexus approach, climate change is a key contributor to water stress and poor health outcomes in low-income suburbs of Cape Town. Specifically, the nexus framing helps to unpack multidimensional health risks to drought and water stress in Cape Town. Nhamo et al., (2018) highlight the relevance of the water-energy-food (WEF) nexus for understanding converging issues in the context of Southern Africa. The learning from the WEF nexus contributed the decision to use the climate-water-health nexus in this study. As Nhamo et al., (2018) describe, the silo approach, often coordinated at the national level in Southern African countries, exacerbates vulnerabilities and plays a crucial role in the failure to meet development targets. This failure is owing to duplication in resource allocation and inefficient resource use. Reflecting on the silo approach highlighted by Nhamo et al., (2018), this thesis uses the WEF nexus theoretical framing as a foundation for this study. This thesis seeks to use the climate-water-health nexus framing to converge three interrelated topics and explore relevant practice and policy opportunities at this key juncture. Indeed, where domains are interconnected, they cannot be appropriately addressed unless they are considered to be interdependent and interactive (Hoff, 2011).

A cognisance of the 'climate-water-health nexus' is increasingly crucial for cities in the Global South, as understanding these interrelations can help build resilience against climate sensitivity, plan for public health needs, and water and sanitation infrastructure (Akanda and Hossain, 2012). Addressing climate-induced health risks at the climate-water-health nexus requires a holistic approach. A nexus structure ensures that development approaches are understood within a broader framework which addresses synergies, risks, and potential trade-offs between multiple interrelated issues (Dougherty et al., 2019).

This transdisciplinary study focuses on the city of Cape Town, South Africa, a context highly vulnerable to the water-related consequences of climate change. The research seeks to understand the pathways through which water stressors, such as inadequate access to clean water and sanitation, flooding, and drought, negatively impact human health, both during the Cape Town drought and the COVID-19 pandemic.

The Cape Town 'Day Zero' drought resulted from three consecutive winters with very scarce rainfall, with climate change and variability contributing to the prolonged deficit of rainfall (Pascale et al., 2020). Cape Town was predicted to be the first major city in the world to run out of water, with the municipal government using the term 'Day Zero' to refer to the point at which water would need to be distributed via collection points instead of through the taps (Maxmen, 2018). Understanding the challenges and lived experiences of the urban poor in South Africa during the recent drought and the current COVID-19 pandemic is a vital step towards finding context-specific responses to future climatic shocks and global health pandemics. Failure to consolidate learning from the current crisis risks exposing vulnerable groups to further harm from future shocks and stressors, which are predicted to increase in prevalence as a result of climate change (Salas, Shultz and Solomon, 2020).

Multi-disciplinary responses which recognise the interrelated nature of global health and climate change are urgently required in the fight against the COVID-19 pandemic, with water and climate being critical elements in achieving the Sustainable Development Goals (Armitage and Nellums, 2020). This thesis intends to bolster the relevant literature in this sphere by exploring issues impacting the urban poor at the climate-water-health nexus.

1.1 Aim and objectives

The aim of this study is to explore how health risks from water stressors are exacerbated by climate change and a pandemic, using a case study of predominantly low-income suburbs in Cape Town, South Africa. The study uses the climate-water-health nexus to understand impacts during the Cape Town drought and the COVID-19 pandemic.

The objectives addressed in this study are as follows:

- Draw on the climate-water-health nexus to understand multidimensional health risks to drought and water stress in Cape Town
- Explore the compound influence of the COVID-19 pandemic on the urban poor in Cape Town, in relation to health and water
- Outline key considerations for the Cape Town water sector in light of the drought and the COVID-19 pandemic

By examining health stressors, vulnerabilities, and compound risk from water hazards and COVID-19, this study makes a case for prioritising access to water and sanitation services for vulnerable populations in Cape Town.

Chapter 2 will critically review the existing literature relevant to this thesis. Chapter 3 guides the reader through the methodology used in this study. Chapter 4 outlines the results of the study, while Chapter 5 is a discussion of the findings, exploring how the results relate to existing literature. Chapter 6 concludes this study, offering a synthesis of key findings and identifying gaps and policy implications at the climate-water-health nexus.

2. Literature review

Current debates centred on the relationship between climate change, health, and water are explored below. The first section focuses on the global literature, to guide the reader through the broader relevant research on the interrelated topics of water, climate change and health. Thereafter, the literature review covers studies specific to the South African context, including research focused on the Western Cape Province and the City of Cape Town.

2.1 Climate change, water, and health – the need for a nexus approach

The nexus concept suggests that different issues are intrinsically related and should be governed as such, originating in reference to linkages between food, climate, energy and water (Boas, Biermann and Kanie, 2016). The terminology has become more broadly used in recent years, and as such should not be limited to the four areas outlined above. Indeed, the nexus approach can be used to help avoid the dominance of any development domains over others (Boas, Biermann and Kanie, 2016). Available literature refers to nexus relationships around health, poverty, gender and education (Clancy, Skutsch and Batchelor, 2002), education, health and water (Kitamura et al. 2014), and education, health and food (Iguchi et al., 2014; Wallace et al., 2014). Reflecting on the benefits of this concept outlined in existing literature, this thesis seeks to address a gap in existing literature by using the nexus framing to explore the interconnected nodes of climate change, water and health.

The fourth IPCC report estimates that globally 'by 2020, between 75 million and 250 million people are projected to be exposed to increased water stress due to climate change' (IPCC, 2007, p.13). The IPCC Technical Paper VI 'Climate Change and Water' projects that water scarcity and malnutrition will likely be among the most prominent health consequences of climate change (Bates et al., 2008). Approximately half of the urban population in sub-Saharan Africa lack access to adequate water and sanitation (Friel, 2011). In the context of increasing urbanisation, water scarcity is of key concern, with sub-Saharan Africa expected to encounter the highest population increase in urban areas in the near-term (Angel et al., 2011). Health impacts related to water scarcity, water supply and sanitation are significant risks that must be addressed in resource-poor contexts (Bates et al., 2008).

Recent research exploring the relationship between climate-induced extreme weather events and health impacts by Leal-Filho et al., (2018) contributes to the current evidence gap on these interactions. However, evidence on health impacts and the consequential management of health risks, specifically during flooding and droughts in sub-Saharan Africa, is currently limited. As mentioned by Leal-Filho et al., (2018) and subsequently outlined in this thesis, water-related, climate-driven extreme weather events such as flooding and droughts appear to be inextricably linked to negative health impacts. This scarcity of research is primarily due to extreme weather events being unpredictable in nature. Researchers are often not well positioned to respond due to delays with funding and ethics approval in the immediate aftermath of an extreme weather event (Bouزيد, Hooper and Hunter, 2013). This

knowledge gap may impede decision-makers ability to design suitable interventions that protect vulnerable groups from health risks associated with drought and flooding. Reflecting on the interconnected nature of health, water scarcity, flooding, and climate risk, as highlighted by Bouzid, Hooper and Hunter, (2013), this thesis explores prevalent health risks resulting from drought, water scarcity and flooding in Cape Town, South Africa.

Multiple studies call for the adoption of a nexus approach to address interrelated development issues in Southern Africa. A nexus approach can be used as an analytical tool and a conceptual framework (Keskinen et al., 2016). However, there are a lack of relevant studies which focus specifically on the climate-water-health nexus in South Africa (Mpandeli et al., 2018; Nhamo et al., 2018; Nhamo et al., 2020). As an alternate model, the Water-Energy-Food (WEF) nexus approach provides an opportunity to bolster resilience against climate change and limit associated vulnerabilities (Mpandeli et al., 2018; Nhamo et al., 2018). The WEF nexus offers a conceptual framework that provides a significant opportunity for policy convergence across sectors and improved resource coordination and management.

A nexus approach is highly relevant for this study as vulnerable groups in low-and middle-income contexts face multiple health threats, including from climate-related water scarcity, drought, flooding and health emergencies. The use of a nexus conceptual framing is valuable to ensure multi-dimensional vulnerabilities from interrelated stressors are captured and sufficiently addressed through enabling strategies and policies. As raised by Boas, Biermann and Kanie, (2016), failing to apply cross-sectoral strategies across related sectors may lead to incoherent policy making or an inability to achieve key targets in the Sustainable Development Goals, leading to trade-offs in sustainable development.

The thesis reflects on literature by Boas, Biermann and Kanie, (2016), Hoff (2011) and Martin-Nagle, (2011), and existing studies by Kitamura et al. (2014); Iguchi et al., (2014); Wallace et al., (2014) and Clancy, Skutsch and Batchelor, (2002), which suggest that fragmentation of interrelated sectors will fail to achieve sustainable results. As such, this study calls for an integrated, cross-sectoral approach to address the interrelated challenges of climate-induced water shocks and stressors, and health, in the context of South Africa. It uses the nexus approach as a conceptual framework, as a pathway to frame an issue and promote coherence in policy and decision-making (Albrecht, Crootof and Scott, 2018). Linkages between sectors have always existed, yet when coupled with population growth and increasing needs for basic service provision such as safe water and sanitation, it is of fundamental importance to understand these interdependencies and multiple vulnerabilities in further detail (Martin-Nagle, 2011). Climate change further compounds issues, highlighting the need for an integrated approach to address overlapping development needs (Martin-Nagle, 2011).

The nexus approach is particularly appropriate as a way to frame this thesis, as the themes under review are multi-sectoral and transdisciplinary, considering the additional threat posed by climate change. This thesis explores the relationship between health, water, and climate change, focusing on the compound risks posed by flooding and water scarcity during the COVID-19 pandemic.

Health risks from climate-induced water shocks and stressors can affect both physical and mental health. The literature on this topic is explored in the section below.

2.2 Climate-sensitive health risks: the global evidence

This study explores both physical and psychological health risk factors experienced as a result of climate change in Cape Town, South Africa. To provide a wider contextual background to the study, this thesis

briefly explores the available global evidence. The study covers both direct and indirect climatic drivers, considering both as contributing factors to poor health outcomes.

Negative health impacts of climate change include heat stroke and stress, as well as related effects on mental health, respiratory systems, cardiovascular health, diarrhoeal infections, and vector-borne infectious diseases such as malaria (Patz et al., 2005; Myers et al., 2011; Thompson, Matamale and Kharidza, 2012; Godsmark et al., 2019). Health effects linked to climate change can be either driven by direct risk factors (i.e. resulting from extreme weather episodes such as floods and heatwaves) or indirect risk factors such as food and nutrition insecurity and air pollution. A range of environmental, social effects, and 'modulating' factors can also be drivers (Myers et al., 2011; Rahman et al., 2019; Godsmark et al., 2019).

The negative effects of climate change exacerbate intergenerational and transnational inequality and hamper the critical efforts made in pursuing global health equity. Moreover, the Lancet Countdown on health and climate change report suggests that trends in climate change vulnerabilities, impacts and exposures pose an unacceptably high health risk to current and future populations around the globe, significantly impacting labour capacity, food security and water-borne disease. Unfortunately, a global inertia to adapt to the negative health impacts of climate change continues (Watts et al., 2018). Figure 1 below outlines some pathways through which climate change can contribute to human health risks

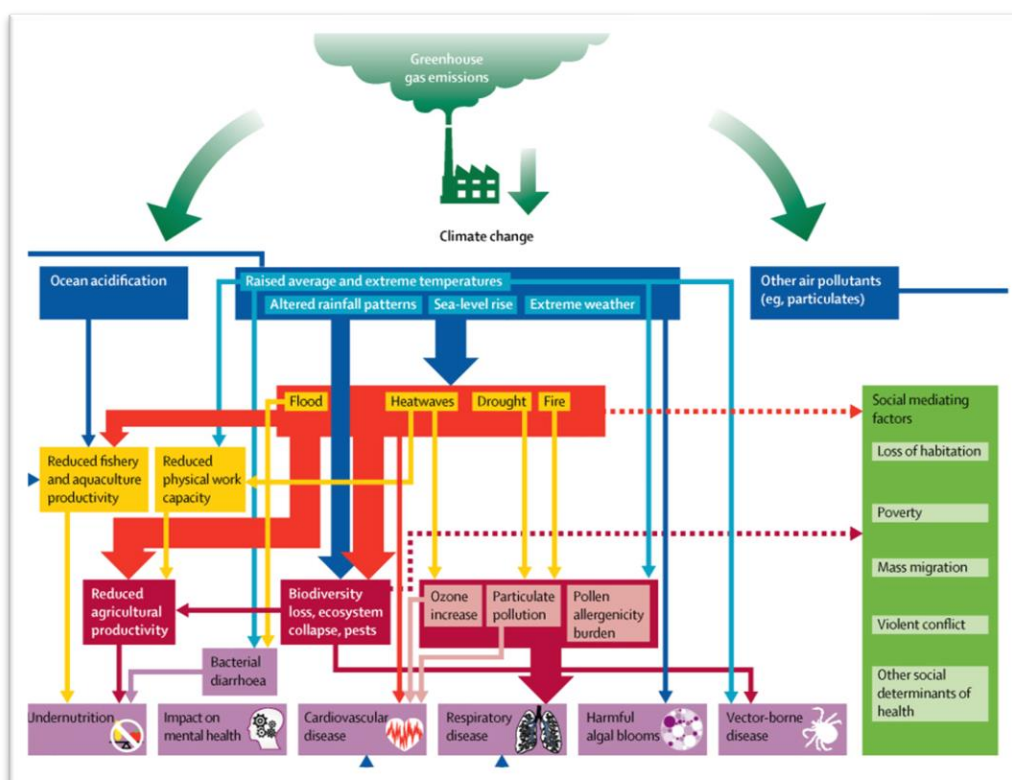


Figure 1. The pathways between climate change and human health (Watts et al., 2018, p.2482)

Negative health impacts are set to increase in the future, as extreme weather patterns accelerate (Bell et al., 2018). Climate change is also projected to increase the prevalence of rodent-borne, vector-borne and water-borne diseases (Khedun and Singh, 2014). Research on the relationship between climate

change and mental health in South Africa is limited (Chersich et al., 2018). Research by McMichael, Montgomery and Costello (2012) suggests that the impacts of climate change may offer health benefits to some. Yet, the overall effects will be increasingly adverse, far outweighing potential benefits. These co-benefits will likely be felt in colder climates and are unlikely to apply to the South African context. The co-benefits of climate change will, therefore, not be a focus of this literature review.

2.2.1 Climate-sensitive health risks in South Africa

This study recognises that there are multiple pathways through which climate-driven water impacts can negatively affect human health. Indirectly, multiple health effects from climate change have been studied in the South African context (Myers et al., 2011). Cape Town, which is characteristic of a Mediterranean-type climate, is particularly prone to climate-induced health risks due to its location in a biogeographical hot-spot (Paz, 2016).

A review by Orimoloye et al. (2019) highlights the climate-driven health risks facing South Africans in rural parts of the country. Other scholars have taken a continent-wide, regional, or provincial approach to assessing the health impacts of climate change in South Africa (Patz et al., 2005; Ramin and McMichael, 2009; Thompson, Matamale, and Kharidza, 2012; Godsmark et al., 2019). To date, there is a lack of research exploring the health impacts of climate change in South Africa at the city level. This thesis contributes to the evidence base on climate-induced risk factors in South Africa by focusing on urban low-income suburbs in Cape Town. This study's findings may apply to other urban hubs in South Africa, particularly areas characterised by a high level of informality.

Climate change impacts on children's health in South Africa's Limpopo province include diarrhoea, respiratory infections, asthma, and malaria (Thompson Matamale, and Kharidza, 2012). Diarrhoeal disease outbreaks, including cholera and dysentery, may rise in future as polluted drinking water supplies may increase. A study by Mutangadura et al. (2005) provides evidence for the relationship between climatic factors, unimproved water sources, and diarrhoeal infections. On a global scale, populations facing poor sanitation, inadequate housing and high burdens of infectious disease, are associated with an increased prevalence of diarrhoeal diseases following flooding events (Confalonieri et al., 2007).

Projected higher temperatures and evaporation rates coupled with reduced rainfall resulting from climate change will place increased pressure on already limited water resources, leading to water scarcity and drought in South Africa (United Nations Development Programme [UNDP], 2021). By 2050, climate change will affect water availability in the majority of South Africa, according to recent evidence (United Nations University World Institute for Development Economics Research, 2016). Indeed, centring this thesis on water-associated impacts of climate change is particularly valuable considering the future outlook of water stress in South Africa. Indeed, the magnitude of water associated health risks compounded by climate change will likely be increasingly prevalent in the country, particularly in urban settings such as Cape Town which is impacted by both drought and flooding (Paz, 2016).

In South Africa, prevalent diseases such as malaria and schistosomiasis may become more widespread due to rising temperatures and shifts in patterns of rainfall resulting from a changing climate (UNDP, 2021). In turn, this will place additional strain on public health systems, particularly in resource-poor contexts. Providing adequate financing for the increase in the current disease burden due to climate change-related health impacts poses a critical challenge (Ebi, 2008; Godsmark et al. 2019).

A recent study by Godsmark et al. (2019) summarises the health impacts, risk factors, and groups most likely to be adversely affected by climate-driven health impacts in the Western Cape province, as outlined below in figure 2. The framing for this thesis aligns with the risk factors highlighted in the blue boxes in figure 2. This thesis focuses primarily on the direct risk factors of increased drought and intensification of rainfall, and the indirect risk factors of water quality and availability, food and nutrition insecurity, vulnerable groups, infrastructure and health services. The direct risk factors were selected due to their relevance to the weather patterns in the Western Cape region of South Africa.

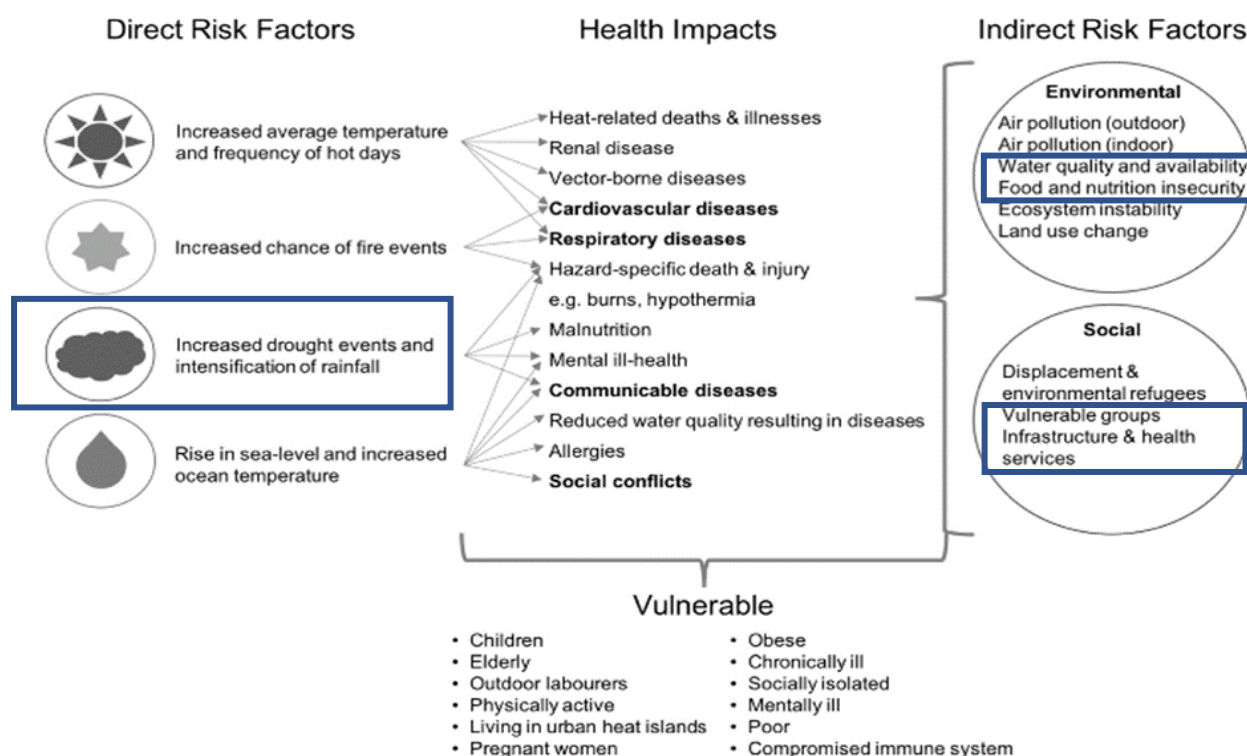


Figure 2: Health impacts of climate change in the Western Cape Amended from Godsmark et al. with emphasis provided by the author, (2019, p.45)

The causal chain between climate change and negative health impacts from extreme weather events can be complex. Understanding the relationship better will help to develop mechanisms to bolster the resilience of vulnerable groups (Orimoloye et al., 2019).

Chersich and Wright (2019) call for climate change to be mainstreamed into all policies for health. The scholars outline the need for further research in this area as a requisite to preserve human health and wellbeing in generations to come. According to Chersich and Wright, (2019), reframing climate change as a significant health threat, could be an appropriate way to ensure an adequately-resourced response in South Africa. Indeed, the question of how to address climate-driven health impacts in South Africa will be of significant importance in the coming decade (Chersich et al., 2018).

Pre-existing vulnerabilities in South Africa further compound water-associated health impacts. How these variables interact is explored in the section below.

2.3 Vulnerability, water shocks and stressors, and health

Given the comparatively high rate of existing morbidities in South Africa, multidisciplinary research plays a vital role in examining how vulnerable groups respond to the COVID-19 crisis through a health, social, and economic lens (Corburn et al., 2020; Joska et al., 2020). This thesis begins to respond to the paucity of research by understanding how water shocks and stressors negatively impact human health during a pandemic and after a city-wide drought and water crisis. This study uses a cross-sectoral approach to understand the health risks posed by both climate and non-climate-driven flooding and service-delivery related water scarcity. The research explores how vulnerabilities from health comorbidities, gender, and disability correlate with access to clean water and essential health services during the midst of a global health emergency.

Evidence suggests that the future impacts of climate change will disproportionately affect the urban poor if there are not significant mitigation and adaptation strategies put in place (Leal-Filho et al., 2019).

Women and girls in resource-constrained contexts are increasingly vulnerable to violence when seeking to meet their daily sanitation and water needs (Joshi, 2011; Sommer et al., 2015). A lack of safe access to water and sanitation and a reliance on communal toilets and washing facilities can significantly increase the risk of sexual and gender-based violence for vulnerable groups. Current evidence suggests that there is considerable under-reporting related to incidences of sexual violence linked to water and sanitation (Sommer et al., 2015). Further research on the topic is critical to inform future policy and programming (Joshi, 2011; Sommer et al., 2015).

In South Africa, knowledge gaps exist around vulnerable populations coping mechanisms and capacities to respond to health threats caused by climate-driven flooding and droughts. In South Africa, sub-populations identified to be disproportionately susceptible to the health impacts of climate change include individuals facing poverty, women, the elderly, young children, and groups with chronic underlying health conditions (Ziervogel et al., 2016).

The pathways through which multiple environmental hazards impact human health are explored in the section below.

2.4 Multiple health risk factors: Climate change, urbanisation and inadequate infrastructure

This thesis focuses primarily on the urban poor in Cape Town. The focus on low-income urban areas is particularly relevant due to the rapid urbanisation rate in South Africa. Urbanisation is occurring primarily and most rapidly in low- and middle-income contexts (Brown et al., 2018). Cities in the Global South, which are often characterised by high levels of informality, are particularly vulnerable to water-related urban environmental risks and the negative impacts of climate change (Jabareen, 2013; Ziervogel et al. 2014).

Recent evidence suggests that over 20% of all households in Cape Town reside in informal settlements (Rodina, 2019; Ziervogel, 2019). Backyard dwellers place further pressures on sanitation and water services, due to the rising number of backyard dwellings on the premises of formal government-provided low-income housing (Govender et al., 2011). Compounding this issue, South Africa is facing a low-income housing crisis, with an unmet need for housing currently estimated at over three million units (Govender et al., 2011).

The rise in populations living in low-and middle-income contexts presents significant risks for infectious disease transmission and can accelerate the spread of pathogens (Neiderud, 2015). Low-quality housing and densely populated informal settlements, coupled with inadequate water, waste management and sanitation provision, provide an ideal environment for the rapid spread of coronavirus and other diseases (Govender et al., 2011; Neiderud, 2015).

There is a need to act with urgency as densely populated urban environments with inadequate water and sanitation provision provide an ideal environment for COVID-19 and other diseases to thrive in. COVID-19 may also impede the government’s ability to respond to water and climate-related health challenges, as will be explored in the next section of this thesis.

2.4.1 Multiple health risk factors: COVID-19, climate change, and compound risks

Compound risks such as flooding impede the effective management of the COVID-19 outbreak. The types of climate-induced global compound risks, as understood by Phillips et al. (2020) are outlined in figure 3 below. In South Africa, significant compound risks are drought, water scarcity and flooding. The findings from Phillips et al. (2020) are consistent with the results of this study, which suggests that local authorities are facing challenges in attempting to enforce social distancing in informal settlements affected by localised flooding. Indeed, methods to curtail the virus such as social distancing, self-isolation, and adherence to strict personal hygiene practices such as hand washing are increasingly difficult to maintain in low-income suburbs (Gibson and Rush, 2020; Corburn et al., 2020).

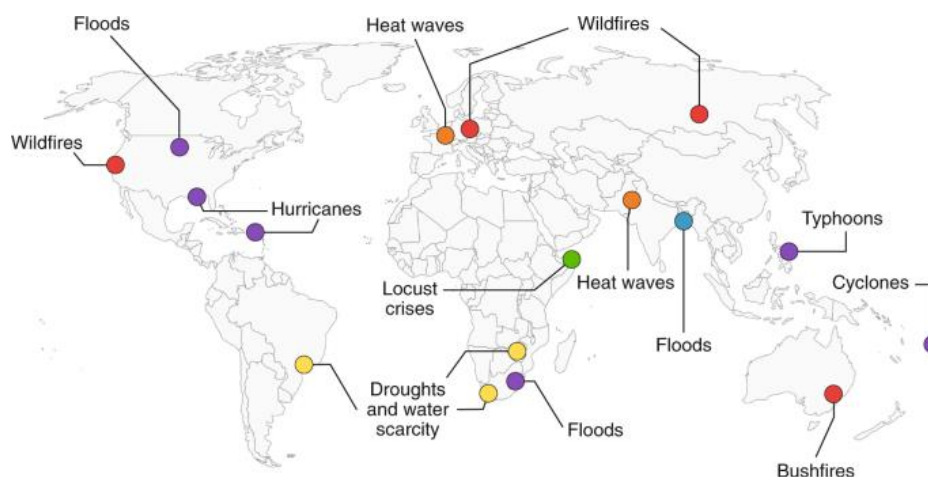


Figure 3: Profile of global compound risks Phillips et al., (2020, p. 586)

Hand washing is promoted by the World Health Organization and many national health agencies around the globe as a simple strategy to curtail the transmission of the COVID-19 pandemic. Unfortunately, this advice is not realistic nor feasible across much of sub-Saharan Africa, where nearly 300 million people face water scarcity and inequity in accessing clean water (United Nations Children’s Fund [UNICEF] and World Health Organization [WHO], 2019). In South Africa, droughts and flooding reduce water quality and impact hygiene practices, such as hand washing (Mosley, 2015; Chersich et al., 2018).

Multiple recent studies emphasise the need for an integrated response to tackling COVID-19 and climate change (Salas, Shultz and Solomon, 2020; Phillips et al., 2020; Jin, 2020; Heyd, 2020). Incorporating pandemic preparedness into climate change adaptation strategies can avoid compartmentalising intersecting challenges. Understanding the interdependencies between health, water, and climate change is critical to ensure an appropriate response to future global health crises.

A study conducted in 25 sub-Saharan countries suggests that high inequality in access to food storage, water, and sanitation, increases COVID-19 vulnerability. The findings indicate that cross-sectoral approaches to addressing such inequalities would significantly improve resilience to future crises (Ekumah et al., 2020). Evidence from the study by Ekumah et al., (2020) is highly applicable to this study, where food insecurity in low-income suburbs of Cape Town increased substantially due to the COVID-19 lockdown.

In the COVID-19 pandemic, inequitable access to water, sanitation and hygiene (WASH) services poses a key challenge. Inadequate water and sanitation provision contributed to previous disease outbreaks, such as the 2014 West Africa Ebola outbreak. Specifically, poor WASH was cited as a crucial contributor to the rapid spread of the disease and the underlying causes of high mortality rates (Kalra et al., 2014).

While this section has outlined the risks posed by COVID-19, climate change and compound water-related risks, the next section focuses in more detail on the role of poverty as a health risk multiplier, summarising relevant literature on the South African context.

2.5 Poverty in South Africa: a health risk multiplier

Understanding the health risks facing low-income households in Cape Town is a core focus of this study. Therefore, it is essential to understand the social determinants of health, of which poverty is a crucial factor.

According to Statistics South Africa data from 2014/2015, almost half of adults live below the upper-bound poverty line, with incomes insufficient to purchase basic nutritious food and essential non-food items such as soap and hygiene supplies (Statistics South Africa 2017a; Baldwin-Ragaven, 2020). In South Africa, high poverty and inequality levels are endemic, already posing considerable barriers to sustainable development (Ziervogel et al., 2014). The country's quadruple burden of disease caused by poverty-related illnesses, HIV/AIDS, chronic conditions, and injuries, is of key concern (Wright et al., 2014; Biney, Amoateng, & Ewemooje, 2020). The Ministry of Health in South Africa is already struggling to address this existing burden of disease (Basu, 2018). Climate change can also increase risk factors in some groups through interaction with other stressors (Wright et al., 2014).

As explored in this study, high levels of informality, inadequate access to sanitation, and wastewater exposure may correlate with physical and psychological health risks. Poverty, health co-morbidities, malnutrition, social inequality, and environmental factors also play a role in disease susceptibility (Madhav et al., 2017). All these factors affect significant swathes of Cape Town's population. Low-income groups also face increasing health risk in urban areas due to a lack of provision for health care and emergency services, coupled with limited measures for disaster risk reduction (Intergovernmental Panel on Climate Change [IPCC], 2014).

Water issues highlight the stark reality of poverty, inequality, and the vulnerability of low-income communities to a multitude of climate-induced water-related challenges in South Africa (Enqvist and

Ziervogel, 2019). High proportions of poor and marginalised residents living in low-quality housing and informal settlements exacerbate the challenge of addressing the COVID-19 outbreak in resource-constrained contexts. These neighbourhoods are often densely populated and lack adequate water and sanitation provision (Chersich et al., 2018). The majority of informal settlements within Cape Town are in low-lying, waterlogged areas which exposes them to flooding (Ziervogel et al., 2016). The limited provision of vital public services, such as water supply, sanitation, and stormwater infrastructure further exacerbates vulnerability in these areas (Enqvist and Ziervogel, 2019). Populations with the lowest adaptive capacity and limited access to necessary service provision continue to be disproportionately affected by COVID-19 through multiple direct and indirect pathways (Baldwin-Ragaven, 2020; Street et al., 2020).

Service delivery protests across the country lay bare the gaps which remain in improving access to clean water and sanitation services in the country (Baldwin-Ragaven, 2020). Water scarcity, flooding and poor access to hygiene facilities are critical compound risks in the current COVID-19 crisis, hampering vulnerable households' ability to cope with the pandemic. In 2017, only 7.3% of South Africa's poorest urban residents had access to a handwashing facility on-premises with soap and water, as compared to 84.3% of the richest urban residents (World Health Organization [WHO] and United Nations Children's Fund [UNICEF], 2017). This highlights how poverty impacts people's ability to perform basic hygiene practices such as hand-washing with soap, which are required to reduce disease transmission. Similarly, poverty compounds COVID-19 through the high reliance on work in the informal economy, with lockdown measures equating to an immediate loss of income for poor individuals (Durrizo et al., 2021).

This thesis explores pathways through which interrelated challenges posed by climate change, water, and health can occur in low-income contexts of Cape Town. The literature on local responses to such issues is explored in the section below.

2.6 A call for localised responses to hazards at the climate-water-health nexus

This study uses water as a focus to explore how health and climate change are intertwined in Cape Town, with possible policy options to address water-related health risks outlined later in this study.

Smith et al., (2014) underscore the need to evaluate the health implications of adaptation strategies at both the community, sub-national, and national level. This thesis responds in part to this gap by synthesising health risks at the community level and offering responses that decision-makers could apply at the municipal level.

City-led approaches aimed at addressing the health impacts of climate change in Cape Town should recognise local actors and organisations as critical stakeholders who can contribute valuable insights into the design of prevention and adaptation strategies. Importantly, connecting top-down government-led approaches and grassroots perspectives can bolster city-level resilience (Enqvist and Ziervogel, 2021). This thesis aims to contribute to the available literature on this topic by focusing on resource-constrained urban areas of Cape Town, primarily from the perspective of local actors and community organisations. Indeed, compiling evidence from a broad set of stakeholders is essential for understanding climate-induced water challenges from diverse vantage points.

Effectively responding to the health impacts of climate change is a crucial challenge for decision-makers. Climate-sensitive health outcomes are experienced across scales, affecting individuals,

households and communities (Sahay, 2019). The problem's multidimensional nature highlights the need for further analysis of climate-sensitive health concerns across different demographics and temporal scales, as is explored in later chapters of this study. For health impacts that are highly localised, strategies at a municipal level offer significant opportunities (Austin et al., 2018; Fox et al., 2019).

The development of sub-national health and climate change policies and strategies are critical due to slow national level policy action (Fox et al., 2019). Consistent with findings from Fox et al., (2019), the implementation of South Africa's national-level climate change and health adaptation plan does not appear to be quickly translating into action at the local level (Chersich and Wright, 2019).

As explored in this thesis, a Cape Town or Western Cape-specific health and climate change adaptation strategy could be beneficial due to the ever-increasing risk of flooding and drought in the province. A City of Cape Town Climate Change Strategy is currently being redrafted and was recently available for public participation. However, the section on health and wellbeing (4.2.5) only provides limited detail on how the City will address the critical health risks posed by climate change (City of Cape Town, 2020).

In the Western Cape province, the burden of non-communicable diseases and social conflict are key climate-sensitive health risks. The overall burden of disease is projected to increase in the future, exacerbated by an upward trajectory of climate-driven risk factors (Godsmark et al., 2019). Dealing with such challenges are further compounded by external threats such as the COVID-19 virus.

2.7 External risk factors for COVID-19 in South Africa

Research on the high-risk areas or COVID-19 'hotspots' in the South African context is beginning to emerge. Current evidence from Cape Town suggests that implementing social distancing is a critical challenge in high-density, informal settlements. A study by Gibson and Rush (2020) analysed the density of two informal settlements in Cape Town using a geographic information data set. However, their study has a key limitation as informal settlement residents need to leave their homes to use communal toilet and water facilities, thus influencing the study results. This thesis offers additional evidence on the heightened risk of exposure to COVID-19 as a result of an inadequate physical environment and the inability to self-isolate or adhere to social distancing.

Furthermore, climate change also hampers the ability of patients with COVID-19 to access health services and receive high-quality care (Salas, Shultz and Solomon, 2020). Climatic shocks such as flooding may disrupt health services and lead to a rush of climate casualties filling hospital beds already struggling to treat COVID-19 patients (Salas, Shultz and Solomon, 2020).

The model mapped below (figure 4) was published in April 2020 and uses local government data to measure COVID-19 contagion risk factors. Indicators such as inadequate access to water and sanitation, low income, informal housing, poverty levels, large household size, high population density, and a reliance on public transport are extrapolated to calculate risk, with historically disadvantaged areas largely exhibiting higher levels of COVID contagion. The risk mapping indicators are consistent with findings from this study and with recent research by de Katz et al., (2020), who studied COVID vulnerability in Gauteng, and Zavaleta-Cortilo et al., (2020), and Phillips et al., (2020) who conducted global research on COVID-19, climate change and compound threats. These authors used similar indicators to define populations who may face increased vulnerability to COVID-19.

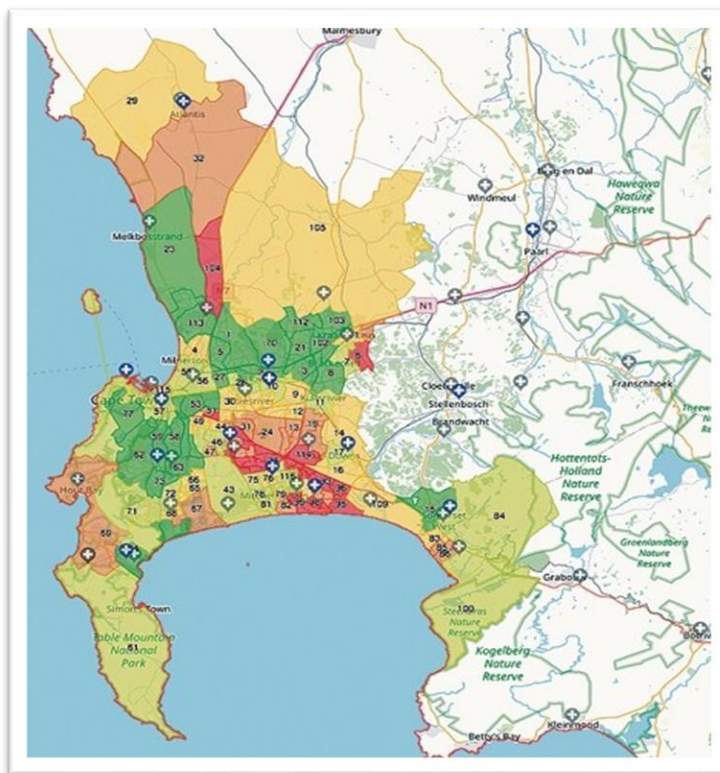


Figure 4: Index of vulnerability to COVID-19 contagion (Source: Municipal IQ, 2020)

High-density suburbs of Cape Town such as Khayelitsha, are comprised of a significant amount of informal housing and inadequate water and sanitation provision. Learning from the 2014 Ebola crisis suggested that mandatory quarantining of households in informal urban areas led to a high disease burden from inadequate waste disposal, which further risked the health of informal residents (Campbell, 2017). Such evidence not only highlights the need for improved WASH facilities in informal settlements in Cape Town but emphasises the need to ensure pandemic responses encompass risks at the climate-water-health nexus.

This literature review has provided an overview of relevant academic discourse around water, climate change, and health, and explored challenges posed by the COVID-19 pandemic in resource-constrained settings. The literature review has contextualised the core themes in this study and outlined the existing research gaps that this thesis aims to contribute to. The lack of relevant literature on the climate-water-health nexus is a critical issue, particularly in light of the increased risk which climate-related drought and flooding pose to human health in South Africa. The chapter has synthesised research from a global, country-level and city-level perspective, and framed key findings in the broader context of this thesis. The next chapter of this study outlines the methodology used in this thesis, covering the study site, data sources, and data analysis.

3. Methodology

This chapter provides an overview of the study site and outlines the different data collection tools and approaches used to analyse data in this research project. The study has been approved by the University of Cape Town's Science Faculty Research Ethics Committee (approval code: FSREC 018- 2020).

3.1 Study site

Cape Town, situated in the Western Cape Province of South Africa, is the study site for this research. The study's key focus encompasses the drought and water crisis that affected the city between 2015 and 2018, and the COVID-19 pandemic, which greatly impacted South Africa in 2020 and into 2021. The thesis is split into sections and thematic areas. The first section explores the health implications of the drought from various perspectives, including decision-makers and low-income households. The second section focuses on the interactions between health and water-related hazards during the COVID-19 crisis, from the vantage point of low-income residents in Cape Town. The third section reviews the Cape Town Water Strategy to explore implications for the Cape Town water sector in light of the impact of COVID-19 and prevailing water-related health risks.

The study sites are mapped below in figure 5. The blue pins signify study sites where Western Cape Water Caucus (WCWC) members conducted interviews (referred to in the section below as ‘community resilience research project’). The pink pins represent data collected in informal settlements during the COVID-19 outbreak (referred to in the section below as ‘COVID-19 informal settlement service delivery data’). The pins with both colours are areas where there was overlap in the study sites between the two datasets.



Figure 5: Map of study sites (Source: Google maps, 2020, amended by author)

3.2 Data sources

The study used a mixed methods research design which combined both primary and secondary datasets to address the research questions. I used predominately secondary data due to the restrictions posed by the COVID-19 pandemic. However, some secondary data sources, namely the community resilience project data, were already planned for use before the pandemic started. Government restrictions were

in place throughout the period in which this thesis was written, with lockdown level 5 and 4 restrictions in place during the planned data collection phase.

Most data sources were comprised of qualitative data. The approach drew upon the holistic qualitative methodology outlined by (Kitchin & Tate, 2013), which uses a thematic analysis approach to ensure the validity of the findings. The COVID-19 informal settlement service delivery dataset was the only dataset which included quantitative data (as participants were asked yes/no questions about the services available in their informal settlements). A detailed explanation of the different data sources is outlined in the sub-sections below, while the data analysis process is explained in section 3.3.

The mixed-methods research approach offered opportunities to synthesise and extrapolate findings from a range of sources. There are limitations to all research methods, yet the mixed-method approach attempts to address this limitation by combining different approaches to ensure complementary strengths and non-overlapping weaknesses (Tashakkori and Teddlie, 2010).

The need to avoid research fatigue and protect prospective study participants' health was especially critical during the COVID-19 pandemic. While the community resilience data set was collected in low-income suburbs prior to the pandemic, I had initially planned to collect additional primary data to complement the existing secondary dataset. The settlements I selected to participate in the research during the pandemic are characterised by high levels of informality and inadequate provision of water and sanitation. These areas also experienced a disproportionately high COVID-19 incidence. Accordingly, it was not justifiable or ethically appropriate to place potential respondents at risk by asking them to participate in face-to-face interviews and focus group discussions as part of this study.

The decision to use secondary data sources was also facilitated by my awareness of the complex social and economic factors at play during the COVID-19 pandemic. In the planned study sites, many people had recently become unemployed. They were facing extreme financial hardship, food insecurity and psychological stress and trauma due to the impact of the COVID-19 crisis. Subsequently, the research approach pivoted mainly towards the use of secondary sources.

The study's primary data collection was limited to three semi-structured telephone interviews with members of the WCWC, (a community-based organisation), as a way to complement and validate the other data collection tools. A limitation of the study was that it was not possible to triangulate all the data sources due to the different content and thematic focuses. Nevertheless, using various sources provided an opportunity to identify common water-related health concerns across a temporal scale.

3.2.1 Qualitative stories: community resilience project data (SenseMaker)

This data was collected under the Community Resilience in Cape Town (CoReCT) Project; an AXA-funded research project focused on urban water governance led by UCT researchers, Gina Ziervogel and Johan Enqvist (African Climate and Development Initiative at the University of Cape Town, 2020). The project aims to gain insights into the lived experiences of water issues, water access, and water service delivery from the perspectives of low-income households in Cape Town, and present key findings to decision-makers. To achieve this aim, the CoReCT project partnered with the WCWC, whose members reside across 19 townships and informal settlements in Cape Town. The research was collected over three months in 2019 and 311 stories were collected in total. The qualitative stories were largely illustrative of local context specific issues, while some of the wider themes are referenced in the literature review. Due to the constrained of relying heavily on secondary data as a result of the

pandemic, it was not possible to conduct the research as initially planned, so the stories are used as a way to provide different examples of larger themes.

I met members of the WCWC during a series of workshops in 2019, which also comprised part of the data collection. The WCWC members were preparing to undertake community-driven research on water access and service delivery in low-income suburbs of Cape Town. The pre-existing links to the WCWC community researchers provided an opportunity to follow the community research process and subsequently analyse their dataset in this study. I analysed the data as it provided valuable qualitative insights into a range of water-related health challenges from the perspectives of low-income households across multiple suburbs in Cape Town, a central theme in this study.

The CoReCT project has built the capacity of the WCWC by co-creating and executing transdisciplinary research collected and analysed through the SenseMaker tool. The WCWC members conducted research in their own communities, interviewing people about water issues they had experienced and the channels through which they had tried to resolve the problems. The SenseMaker is a data collection tool through which interview data is captured. WCWC members tasked 12 of their members with collecting stories in their communities between July 2019 – October 2019 (African Climate and Development Initiative at the University of Cape Town, 2020).

3.2.1.2 Community resilience project workshops (SenseMaker)

I attended two SenseMaker workshops in July 2019 and October 2019. The workshops were organised as part of the CoReCT research project and hosted by the WCWC, Environmental Monitoring Group, UCT African Climate and Development Initiative (ACDI) and Stellenbosch University Centre for Complex Systems in Transition.

The first workshop in July 2019 was an opportunity to meet WCWC community researchers, provide a brief overview of the planned study to the community researchers, and obtain feedback on the approach. The workshop was designed to introduce WCWC members to the SenseMaker tool and agree on the research questions and direction. Thus, the workshop helped me understand the tool's parameters before the WCWC members conducted the research. Workshop attendees collaborated with ACDI to co-design the research questions, after understanding the functionality of the tool.

The second SenseMaker workshop took place in October 2019 once the WCWC community researchers had completed the data collection phase. The purpose of this workshop was to share the initial findings from the research, reflect on the learning from the data collection process, and consider approaches to return the stories to the communities from which they were collected. Participation in this workshop provided a valuable opportunity to re-familiarise with the community researchers and understand common themes which arose from the fieldwork. WCWC members raised health and sanitation issues related to water scarcity and flooding as important risk factors during the workshop. Through this exploration of common themes, I reflected on the findings and validated the relevance of my research parameters.

In total, WCWC members collected a non-representative sample of 311 stories from Dunoon, Makhaza, Joe Slovo, Green Park, Mitchells Plain and other low-income suburbs of Cape Town. The circle sizes in figure 6 below are determined by the number of stories collected per suburb.



Figure 6: CoReCT project study sites (Source: African Climate and Development Initiative at the University of Cape Town, 2020)

3.2.2 Drought Learning interviews

I analysed previously recorded video interviews as part of this study. The Cape Town Drought Response Learning Initiative team conducted 39 interviews in 2019 with high-level technical advisors to the City of Cape Town, local government employees, private sector stakeholders, academics, and community activists. The rationale for using this dataset was to gain an in-depth understanding of the health risks associated with the drought, from a diverse set of stakeholders directly involved in the crisis response. Although the interviews were not predominantly health-focused, multiple health-related issues emerged, which provided highly relevant contextual information surrounding the drought and water crisis.

The Cape Town Drought Response Learning Initiative is the result of a collaboration between academics, a facilitator and a filmmaker. The project was co-led by Conversations that Count, CineSouth Studios, and UCT ACDI academics Professor Mark New and Associate Professor Gina Ziervogel. The objective of the project was to document learning and observations from the Cape Town drought and water crisis and disseminate key findings to bolster urban resilience and improve social outcomes. Each interview is approximately hour-long. The videos were initially viewed via the drought library website (The Cape Town Drought Response Learning Response Initiative, 2020). Thereafter, all videos were downloaded and transcribed using Otter.ai. The transcriptions were cross-referenced against the original recordings and checked for errors. All 39 video transcripts were then imported into NVivo Pro 12 for coding.

3.2.3 COVID-19 informal settlement service delivery data

Asivikelane is an isiZulu term that translates to "we protect each other". It is a joint initiative of a group of South African NGOs, led by the International Budget Partnership (2020).

I identified the International Budget Partnership (IBP) after looking online for publicly available datasets relevant to COVID-19, water and health in the Cape Town context. IBP supported informal settlement partners to collect data by conducting surveys in their communities from March 2020 onwards. The collaborative development project amplifies the voices of residents of informal settlements in South Africa to understand the lived experience of service delivery during the COVID-19 pandemic. IBP subsequently shared key findings and service delivery issues in each informal settlement with municipal government actors.

The NGO group collected quantitative data from communities on water service delivery and sanitation in informal settlements of Cape Town throughout the COVID-19 crisis. A broad range of informal settlements were surveyed each month, but the proportion of responses from each suburb varied from month to month.

The questionnaire asked residents a series of polar questions regarding water access, toilet cleaning, and waste collection. The dataset also included qualitative information and allowed residents to add additional narrative and comments on water access and shared sanitation issues. The data was available to download on a bi-weekly basis in Excel format through the website (International Budget Partnership, 2020). After downloading the datasets, I put them in chronological order from March to September 2020. The dataset included topics outside the scope of this study, so I only extracted data within the remit of this study. The parameters for relevant analysis to include in the study are outlined in section 3.3.2 COVID-19 informal settlement service delivery data (Asivikelane).

I included this dataset to understand the potential health implications of water service delivery challenges during the COVID-19 pandemic. The qualitative element of this dataset provided more richness, which allowed me to capture critical information on health risks from insufficient water access and sanitation during the pandemic. This dataset was also a useful reference to compare with the findings of the three semi-structured phone interviews which I conducted during the COVID-19 crisis.

3.2.4 Cape Town Water Strategy

The City of Cape Town developed the Cape Town Water Strategy against the backdrop of the severe drought which affected Cape Town from 2015 – 2018 (City of Cape Town, 2019b). The goal of the strategy is to pave the way for Cape Town to be a resilient, water-sensitive and sustainable city.

The Cape Town Water Strategy was reviewed in this study to understand the scope of water reforms planned by the City of Cape Town and to cross-reference the strategy plans against the lived experiences of low-income households in Cape Town. I selected the water strategy as it provides an up to date road map of how the City of Cape Town plans to address water challenges in the city; issues that are central to this study. The review took into consideration the results from the other datasets, particularly concerning prevailing issues facing low-income households in the city. The document review was undertaken using a health and climate lens to understand the extent to which the strategy considered the climate-water-health nexus. The use of a 'health lens' meant reviewing the strategy to understand the extent to which physical and psychological health risks that may negatively interact with water, were

considered in the strategy. Similarly, the use of a ‘climate lens’ sought to understand the extent to which water-related climatic risks were referred to as current or emerging threats, in the strategy.

This document review was particularly relevant in light of the COVID-19 pandemic when inadequate water access and sanitation provision in low-income parts of Cape Town was a pivotal barrier to curtailing the spread of the virus.

The City of Cape Town plans to implement the strategy through a three-pronged approach, including the Cape Town Water Transition Plan, the Water Services Development Plan and the Collaborative Resilience Action Plan (City of Cape Town, 2019b, p.66). I searched for all the implementation planning documents online. However, the Water Services Development Plan was the only implementation document available for review at the time of writing in September 2020. An online search for the Water Transition Plan and the Collaborative Resilience Action Plan did not return results. It is not clear whether they are not public-facing documents or whether the City of Cape Town is yet to finalise them.

I initially examined the Water Services Development Plan alongside the water strategy. However, it appeared the plan has not been updated since 2017 and does not include new indicators that directly align with the water strategy goals (City of Cape Town, 2017). Reviewing the three implementation plans in parallel would have provided a key opportunity to compare the strategy plans against the objectives, key performance indicators, and targets in the implementation documents. Given the strategy has only recently been developed, it is not surprising these other documents are not available.

3.2.5 Semi-structured interviews

I interviewed three individuals in May and September 2020 by telephone. Lydia Peterson, a Mitchells Plain-based climate change activist, was interviewed on 27th May 2020. Ann October, also a resident of Mitchells Plain, provided further insights in an interview on 8th September 2020. Zinzi Mgwigwi, a resident of Dunoon informal settlement, was interviewed on 9th September 2020. The participants are active or recently active WCWC members and residents of Mitchells Plain and Dunoon.

Conducting the interviews at different stages of the COVID-19 pandemic provided the opportunity to gain insights across a temporal scale. In May 2020, lockdown level 4 was in place, with broad-ranging restrictions on personal movement. By September 2020, the lockdown restrictions had reduced to level 2, with many households able to return to work and operate under comparative freedom. The two participants interviewed in September 2020 were also able to reflect on the seasonal flooding and associated health impacts felt during the peak of the pandemic. Each of the three semi-structured telephone interviews lasted approximately 25 minutes and were conducted in English. The interviews were audio-recorded with the prior permission of the study participants and then imported into Otter.ai for transcription. The original recording and transcripts were reviewed and checked for errors. All three participants gave their consent to have their full details included in the study, so quotes were not anonymised.

I asked informants a series of predetermined, open-ended questions around the topics below:

- Issues with accessing clean water in the community, and the effect upon households or communities during the pandemic
- The role of winter flooding in Cape Town in exacerbating other health issues for households or communities during the COVID-19 pandemic

- Awareness of an increase in other health issues (physical or psychological) in the community during the pandemic
- Reflections or recommendations for the City of Cape Town on water and health issues during COVID-19
- Reflections on similarities in the health issues experienced as part of the Cape Town drought/ water crisis and the COVID-19 pandemic

The aim of using a flexible questioning technique was to guide the conversations and allow participants to reflect on issues directly relevant to their households and communities, rather than the interviewer determining the agenda based on their interests (Barbour, 2008). I asked the informants to consider water-related health impacts that affected them, members of their household, or their community. This approach provided flexibility to gain broader, more relevant insights and aligned to the parameters used in the SenseMaker study. The use of semi-structured interviews to supplement the other data sources also allowed me to explore specific thoughts, beliefs and feelings on a topic, and get detailed feedback on issues around water and health impacts during the COVID-19 pandemic (DeJonckheere and Vaughn, 2019).

3.3. Data analysis

The exact steps taken per dataset are outlined below. I analysed all data through a health risk lens, to draw out key themes relevant to the scope of the study. Both deductive and inductive approaches were used to analyse the data. Pre-determined themes around the climate-water-health nexus framed the review of the datasets. Simultaneously, I also applied an inductive approach to work through the data and let additional relevant key points emerge gradually from the data (Hsieh and Shannon, 2005).

All data sources used in this study were analysed using NVivo Pro 12 and Microsoft Excel. Some scholars have considered the use of software in the data analysis process to add rigour to the qualitative research process (Richards & Richards, 1994; Welsh, 2002). The added accuracy is partially due to the NVivo search functionality, which provides an opportunity to interrogate the data thoroughly and validate or disprove a researcher's insights into the data (Richards & Richards, 1994; Welsh, 2002). Using data analysis software was also a useful tool to organise the data more effectively. As such, I was able to code data more quickly and efficiently. The format and structuring of NVivo made it easy to identify linkages and duplication between different themes (Smith and Hesse-Biber, 1996).

I used the semi-structured interview transcriptions, Drought Learning interview transcripts, SenseMaker Excel spreadsheet, COVID-19 community data Excel spreadsheets, and PDF copies of the water strategy, to conduct NVivo word searches (with synonym 'stemmed' words). I applied this approach to cross-reference information and capture all essential material. I identified similar or related stories, and these were grouped/coded into broader umbrella themes.

The analysis process varied slightly according to the specific dataset, with attempts made to follow a consistent, systematic approach across all of the data. The content analysis was based on the process as described by Mayring (2000) and Pope et al., (2006), which involves using systematic coding and categorising data to explore large amounts of textual content and determine trends, frequent word use and patterns, and the relationships between different themes. Using a content analysis approach enabled me to systematically work with many information sources and encode multiple sets of qualitative information. According to Coffey and Atkinson (1996), coding is a way to relate our data to our ideas about our data.

The inductive approach was taken predominately in the SenseMaker stories and the Drought Learning interviews, which were the first datasets to be analysed before I had a clear idea of what themes may arise. Once common themes were identified, I took a deductive approach to explore the COVID-19 community data and the water strategy document. For the telephone interviews, I initially used a deductive approach by asking pre-determined questions to the three WCWC interviewees. An inductive approach was then applied to the coding of the interviews in NVivo to explore additional themes which arose through the flexible questioning approach.

3.3.1 Community resilience project data (SenseMaker) and Drought Learning interviews (data analysis)

I did not have access to the SenseMaker software programme to identify and analyse trends in the data, so 311 SenseMaker stories were initially analysed in Microsoft Excel using an inductive research approach. This involved reading through each story and making initial notes and observations. As I had taken part in the SenseMaker workshops, I had some preconceived ideas of the content and was able to compare the insights raised in the workshop to the written stories at field level. At this stage, I started to consider the parameters for relevance to include certain story themes and excluded stories that pertained only to issues of water billing or the installation of water management devices. I subsequently used a deductive approach to identify key themes and patterns using NVivo Pro 12 and developed key word searches to cross-reference stories and ensure all relevant information was captured. . The parameters for inclusion included any reference to physical or mental health risks or impacts, and sanitation and hygiene. All references had to be directly referring to their experience of the drought and water crisis, rather than illness due to external or unrelated factors. Search terms used included “health”, “hygiene”, “illness”, “sanitation”, “sick”, “anxiety”, “stress”, “unwell”, and “panic.

For consistency, when analysing the drought video library stories, I aligned the parameters for the inclusion of stories with the process used for the SenseMaker stories and used the same deductive approach to code key themes relevant to health.

The majority of stories did not provide much granularity, and it was logical to merge similar stories under the same theme when detailed insight was limited. Stories within the study parameters included any reference to physical or mental health risks or impacts, as well as a reference to sanitation and hygiene. All stories needed to be centred around water-induced health risks or impacts to be included in the study. Some stories were coded against more than one theme as respondents raised cross-cutting issues.

I used a systematic approach to align the data from the Drought Learning interviews and SenseMaker data under the umbrella theme of ‘water-associated health risk factors and impacts experienced during and after the Cape Town drought’. Aligning the two themes was essential to avoid duplication when presenting the results, yet it is key to note that the data sources and topics are divergent.

I tried to ensure the chosen health themes were relevant to both datasets. However, due to the differences in the sources, a few separate themes were maintained to capture all the relevant stories accurately. For example, only SenseMaker respondents mentioned pre-existing health conditions as interacting with water access challenges, or health issues arising from unclean drinking water. As such, these themes were included but categorised only under the SenseMaker results.

3.3.2 COVID-19 informal settlement service delivery data (Asivikelane) (data analysis)

I converted the quantitative data from the Asivikelane dataset (average monthly sample size of 113) into percentages to understand the proportion of residents who had access to water, clean toilets, and sanitation products such as soap and hand sanitiser over the study period. Thereafter, I analysed all additional qualitative data in the survey using Excel and included only data relevant to water, health and sanitation. I included the sample size for each month as a reference as the residents interviewed varied significantly from month to month.

3.3.3 Cape Town Water Strategy (data analysis)

I imported the Cape Town Water Strategy into NVivo and coded it according to relevant themes relating to health, sanitation and water. I then identified common themes and connections between the topics that emerged. I reviewed the water strategy to understand how if at all, the interactions between health, water, and climate change were reflected. In addition, I looked to answer questions around the extent to which the direct health impacts from water scarcity and/or flooding in low-income parts of the city were included in the strategy.

4. Results

This chapter is divided into three distinct sections to cover each of the themes from the data analysis process. The first theme covers water-associated health risk factors and impacts experienced during and after the Cape Town drought. This section presents results from the severe drought and water crisis as captured in the drought library, and from the SenseMaker stories collected in the period thereafter. The second theme highlights water-associated health risk factors and impacts exacerbated during the 2020 COVID-19 pandemic, drawing on COVID-19 informal settlement service delivery data and semi-structured interview data. The third section includes a document review and gap assessment of the Cape Town Water Strategy. The Cape Town Water Strategy is used as a proxy to assess gaps in policy-making and to identify opportunities for the city to align water policies and practices with the broader climate-water-health nexus. The gaps are framed within the context of the health and water-related findings which arose during the COVID-19 pandemic, and the water-induced health impacts which still exist in low-income suburbs of Cape Town beyond the period of drought.

4.1. Section one: Water-associated health risks during and after the Cape Town drought

The sample size of the datasets included in this analysis varied significantly. A total of 311 stories from the SenseMaker study were analysed (1 story = 1 respondent), along with 39 Drought Learning interviews. SenseMaker respondents raised health concerns in 103 of those stories. Meanwhile, 22 out of a total of 39 drought response interviews cited health as a concern during the water crisis, equating to 56% of the total sample. The Drought Learning interview respondents raised both potential public

health risks and direct health impacts, with both included within the parameters of the analysis. In the SenseMaker stories, only direct health impacts were cited by households.

Figure 7 displays the health concerns raised in the SenseMaker stories and figure 8 displays health concerns cited in the Drought Learning video interviews. Pre-existing health conditions and health risks linked to unclean drinking water were only categorised in the SenseMaker analysis.

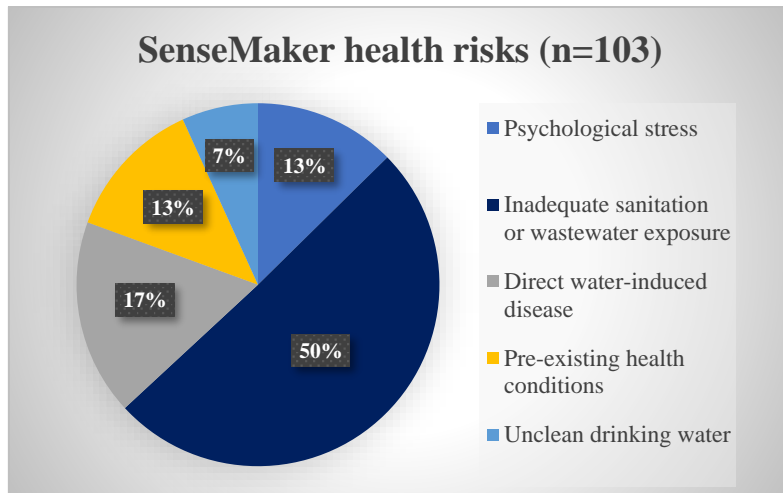


Figure 7: Profile of SenseMaker health risks (Source: African Climate and Development Initiative at the University of Cape Town, 2020)

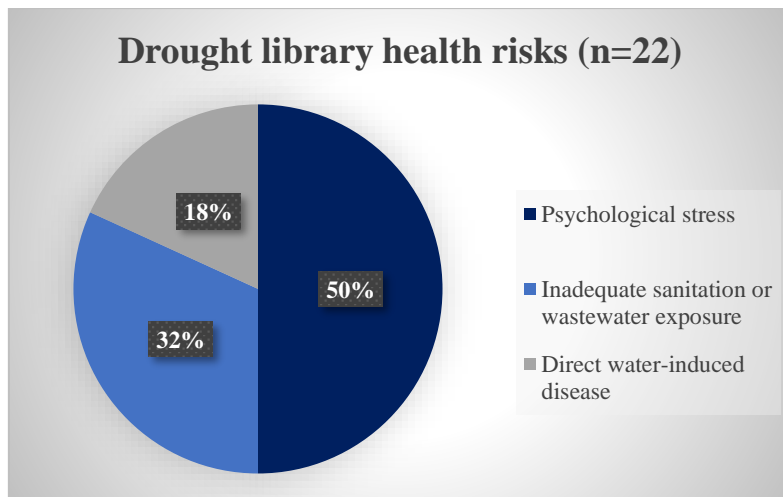


Figure 8: Profile of health risks from drought library (Source: Cape Town Drought Response Learning Initiative, 2020)

Health risk	SenseMaker	Drought library
Psychological stress	13%	50%
Inadequate sanitation or wastewater exposure	50%	32%
Pre-existing health conditions	13%	
Unclean drinking water	7%	

Table 1: Summary of health risks by source

4.1.2 Inadequate sanitation or wastewater exposure

Fifty-two SenseMaker stories (16% of 311) raised inadequate sanitation or wastewater exposure as a health issue; the most commonly cited health concern in this dataset. Seven (17% of 39) Drought Learning interview respondents mentioned inadequate sanitation or wastewater exposure.

All SenseMaker stories in this category referred to sanitation or wastewater exposure problems in their immediate environment. Six SenseMaker stories referred to both sanitation issues from wastewater exposure and direct water-induced disease and illness:

There is a dam in front of my house and the children are playing in the dirty water. As a result, they are sick with diarrhoea and have pimples on their bodies.
(SenseMaker story [85])

There is a crisis in the community I live in. The water is dirty from drains that community members throw in all sorts of things like dirty disposables nappies, tissue paper, dirty papers etc., causing sewer and stormwater drains to be blocked. This leads to water, instead of going inside the stormwater drains, it goes onto the streets
(SenseMaker story [179])

In contrast, Drought Learning interviews often cited potential public health risks for “Day Zero” or referred to scenarios modelled under increased levels of water insecurity:

[It is important to] find out the relationship between water sanitation and public health. That's because the problem is less about not having drinking water, there seems to be enough of that. But when you're dumping your waste, not in the toilet anymore, but somewhere else, that rapidly becomes a public health problem.
(Andrew Boraine, CEO: Western Cape Economic Development Partnership)

It doesn't take very much imagination to realise that if the sewers block up, we have a very serious health problem. In fact, we all know that because when a typhoon hits an area, one of the big things that happen is people get sick. (Kim Kruyshaar, Owner: Green Audits into Action)

Fifteen SenseMaker participants also mentioned the high density of low-income housing and inadequate or outdated infrastructure as critical problems.

I am a resident of Delft. Due to the population overlapping with the high-density housing projects, our sewerage drains are blocked with sewerage water overflowing daily because of outdated infrastructure. (SenseMaker story [166])

As outlined above, respondents gave specific examples of how poor planning has left them exposed to flows of leaking sewage.

4.1.3. Psychological stress

Psychological stress was the top health concern cited by Drought Learning library respondents (mentioned by 11 of 22) and joint second most referenced health impact from SenseMaker respondents (present in 13 of 103 stories).

Three SenseMaker respondents mentioned psychological distress caused by broken water management devices and a lack of means to pay high water bills. Water management devices have replaced water meters in some suburbs of Cape Town and are designed to provide a set daily allocation of water.

My water bills come out extremely high. I have a water management device and often sit for days without water, it's very depressing. (SenseMaker story [172])

Four SenseMaker respondents cited threats to personal safety and social conflict, which subsequently led to psychological stress. One story highlighted a feeling of anxiety due to a broken water management device that left the household without water for a month and meant the family had to borrow water from neighbours. This type of story related to water management devices is illustrative of local issues and is not referenced in the wider literature review. This was a contentious and stress-inducing issue for the respondent as there was only a limited supply of water available due to water management device restrictions.

Another story categorised under psychological stress related to fear and anxiety arising from a dependency on shared toilet facilities.

I stay in an informal settlement in Site C. I don't stay in a brick house. I depend on a communal tap which is at a distance to reach. I don't have [a toilet], I depend on a communal one. This is dangerous at night as one can be raped. (SenseMaker story [318])

Only one SenseMaker story mentioned psychological stress arising from the uncertainty of the Cape Town drought and Day Zero:

I reside in an informal settlement in Langa township. The Day Zero talk scared me, as we heard it from people who didn't know how/what it was going to look like, so everyone talked as if they knew. Some told us that we won't have water for months...that was a very scary thing. I am blaming the City of Cape Town for not having programmes to help us know what is happening around us when it comes to drought. (SenseMaker story [332])

Drought Learning interview respondents felt that different factors drove anxiety, on both a personal level and their perceptions of anxiety in the wider community. These factors including work-related stress for the City of Cape Town employees directly involved in the drought response, concerns about how to provide water for families, and feelings of helplessness and panic arising from uncertainty in

crucial messaging from the City of Cape Town. Emotional strain and anxiety due to direct involvement in the drought response was cited in six Drought Learning interviews. Examples below provide further detail into the challenges raised.

There was a real physical crisis, but there was also a social and psychological crisis in our society. (Andrew Boraine, CEO: Western Cape Economic Development Partnership)

The water crisis was quite a tough period. We worked incredibly long hours from early morning to late at night, a lot of weekends, which was personally a massive challenge with two very young children. A lot of us developed health issues during the crisis, with some people from stress, some just a lack of sleep. But I think it did play a big personal toll on myself and a lot of others. (Helen Davies, Chief Director: Green Economy, Western Cape Government)

Andrew Boraine, CEO of the Western Cape Economic Development Partnership, cited the public communications and messaging around Day Zero as a key driver of anxiety during the water crisis. He described the wording, which suggested that day zero was inevitable, as problematic and offering no message of hope to citizens.

I think citizens and businesses were devastated by that message of Day Zero. And what happened is that it caused a very negative reaction in the system when people are scared. People tend to start by responding in a very selfish way. I'm going to buy up as much water as I can get in the shops, you know, stuff everyone else. I'm going to draw a big borehole on my property to safeguard me and my family or my business, stuff everyone else. (Andrew Boraine, CEO: Western Cape Economic Development Partnership)

He also drew attention to how the messaging caused an adverse reaction, which led to people responding selfishly due to being offered no alternate mitigation options. Accordingly, he said this drove the feeling of panic among citizens.

4.1.3.1 Psychological stress, disability and gender

In the full SenseMaker dataset (311 stories), 65% of the overall participants were women, and 32% were men. 3% identified as other or did not choose to disclose their gender. Those reporting psychological distress were disproportionately women; 85%, in comparison to 15% men.

In the full SenseMaker sample, around 18% (58) of respondents identified as having a disability. This is far above the disability prevalence in South Africa of 7.5% (Statistics South Africa, 2014) and could be linked to people's social grant status, where disability is quite a broad category. Thus, the results must be interpreted circumspectly for claiming interactions.

A gender and disability analysis for the Drought Response interviews was not conducted as many stories related to psychological stress were referencing the wider population as suffering from anxiety related to the drought rather than specific individual stories.

4.1.4 Direct water-induced disease

Eighteen SenseMaker stories (5% of 311) and four Drought Learning interviews (10% of 39) were coded against this theme. The SenseMaker stories related to illness were as a result of living in unsanitary conditions, or from children playing in or being exposed to unclean water. Diarrhoeal infections were widely cited, as were rashes or other water-borne diseases in children. Four SenseMaker respondents mentioned that children were hospitalised or required medical treatment due to water-related diseases. Other SenseMaker stories highlighted health issues that were the direct impact of water scarcity at the household level and associated problems of being unable to maintain personal hygiene. Broken water management devices and insufficient water to flush toilets were also reasons for water-related diseases.

Here in Joe Slovo, we suffer from dirty, grey water. Children play in this water, and we see them becoming sick. The water sometimes stinks badly, and we can't open our houses. This water, at times, causes pimples or rashes on our children, and we are forced to send them to the clinic. We don't have money and are forced to borrow money from other people. (SenseMaker story [251])

In front of my gate I have a storm drain and most of the time it overflows, maybe 3 times a month. My problem is that I have children here and it's easy for them to get sick and catch diseases. (SenseMaker story [226])

Referring to water-induced disease on a divergent topic, Drought Learning interviews cited hypothetical disease risk due to expected water scarcity under post-Day Zero water rationing or an increased water-scarce scenario.

4.1.5 Pre-existing health conditions

Thirteen SenseMaker stories described water issues as impacting people's ability to manage pre-existing conditions. Four SenseMaker stories referred to water scarcity as a barrier to maintaining regular medication schedules. Four respondents mentioned that they had to delay the planned time to take their medication due to unclean water or no available water.

I have a sick husband who needs to take medication, but sometimes during the day, there's no water until the next morning. Sometimes we sit without water for days. (SenseMaker story [140])

When I woke up this morning, I saw the colour of the water was brown, and I couldn't get water. I went back home without water. I stayed at home for about an hour, then went back to the tap. I found that the water was clean. I found this to be a problem because I had to make coffee for my mother so that she can eat and take medication, but because of the water, she has delayed the time for her medication due to the water colour. (SenseMaker story [216])

Other issues raised pertained to people being unemployed due to long-term sickness. Being unable to make an income then hampered their ability to resolve water issues. Inadequate water access placed an additional burden on chronically sick, low-income households, exposing them to further health risks from poor sanitation or wastewater exposure.

My problem is the water device is leaking since it has been installed by the City of Cape Town. It was October last year and its leaking with no water coming out. I reported to the officials, but no one helped me at all. I have been told to hire a plumber, but I can't afford to since I am unemployed because of sickness. My husband has passed away, and he was my breadwinner. My children are bigger now and married. I am staying alone and only helped by my neighbours who are also not working. (SenseMaker story [103])

Another respondent cited that pre-existing health concerns limited her mobility and thus her ability to access water.

I am an old woman staying alone. Health-wise I am challenged as I suffer from arthritis, diabetes, and another disease. I do not have the energy to carry heavy items. I struggle because the water point is a bit far from me. I suffer in my knees from arthritis. When I complained to one of the municipal officials, he said there is nothing he can do as according to their way of operation and the law, there is nothing wrong with the water point, and I must go to the old age home and not stay alone. (SenseMaker story [284])

A woman in the 70-89-year-old age bracket told this story above, highlighting the issue of water access in informal settlements for older people and people with impaired mobility.

4.1.6 Unclean drinking water

Seven SenseMaker participants recalled situations where they lacked the basic necessity of clean drinking water.

I grew up here in Green Park, I had never seen brown water in this area or community. But now we are drinking brown water. Children get sick from this water. Sometimes we don't get water at all for the whole weekend. I don't know what has changed or happened where. (SenseMaker story [218])

My experience in this regard is when people from the City of Cape Town came to our community to place water meters without explaining that the water will only be available in 350 litres per day. This is causing inconvenience in my household because I often have to wash my children's clothes, and at times am unable to do so. You have to close the door because of green flies. My children are also affected by playing in the dirty water and other children are in hospital because of drinking unhealthy water. Sometimes there are conflicts between us, people are angry and frustrated with the situation. (SenseMaker story [78])

SenseMaker participants mentioned that contaminated drinking water led to poor health outcomes. Other stories did not provide further detail on health risks but focused on the colour of the water and the need to avoid drinking it:

4.2. Section two: Water-associated health risks during the COVID-19 pandemic

This section presents results from primary and secondary datasets collected during the COVID-19 pandemic. The sources outline key health and water-related risks which impacted low-income households in Cape Town between March and September 2020. The primary data source is three semi-structured telephone interviews with residents of low-income communities in Cape Town. Secondary data collected by Asivikelane complemented the interviews. The themes that emerged from the two datasets were difficult to align, so the results are displayed separately. The first sub-section covers the Asivikelane data, while the second sub-section focuses on the results of the semi-structured interviews.

4.2.1. Asivikelane data results

	Was there enough water for all residents in your settlement, over the last 7 days? (% reported no)	Do you have enough soap or hand-sanitiser? (% reported no)	Were the toilets cleaned in the last 7 days? (% reported no)	Sample size
March 2020	25%	Question not asked to participants	21%	61
April 2020	26%	Question not asked to participants	28%	123
May 2020	27%	90%	52%	160
June 2020	14%	84%	30%	163
July 2020	26%	83%	35%	89
August 2020	32%	Question not asked to participants	32%	86

Table 2: Asikevelane data results. Data from IBP, (2020)

The results in table 1 highlight that in every month of the pandemic, a significant proportion of respondents have had insufficient water access. The results show that water access did not improve before the peak of the COVID-19 outbreak (June) or directly thereafter. Nor was there a significant improvement in the provision of essential hygiene products such as soap and hand sanitiser. Access to soap or sanitiser peaked in July 2020, with 17% of the sample reporting access. Similarly, there was not a clear trend in improvement to communal toilet cleaning by local authorities during the pandemic.

Due to the nature of the data source, it was not possible to ascertain the extent to which these water and sanitation issues were pre-existing prior to COVID-19 and merely exacerbated during the health crisis.

One interviewee commented that:

Our toilets are blocked, and we don't know where to report this. It is very unhygienic as sewage is coming out of those toilets. (K2, Khayelitsha, July 2020)

The insights from this dataset provide a useful situational analysis of the living conditions in low-income communities during the COVID-19 pandemic. In some instances, health risks directly led to adverse health outcomes, disproportionately affecting children.

Toilets are not cleaned because the contract expired. We would like to know from the City of Cape Town when will they renew the contract because it's very unhygienic to live like this. We have children and they are getting infections and its very bad. (K2, Khayelitsha, May 2020)

Ever since the lockdown started we didn't receive any sanitisers or soap and we have children who are playing outside. They will get infected easily. (Bosasa, May 2020)

Respondents raised direct health impacts in April, May and June 2020. Other residents' feedback in July and August 2020 indirectly cited health risk factors such as blocked and unclean toilets, a lack of personal hygiene products such as soap, and inadequate access to clean running water.

We don't have taps. We are still waiting for the Department of Water and Sanitation to install taps for us. We can't even wash our hands. We will get sick and we have Coronavirus in this area. (Iraq, June 2020)

I don't know what a hand sanitiser is. I have only seen it on TV because I don't have money to buy it. (Marikana Slovo, July 2020)

We need sanitisers because we don't feel safe. We can't even wash our hands as we have to save the water that we have for drinking and cooking. (Burundi informal settlement, April 2020)

Results show a considerable reliance on government service delivery to provide hygiene products such as soap. Findings also suggest that dependence on communal, unsanitary toilet facilities increased the risk of contracting COVID-19 and other water-borne diseases. A lack of soap or sanitiser further exacerbated the risk of using communal sanitation facilities, particularly toilets.

Residents from Khayelitsha cited cleaning communal toilets themselves during the COVID-19 outbreak, placing individuals (without proper protective equipment) at heightened risk of exposure to COVID-19 and other water-borne diseases.

We clean the toilets ourselves lately as the cleaning people stopped. (BM, Khayelitsha, August 2020)

We have flooding because of the rain. Sewerage drains are blocked and overflowing, now that mess is getting into the people's houses. We don't know what to do. (Philippi, June 2020)

During the COVID-19 outbreak, residents of Philippi cited seasonal flooding as a health risk. Wastewater effluent entered people's homes, causing a threat to both physical and mental health.

4.2.2. Semi-structured interview results

Findings from the Asivikelane dataset were substantiated through semi-structured telephone interviews with residents of low-income communities in Cape Town. All three had participated in the Sensemaker study as citizen researchers. The different themes that emerged from the interviews are outlined below.

4.2.2.1. Food security

All three participants reported inadequate food access during the COVID-19 outbreak, with the initial lockdown quickly contributing to increased food insecurity. The risk of malnutrition was a critical health concern experienced in Dunoon and Mitchells Plain. Feeding schemes and soup kitchens were subsequently set up by the participants interviewed in both suburbs. As of 8th September 2020, the soup kitchen in Dunoon was serving between 150 and 200 residents per day. Similar figures were reported from the soup kitchen operating in Mitchells Plain. The majority of Mitchells Plain's soup kitchen recipients were children, indicating the ongoing need to provide adequate nutrition to vulnerable households during the outbreak, even after the government eased lockdown measures.

Lydia Peterson suggested that this was the only meal they would have for the day for many of the households reliant on soup kitchens. In the interview, she said that initially soup kitchens started in the area to support vulnerable children, but this quickly expanded to include older people, people with frailty, disabilities, or limited mobility.

*COVID-19 has had a huge impact on food security as well as existing social issues.
(Lydia Peterson, Mitchells Plain, May 2020)*

Respondents also raised the link between food insecurity and the virus trajectory in low-income suburbs of Cape Town. They described how many families could not afford to buy food and store it at home and were therefore unable to adhere to some of the lockdown restrictions. Households in Mitchells Plain and Dunoon had to trade-off the risk of contracting COVID-19 with having the means to feed their families. All three respondents explained how in high-density areas, people unable to shelter in-situ for prolonged periods due to poverty, faced a significant risk of contracting the virus. High pre-existing poverty levels meant that families did not have the financial capital to bulk buy perishable food goods and were mostly reliant on soup kitchens or community feeding schemes. Figure 9 and 10 displayed below were provided by Ann October and show children lining up to collect food at a soup kitchen in Mitchells Plain during the COVID-19 pandemic.

4.2.2.2. Psychological stress

Mental health was a key theme throughout the interviews. The interrelation between food security and mental health was mentioned by Lydia Peterson, who was running a mental health assistance wellness clinic during the outbreak. She suggested that people were caught in a negative coping cycle, always worried about where to get food and water. Ann October mentioned that, as a pensioner, she was personally under increasing mental strain to try to support other vulnerable community members through her soup kitchen initiative. All the participants interviewed mentioned that mental health declined in their communities during the pandemic. Poor psychological health was heightened due to a high proportion of job losses during the lockdown period. Lydia Peterson said that vulnerable groups were simply not getting the support they needed during the COVID-19 pandemic, with children, older people, and people with disabilities disproportionately at risk.

Being unemployed and being locked down has created so much mental un-wellness already. It has impacted people to the effect that we're sitting with so many social

issues that we had to have dealt with from the beginning, but now Covid has exacerbated that as well. So we're sitting with a situation that we feel that nobody is assisting anybody here. (Lydia Peterson, Mitchells Plain, May 2020)

When asked whether there were similarities between the COVID-19 pandemic and the Cape Town drought, both Ann October and Zinzi Mgwigwi said that the health impacts were far worse from COVID-19, as countless job losses led to psychological stress and food insecurity. Conversely, there was not a clear correlation of job losses during the Cape Town drought.

According to Lydia Peterson, cases of gender-based violence in Mitchells Plain also rose exponentially during the COVID-19 lockdown period. As understood by Lydia Peterson, this rise was, in part, exacerbated by deteriorating mental health from increasing unemployment and hardship.

4.2.2.3. Pre-existing health conditions

Results suggest that managing pre-existing health issues during the COVID-19 pandemic were aggravated by inadequate access to clean water. According to the interview with Ann October, this was a key concern for residents of Mitchells Plain. Water scarcity meant that people on chronic medication could not take their prescribed medication as per the dose schedules, an issue also expressed by SenseMaker participants. Ann October explained that a few residents passed away from pre-existing health issues, as they could not access the medical support they required during the pandemic. According to the interview, other community members in Mitchells Plain were at severe risk of malnutrition during the lockdown.

In the community, some people passed away from contracting the (COVID-19) virus, some people passed away from health failure, and others died from not having access to proper food. (Ann October, Mitchells Plain, September 2020)

Lack of water access also meant that terminally ill people could not clean themselves or meet their daily sanitation needs. Water cut-offs occurred in Mitchells Plain very frequently and caused problems for people already facing health challenges. Participants did not suggest that water cut-offs had increased in frequency during the pandemic but raised these concerns to highlight how the COVID-19 lockdown compounded pre-existing water concerns and disproportionately impacted low-income communities in Mitchells Plain.

The challenges were further exacerbated by lockdown restrictions and daily curfews, which meant people could not leave home at certain times of the day.

There is a lady (in the community) that has HIV and tuberculosis, and she can't even go out to get medication at the clinic because of the fear of contracting COVID-19. She is now getting more and more sick as she can't keep up with her treatment. (Ann October, Mitchells Plain, September 2020)

Vulnerable people in Mitchells Plain with pre-existing health conditions such as tuberculosis were worried about leaving their homes during the outbreak for risk of contracting COVID-19. They were subsequently unable to access their regular medication, and their health declined as a result.

4.2.2.4. Inadequate access to water and sanitation services

Water scarcity and unexpected water cut-offs during the COVID-19 pandemic were critical issues in Dunoon and Mitchells Plain. In Dunoon, Zinzi Mgwigwi considered water scarcity as a significant and reoccurring problem during the outbreak. Water cuts were said to be daily in Dunoon, often for hours

at a time. She mentioned that water cuts were widespread before the COVID-19 pandemic but suggested that the increased demand for water due to a higher frequency of handwashing worsened the impact of water scarcity during the pandemic. Whilst the City of Cape Town provided water trucks to the area to alleviate water challenges during COVID-19, the amount provided was insufficient to cater to the needs of the entire community, leaving households particularly vulnerable to disease exposure.

Limited access to water led to multiple health risks, negatively impacting food security. Zinzi Mgwigwi was employed at a soup kitchen in Dunoon during the pandemic, supporting vulnerable households that were unable to feed their families.

Now as we are running the soup kitchen, sometimes we are preparing to cook food, but there is no water to cook with. This is a challenge as people are hungry. (Zinzi Mgwigwi, Dunoon, September 2020)

She raised concerns about sanitation during the COVID-19 outbreak, which placed community members at heightened risk of transmitting the virus. Insufficient water in the community made it very difficult for people arriving at the soup kitchen to adhere to the necessary protocol of hand washing. As people did not have household water access or sanitisers, and communal water was frequently interrupted, a bucket had to be provided for families to wash their hands before entering to collect food. Zinzi Mgwigwi mentioned that very often she was unable to wash her hands or bathe at home during the COVID-19 pandemic due to water scarcity. She suggested that the majority of community members in Dunoon were not aware that the water was about to be suspended and were unable to prepare or store water. This then impaired their efforts to prevent COVID-19 infection through good hygiene practices.

It becomes difficult for us to be hygienic at the soup kitchen. People still need to eat, and you can't chase them away and say you must leave because there is no water to wash your hands. (Zinzi Mgwigwi, Dunoon, September 2020)

Others, according to Zinzi Mgwigwi, were not aware of the importance of handwashing. She advised that it was also not realistic to expect people to have the financial capital to buy hand sanitiser or soap when such a high proportion of the community's residents were unemployed.

When they go on national TV and say 'wash your hands, buy sanitisers'. For them, it is easy because they can afford to do that. Here, some people can't afford to buy hand sanitisers, let alone a mask. (Zinzi Mgwigwi, Dunoon, September 2020)

Ann October recommended that the City of Cape Town increase water provision to low-income areas of the city as many health concerns had a direct relationship with water scarcity.

4.2.2.5. Compound risks and informal housing during the COVID-19 pandemic

Climate hazards interacted with the COVID-19 pandemic in Dunoon informal settlement when the area was hit by severe flooding in mid-July 2020. Zinzi Mgwigwi said that many families arrived at the soup kitchen after losing their homes and possessions from the flooding amid the peak of the COVID-19 pandemic in the Western Cape. Families were supported by the community soup kitchen and community organisations who provided them with food, clothes, and tents for shelter.

There were long queues at the Dunoon clinic during the flood. Lots of people got infected with COVID-19. (Zinzi Mgwigwi, Dunoon, September 2020)

The flooding was a significant health risk factor for vulnerable families who had lost their homes. According to Zinzi Mgwigwi, people may have become more susceptible to contracting illnesses during this period from prolonged exposure to cold weather and rain.



Figure 9: Flooding in Dunoon, July 2020 (Source, Zinzi Mgwigwi, 2020)

Zinzi Mgwigwi provided figure 9 above, which shows how the July flooding in Dunoon impacted residents of informal settlements during the peak of the COVID-19 crisis.

Other health issues experienced in Dunoon informal settlement were centred around the high risk of community transmission of COVID-19 once people had tested positive. Zinzi Mgwigwi mentioned multiple scenarios where community members received a positive result but were told to return home to quarantine as there was not an available government facility they could access. According to the respondent, the government had not yet completed the construction of a public quarantine centre in the community.

How do you do quarantine in an RDP house (government subsidy house)? There is no way you can do that unless you can afford to extend your house. How do you say someone must go and quarantine themselves in a 10 person household all in one room, one bedroom or one shack? (Zinzi Mgwigwi, Dunoon, September 2020)

As mentioned, the shacks in Dunoon are very cramped, with properties very close to one another. High-density housing made it very difficult to prevent community transmission of COVID-19. According to the same interviewee, in some cases, the virus was contracted by those who went out to work and then came home to stay in cramped living conditions and subsequently passed it on to other family members.

4.3. Section three: Implications for the water sector in light of COVID-19 and prevailing water-related health risks

This section presents results from a document review of the Cape Town Water Strategy. The water strategy was analysed to understand how the City of Cape Town considered the health and climate

dimensions of water at the time of development. The review provided an opportunity to consider whether the scope of the strategy was still broad enough in light of the ongoing water challenges facing low-income communities, particularly during the COVID-19 pandemic.

The strategy refers to health 11 times in the document, compared to sanitation (61 times) and disease (once). Drought and climate were also searched for in the strategy, appearing 61 and 73 times respectively. Improving sanitation services and access to safe water is core to the strategy and is one of five pillars that provide the foundation of the document. Working to enhance the experience of water access in informal settlements is central to this commitment. Importantly, the city acknowledges in the strategy that water service delivery and sanitation services in informal settlements remain a crucial challenge. The Cape Town Water Strategy does not capture the health risks associated with drought, water scarcity or flooding in considerable detail. It also does not refer to the climate-water-health nexus or associated cross-sectoral factors. The water strategy suggests that the drought did not directly impact households' water supply in informal settlements, as water continued to be supplied for free through public taps. This may explain in-part why key stakeholders interviewed did not mention direct negative health effects from the drought.

Reviewing the 11 references to health in the strategy produced a few different results. Firstly, public health protection is named as a 'cumulative socio-political driver' in the strategy but is not discussed further in detail. References to health primarily concern water quality, the safe use of water, and protecting the health of waterways. These non-human-health references were excluded from the analysis as they were outside the scope of the study.

The strategy also mentions health in the section of water quality monitoring. This section of the strategy briefly cites illness and disease in the context of ensuring water quality is adequate to avoid high-risk waterborne pathogens, which may lead to disease in humans. Similarly, the strategy cites water pollution as a critical risk factor for human health and well-being. This reference is situated in the key challenges section and refers to improving stormwater management in informal settlements.

The strategy references waterborne disease as a risk factor in regulating water quality. Still, associated health impacts such as cholera and other waterborne diseases from water scarcity or inadequate access to safe running water are not included. Cape Town is characterised by increasingly variable patterns of rainfall and is susceptible to drought and flooding, all of which are conditions in which waterborne diseases can flourish.

Maintaining clean, shared facilities is another significant challenge. Improving sanitation, therefore, is a much higher priority than water supply and other services in informal settlements. (Cape Town Water Strategy, 2019)

The water strategy is a high-level document that outlines the approach to water and the key priorities of the City of Cape Town; it does not include a detailed action plan. Nevertheless, scrutiny of the strategy highlighted the lack of focus on health impacts directly associated with water. This lack of connection exposes the need to break down silos and view the water strategy with a broader transdisciplinary perspective. This positioning is critical when coupled with the compound risks arising from COVID-19. The insufficient focus on health-related issues in the strategy is a concern, as the strategy's principles directly guide the subsequent implementation approach.

This chapter of the thesis has outlined the key results of this study. The chapter below provides a synthesis and discussion of the results in the context of the existing literature.

5. Discussion

The first objective of this study assessed multidimensional health threats in Cape Town as a result of drought and water stress, using the climate-water-health nexus. This question was addressed through an analysis of the community resilience project data and the Drought Learning library dataset. Multiple different health risks were identified, with inadequate sanitation and wastewater exposure the leading concern for low-income households. With relation to the nexus framing, the study's findings show clear and direct interactions between health risks and water stress. For example, the SenseMaker dataset highlighted multiple examples of a relationship between exposure to wastewater and increased incidence of diarrheal infections in children. Some evidence exposed the impact of the climate-driven drought on mental health, while the findings largely point to climate change as exacerbating water stress.

The second objective explored the compound influence of COVID-19 on health and water, solely focusing on data collected from low-income suburbs of Cape Town. This question was addressed through analysis of the COVID-19 informal settlement service delivery data and three semi-structured interviews with residents in Mitchells Plain and Dunoon informal settlement. The findings suggest that the COVID-19 crisis was an additional stressor for low-income households, which served to amplify their pre-existing health and water issues. Key health risks during the pandemic included heightened physical and psychological health burden as a result of mounting food insecurity, poverty, and inadequate access to clean water.

The third objective focused on the Cape Town water sector and reflected on key water implications in light of the drought and COVID-19 pandemic. This question was addressed through analysis of the Cape Town Water Strategy. Findings suggest that decision-makers in Cape Town may benefit from exploring opportunities to integrate policy and practice to reflect cross-sectoral issues such as climate-driven water impacts on health and wellbeing. Specific insights include moving away from a traditionally sector-specific, siloed approach, towards a more integrated strategy approach that reflects the importance of the climate-water-health nexus. Such an approach could be used to complement the existing sector-specific strategies such as the Cape Town Water Strategy.

The study has addressed all the research questions and generated contemporary, relevant learning, which can be employed ahead of future health and climatic crises. This study has contributed to the evidence base on the relationship between climate-induced water shocks and stressors, and health risks in the South African context. The research has focused on threats to human health in Cape Town over a temporal scale, using datasets from the Cape Town drought through to the COVID-19 pandemic.

The sequential approach has provided valuable insights into the associated health burden related to the drought, as well as compound risks low-income households faced during the COVID-19 pandemic. Understanding some of the key health risk factors during differing times of crisis provide useful qualitative insights into gaps that could be addressed through cross-sectoral collaboration at the intersection of the climate-water-health nexus.

The findings are particularly pertinent to the water sector, as the results expose critical gaps in the recently published water strategy. For example, health impacts from water scarcity or inadequate access to safe running water are not referenced in the strategy. This study offers some practical implications and reflections in light of the water-related health challenges which still prevail in the city, such as the need to move away from a siloed approach to understand multidimensional concerns.

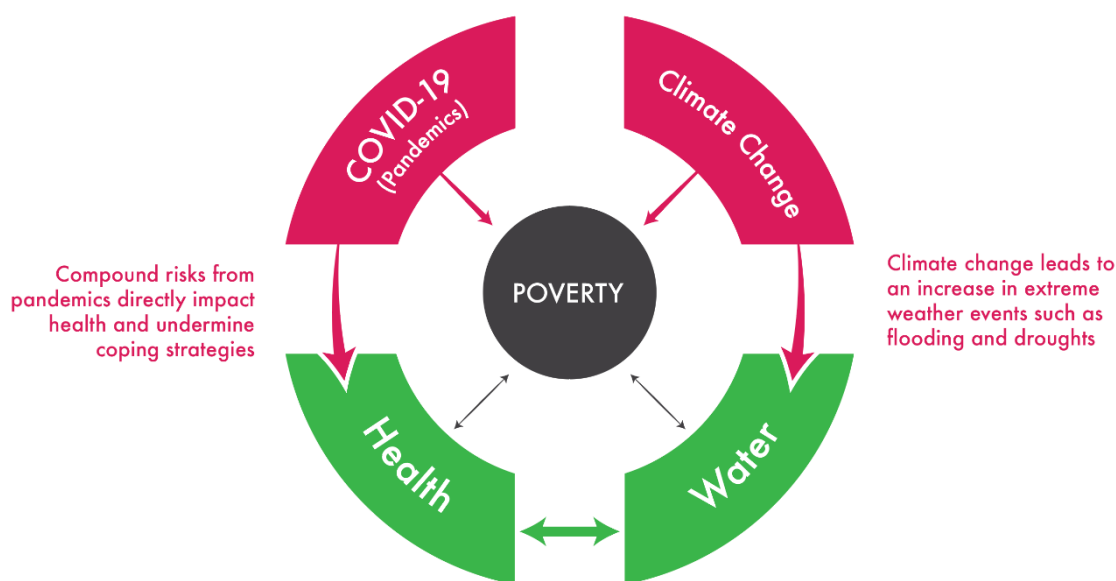


Figure 12: A diagrammatic representation of the interactions between prominent risk factors for health and water (Source: Authors own)

Figure 12 introduces a diagrammatic representation of this study's relevant findings, which will be elaborated upon hereafter. The findings of this study suggest that the interactions between climate change, water and health in the initial nexus conceptualisation, as three directly interlinked nodes, could be reconsidered. While there is extensive available literature supporting these relationships, in this study, the direct impacts of climate change on health did not emerge very significantly. This could be in part due to the types of datasets sampled. The study found some interactions between the two nodes of climate and health in the nexus, specifically the impact of the drought on psychological distress, as explored in the Drought Learning library dataset. However, the direct impact of the drought on the health of low-income groups surveyed in this study appeared to be a secondary concern.

In the study site, climate change contributed to health risks through water-related extreme weather events and water stress. However, there is an important attribution gap as not all water-related health risks in this study were climate-driven. Several health threats raised by low-income groups were concerning water scarcity due to service delivery challenges, inadequate sanitation, or other environmental mediators. For this reason, a clear causal chain between climate change and health is not included in figure 12, due to challenges around attribution and causality. Instead, the findings suggest that the joint pressures of climate change and COVID-19 emerged as key stressors on health and water, as represented in figure 12, with service delivery challenges and poverty significantly increasing vulnerability.

The sets of arrows in figure 12 each represent different findings from the study. The wider pink arrows represent direct causality. On the left of figure 12, COVID-19 contributes to health risks and poor health outcomes through multiple pathways. Causal pathways identified in this study include transmission of the virus and the associated mental health burden of fear of exposure to the virus. The results suggest that mental health implications were of particular concern for low-income households with multiple comorbidities such as HIV/AIDS and tuberculosis. COVID-19 also indirectly impacted health through lockdown-related unemployment, subsequently leading to food insecurity and psychological distress.

Overall, the pandemic has undermined resilience efforts and impeded the ability of households to manage increased stressors.

On the right of figure 12, there is a direct causal chain between climate change and water, as a result of extreme weather events and water stress. Indeed, the availability of water resources and water quality are negatively impacted by climate change (Yu, 2016). Water insecurity is a cross-cutting issue that intersects with other poverty-driven concerns in resource-constrained contexts. Inadequate access to clean water and poverty are mutually reinforcing, as are water insecurity, urban poverty and poor health outcomes (Adams, Stoler and Adams, 2020). Extreme climatic weather events such as flooding (which impacted low-income households during the COVID-19 pandemic) highlight how climate change affects vulnerable groups' health and well-being and reduces their coping capacity.

The wide green arrow between health and water represent the direct interactions between these nodes. Water and health emerged from the data as two closely interrelated variables in the nexus. Health and water are inextricably linked, with water a vital resource in maintaining human health, particularly during a global pandemic such as COVID-19. In line with this study's findings, existing evidence suggests that water insecurity negatively impacts mental health, particularly self-reported anxiety and depression (Workman and Ureksoy, 2017). Importantly, water insecurity does not occur in isolation from other stressors such as climate change, food insecurity and inadequate housing (Roy et al., 2016). The existing evidence for these interactions, as explored by Workman and Ureksoy, (2017), bolsters the validity and relevance of the climate-water-health nexus approach used in this study.

Both the inward-facing pink arrows portray the indirect pathways through which COVID-19 and climate change may exacerbate poverty. While evidence on the influence of COVID-19 on poverty is only now beginning to emerge, significant literature supports the negative impact of climate change on poverty (Hallegatte, and Rozenberg, 2017; Hallegatte, Fay, and Barbier, 2018; Angelsen, and Dokken, 2018). Climate change impacts will be highly heterogeneous, disproportionately impacting low-income groups with low adaptive capacity. The findings of this study offer contemporary evidence on the probable impact of the COVID-19 pandemic on poverty, in the context of Cape Town, South Africa. Increased poverty has likely led to households being unable to pay for soap or hand sanitiser, potentially increasing health inequalities, disease risk, and exposure to COVID-19 infection.

Throughout this study, poverty emerged as an important mediating factor that negatively impacts the nexus variables. This is displayed in figure 12 through the black arrows. These arrows highlight the interactions between health and poverty, and water and poverty, understanding these variables to be inextricably linked and negatively reinforcing. As explored in this study, causal pathways include poverty and informality leading to inadequate sanitation and exposure to wastewater, thus resulting in exposure to water-borne disease.

In figure 12, COVID-19 is depicted as an external pressure on health and poverty. In the climate-water-health nexus framing, pandemics can be incorporated under the umbrella of health as periodic health threats.

The findings from this thesis are consistent with the climate change and health framework used, as amended from Godsmark et al., (2019). The results expose risk factors such as increased drought and rainfall, water quality and availability, and physical infrastructure, as contributors to multiple health impacts, with vulnerable populations disproportionately affected. Another contribution from this study is the concrete connections identified between the different interrelated parts that make up the study's focus, particularly highlighting in practice how water, climate change and COVID-19 interact through physical and mental health outcomes in the Cape Town context.

COVID-19 is a novel virus that poses significant physical and mental health risks through multiple pathways. Amid an evolving, volatile crisis, this thesis has exposed health risks related to inadequate water service provision and climate-induced shocks, such as drought and flooding. Such challenges must be addressed to preserve human health both in the current crisis and in preparation for future pandemics. As highlighted by Phillips et al., (2020), the compound risks caused by climatic hazards during the COVID-19 crisis have laid bare multiple pre-existing health risks and service delivery inadequacies that must be addressed as a matter of urgency.

Findings from this research suggest that increased vulnerability from health co-morbidities, gender, and disability may negatively impact access to water and health services in areas characterised by high levels of informality. Specific examples include fear of gender-based violence from using communal toilets, concerns of people with tuberculosis and HIV unable to access health services during COVID-19, and disproportionately high levels of perceived psychological stress in women and disabled groups. While not accounting for external variables, these issues may be an initial indication of a link between multi-dimensional vulnerability in low-income households, and water and health access. This is a particular concern, especially during periods of crisis. Approaches on how to bolster the resilience of vulnerable groups ahead of future health emergencies requires further exploration, yet the use of a nexus approach may help to understand interactions and negatively reinforcing variables.

Findings from this study contribute to the research gap identified by Wolbring and Leopatra (2012), who suggest that there is a gap in understanding how people with disabilities are impacted by climate change, and water and sanitation insecurity. Evidence from Birch et al., (2012) suggests that inadequate access to clean water and sanitation poses serious health risks to women, particularly during pregnancy and menstruation, when additional hygiene practices are required. Findings from Birch et al., (2012) are particularly worrying in the context of this study, where women already face multiple barriers to safe water access in low-income suburbs of Cape Town. The next section of the discussion will focus on the first research question and discuss the significance of the health risks experienced during and after the drought.

5.1. Section one: Water-associated health risks during and after the Cape Town drought

Results from this section of the research suggest that inadequate sanitation and exposure to wastewater directly correlate with physical and psychological health risks, particularly for households in low-income parts of Cape Town. This finding highlights a clear interaction between health and water in the nexus conceptualisation. There is a significant disparity between the issues raised by respondents of the Drought Learning initiative and the SenseMaker participants. This was anticipated due to the variance in target groups and divergence of topics. Evidence from this study suggests that informality, inadequate access to sanitation services, water scarcity, and poverty are critical factors linked to poor health outcomes. Findings from this section of the study are consistent with research by Lwasa (2010), which focuses on the nexus of urban poverty and climate-induced stressors. According to Lwasa (2010), it is crucial to understand housing conditions and neighbourhood environmental contexts when framing climate vulnerability, as these factors affect how households can adapt to shocks and hazards. As explained by Reckien et al. (2017), urban areas house diverse populations with differing vulnerabilities to climatic hazards, such as water shocks and stressors. How different groups are affected by such stressors is highly dependent on individual, social and economic factors.

The majority of the SenseMaker stories did not provide a granular account of their health issues, which made it difficult to assess whether compounding factors such as pre-existing health conditions impeded their ability to address other water-related problems. However, it is clear that water scarcity and a lack of access to safe drinking water significantly hampered the ability of individuals with underlying health issues to manage their chronic conditions.

Respondents in low-income areas of the city provided examples of direct health impacts arising from inadequate sanitation and wastewater exposure. In contrast, Drought Learning respondents, (predominately from a more affluent sample), primarily discussed physical health risk factors that could arise under a Day Zero scenario. Many of the Drought Learning library participants were key decision-makers, with in-depth involvement in shaping the City of Cape Town's response to the water crisis. However, they did not have the same insights into water issues on the ground that were characteristic of the SenseMaker sample.

It is noteworthy that over half of the total Drought Learning library sample raised physical or psychological health risk factors resulting from the drought during their interviews, showing an otherwise secondary interaction between climate change and health in the nexus framing. According to some Drought Learning library participants, attempting to cope with, and address the Cape Town drought and water crisis, had a significant impact on the mental health of local government staff and non-state actors directly involved in the response.

According to Berry, Bowen and Kjellstrom (2010), climate change will adversely affect mental health through different pathways. The first pathway is through increased natural disasters affecting human settlements, which often trigger an initial anxiety-related response, followed by more significant longer-term mental health issues. Perspectives from Drought Learning library respondents suggested that anxiety and panic were widespread in Cape Town after the communications around Day Zero. Secondly, climate change may negatively impact physical health through disease, injury, heat stress and food insecurity, further impacting mental health outcomes (Berry, Bowen and Kjellstrom, 2010). The second pathway identified by Berry, Bowen and Kjellstrom, (2010), aligns with the findings from the SenseMaker dataset. Results from the data indicate that water stress leads to poor health outcomes directly through water-borne disease and indirectly through food insecurity. These challenges disproportionately impact low-income households and are further exacerbated by climate-driven extreme weather events such as flooding and droughts. Findings from this study suggest that water scarcity and reliance on communal water and sanitation facilities are additional pathways that contribute to psychological distress, particularly for women and people with disabilities. As explored in figure 12, (pg. 46), poverty significantly compounds water and health issues and is exacerbated by climate change.

The SenseMaker data results show that women's stories were more likely to include elements of psychological stress than men's. Men might not feel comfortable to disclose personal stories about their mental health, especially to a majority female group of community researchers. Nevertheless, this should not detract from the important gender dimension and the heightened vulnerability of women in low-income communities. As highlighted in earlier sections of this study, women face an increased risk of sexual and gender-based violence from reliance on communal toilets and sanitation services (Sommer et al., 2015). This finding is plausible considering the exceptionally high levels of sexual and gender-based violence in South Africa (Mosavel, Ahmed and Simon, 2012).

WCWC members collected stories shortly after the Cape Town drought and water crisis, which was characterised by increased collective stress and trauma levels. Furthermore, women in South Africa are more commonly responsible for household duties and caring for children and other family members (Helman and Ratele, 2016). Therefore, women are more likely to have heightened exposure to water-

related problems such as unavailability of water to cook and to clean, thus compounding multiple household responsibilities and leading to increased psychological stress.

Another key finding from the SenseMaker dataset was the potential connection between residents who suffered from psychological stress and those who reported having a disability. Just under half of the participants who cited suffering from psychological stress also had a disability. This preliminary finding suggests that living with a disability may contribute to increased anxiety for those living in informal settlements when faced with inadequate physical access to in-part water and sanitation services. However, this result must be interpreted circumspectly for claiming interactions as the surprisingly high disability figures may be attributable to a measuring issue during data collection, such as sampling bias or an unclear definition of disability. Nevertheless, the gender and disability findings from this section of the study appear to support findings by Reckien et al., (2017) who suggest that women and people with disabilities are on average, more vulnerable to the impacts of climate change than men, particularly those who reside in informal settlements.

This section's findings interestingly suggest that the Cape Town drought and water crisis were not the predominant concerns of low-income households. Residents in low-income suburbs were instead faced with numerous other water issues which affected their daily health and wellbeing. Critical external factors influencing health outcomes include inadequate housing and physical infrastructure, exposure to wastewater effluent, and prolonged periods of water scarcity as a result of service delivery shortfalls.

Low-income households were faced with multiple water-related health risks before, during, and after the Cape Town drought. Water scarcity was a pre-existing problem before the drought, which continued to impact low-income households throughout the COVID-19 pandemic. For example, water scarcity was cited as a prevalent barrier to toilet flushing, maintaining personal hygiene, and keeping chronic medication schedules on track. Low-income households in most cases made no reference to the drought as the cause of their water scarcity.

This research has explored the link between flooding and physical and mental health outcomes. Findings by Fernandez et al., (2015) suggest flooding harms mental health, yet there are limited studies that consider confounding controls. This thesis contributes to this evidence base with anecdotal evidence suggesting that flooding can negatively impact mental health and increase the disease burden in low-income settings of Cape Town, South Africa. Findings from this study also raise multiple issues around the linkages between flooding and poor physical health outcomes in low-income settings due to water-borne disease. This study exposes the heightened risk of diarrhoeal infections and water-borne disease from heavy rainfall events and flooding, which agrees with findings by Hashizume et al., (2008). The study looked at vulnerability to diarrhoeal disease after a flood event in Dhaka, Bangladesh. Findings from Hashizume et al., (2008) suggest that low socio-economic groups were the most vulnerable to flood-related diarrhoeal disease.

This next section of this study discusses water-associated health risks that affected low-income residents during the COVID-19 pandemic in South Africa.

5.2. Section two: Water-associated health risks during the COVID-19 pandemic

Data from Asivikelane and key informant interviews suggest that inadequate water access has been a significant issue for low-income households in Cape Town during the COVID-19 pandemic,

highlighting a clear link between the pandemic and water and health variables in the nexus. This is a particularly concerning finding given the need for enhanced handwashing as a means to help curb virus transmission.

Between 14% and 32% of residents struggled to access adequate water supply in Cape Town's informal settlements between March 2020 and August 2020. It is difficult to know if water access levels varied prior to the pandemic. The fact that several neighbourhoods included in this study also became COVID-19 hotspots (Mitchells Plain, Khayelitsha) might be the unfortunate outcome of inadequate water services – although the exact paths of infection are unknown and beyond the scope of this thesis.

The reliance on communal water sources also posed a critical health risk for COVID-19 transmission. Users were required to queue for water in public which made it challenging to adhere to spatial distancing (Wilkinson, 2020). Public health recommendations such as regular hand washing, self-isolation, and physical distancing are not feasible for many low-income households in Cape Town. As described by Wilkinson (2020), public health measures recommended to curb COVID-19 transmission assume easy access to essential services such as clean water and physical space.

This study highlights the challenges of trying to manage compound risks of climate variability, food insecurity, economic hardship, flooding, inadequate water and sanitation, and a pandemic. Compound risks from climatic hazards exacerbate health inequalities and undermine coping mechanisms, making it more difficult for low-income households to manage extreme health events, such as pandemics (Zavaleta-Cortilo et al., 2020; Phillips et al., 2020). An example of compound risks observed in this study is the flooding in Dunoon informal settlement which coincided with the peak of the COVID-19 pandemic. The cross-sectoral approach provides a key opportunity to push for protective policies which do not expose low-income households to a plethora of climate and water-related health risks.

The example of flooding in Philippi highlights the difficulty for low-income households to manage multiple risks to health when they have limited resources and capital at their disposal. During the COVID-19 outbreak, wastewater effluent entered the homes of Philippi residents, affecting both their physical and mental health.

The inability of low-income residents to 'shelter in place' in densely populated informal settlements heightens the risk of contracting COVID-19. This threatens vulnerable populations with pre-existing health conditions in particular. As the COVID-19 crisis and national lockdown have highlighted, violent crimes against women and children appear to be more prevalent in times of crisis or heightened stress (Joska et al., 2020). Before COVID-19, the South African population was already facing serial collective trauma and complex post-traumatic stress disorder from constant shocks and stressors (Naidu, 2020). This pre-existing level of psychological stress is vital to note in the context of this study. Mental health was a predominant issue for many households before the additional hazards posed by water scarcity, flooding, sanitation problems, and COVID-19.

The heightened vulnerability of women living with HIV in South Africa during the COVID-19 pandemic, (as mentioned by interviewed participants), is consistent with research by Joska et al., (2020). Their study raises concerns around deteriorating mental health and negative impacts on access to healthcare for those with chronic conditions during the pandemic. According to Wilkinson (2020), there is a dearth of literature that focuses on the disease burden from COVID-19 co-morbidities such as hypertension, diabetes, HIV/AIDS, malnutrition and tuberculosis in informal or low-income contexts. This thesis has offered anecdotal evidence from low-income households in Cape Town which suggest that co-morbidities such as HIV/AIDS are a significant barrier to healthcare access during the pandemic.

All three interview informants cited food insecurity during the COVID-19 pandemic as a critical concern. Household food security is a pervasive health challenge in the country, with 21.3% of South Africa's population facing food insecurity in 2017 (Statistics South Africa, 2017b; Tomita et al., 2019). The major shock caused by COVID-19 and the subsequent lockdown and public health policies designed to curtail the pandemic led to many low-income households losing employment. This correlated with a subsequent rise in food-insecure households in South Africa, particularly affecting those that did not benefit from social protection mechanisms (Arndt et al., 2020). The significant dependence of low-income households on community soup kitchens during COVID-19, (as outlined by the three key informants), adds weight to this argument. According to the study by Tomita et al., (2019), food insecurity can also have a significant impact on mental health, with depression or depressive symptoms linked to household food insecurity.

As raised in the Asivikelane data, the health challenges of low-income households are exacerbated when residents lack clean water and access to soap or hand sanitiser. This study challenges the government's assumption that households have the financial capital to purchase soap or hand sanitiser, with many residents citing unemployment as a barrier to the affordability of sanitation products.

Residents of informal settlements in resource-constrained contexts are inadequately prepared to cope with the challenges posed by COVID-19 as their health, water and infrastructure basic needs are already unmet or in short supply (Corburn et al., 2020). This thesis suggests that a reliance on unclean communal sanitation facilities during the COVID-19 outbreak may have contributed to the upward trajectory of the virus in areas characterised by high levels of informality and inadequate sanitation. Evidence suggests that shared toilets pose a general disease risk, mainly when excreta is not adequately managed. Sanitation concerns and inadequate waste disposal also pose biohazard risks, including potential COVID-19 transmission (Wilkinson, 2020). While there is not yet strong evidence of faecal transmission of COVID-19, shared toilets and sanitation facilities pose a transmission risk as residents need to queue up in densely populated areas. This risk is heightened if toilets are not cleaned properly between service users (Wilkinson, 2020; Gibson and Rush, 2020). Findings by Gibson and Rush are consistent with a Gauteng-based study by de Katd et al., (2020), which consider shared use of water and toilet facilities as key COVID-19 risk factors. Further hazards arise when people who are required to self-isolate are reliant on communal water and toilets (Wilkinson, 2020).

Key informants raised concerns around the increased rates of gender-based violence during the peak of the COVID-19 crisis. Respondents interviewed in Mitchells Plain echo findings by Joska et al., (2020), who show that the national lockdown in South Africa correlated with a surge in domestic and gender-based violence. In the first week of lockdown in South Africa, there were 87,000 cases of inter-personal and domestic violence reported, linked in part to increased stress and confinement (Joska et al., 2020). As highlighted in the first section of this chapter, household trauma and collective trauma are already key concerns in South Africa. Negative mental health impacts from COVID-19, food insecurity, and psychological stress from the risk of domestic violence, further compound pre-existing health and water issues for low-income residents in Cape Town. Addressing the multiple risks to physical and mental health is increasingly important, with water concerns related to water scarcity, flooding and droughts projected to increase in incidence as a result of climate change (Baldwin-Ragaven, 2020; Godsmark, 2019).

It is vital to reflect on the social determinants of health, particularly multi-dimensional poverty, and use this lens to frame the health and climate-induced water impacts that face low-income households in Cape Town. Socioeconomic inequalities from variances in education, water and sanitation, housing, and employment contribute to the burden of ill-health facing poorer populations (Umuhoza and

Ataguba, 2018). In Cape Town, the social determinants of health are stark. The data from this study shows a large disparity between the health issues raised by SenseMaker respondents who reside in low-income areas and responses on the water crisis by participants interviewed as part of the Drought Learning initiative. The social determinants of health have affected how different populations have managed the COVID-19 crisis in Cape Town. The multi-dimensional challenges facing low-income households in Cape Town underscore the need to tackle health, climate change, and water issues simultaneously, through the integration of policies and practices at the climate-water-health nexus.

The findings from this study and others examining the COVID-19 pandemic are relevant not just to COVID-19 but also to future health and climatic crises. This research's findings help build the evidence base on some of the challenges, risk factors, and vulnerabilities facing residents of informal settlements during the COVID-19 crisis. As COVID-19 is a novel virus and there has been limited time for scholars to conduct in-depth research, this research contributes in part to this gap. The study responds to the call from Corburn et al. (2020), for multidisciplinary research to understand how vulnerable groups are coping during the COVID-19 pandemic. Moreover, it echoes calls for integrated policy and practice initiatives, focusing on tackling COVID-19 and the negative health impacts of climate change concurrently (Salas, Shultz and Solomon, 2020; Herrero and Thornton, 2020).

Specifically, this study's findings indicate that the City of Cape Town may benefit from exploring possibilities to complement the water strategy with a wider cross-sectoral policy that considers the climate-driven impact of water stressors on human health. This approach may be particularly valuable ahead of future health and climatic emergencies. A city-level climate change and health adaptation strategy is one relevant example of what an umbrella strategy could include.

Such an adaptation strategy could encompass pandemic preparedness at the local level, to enhance mechanisms to protect vulnerable groups ahead of the next global health crisis. Action research that focuses on the current coping mechanisms and adaptive capacity of low-income households in Cape Town to the health impacts of climate change could serve as a foundation for the development of such an integrated strategy.

The next section of this thesis discusses the findings from the review of the water strategy, in light of the challenges discussed in the previous sections.

5.3. Implications for the water sector in light of COVID-19 and prevailing water-related health risks

Scrutiny of the water strategy exposed the lack of focus on health impacts caused by, or directly associated with, water scarcity, flooding, and drought. This study suggests that the City of Cape Town could view the core pillars of the water strategy through a broader lens in light of the current public health crisis, and frame the issues within the climate-water-health nexus. The results of this research, and the reality of what the COVID-19 pandemic has brought to light, has shown the interrelated issues of water, health and climate change, and the direct pathways through which water scarcity can lead to disease transmission and psychological ill-health.

The current global health crisis offers an opportunity to reflect on the prevailing water issues facing low-income communities in Cape Town and adopt approaches that bolster resilience and increase adaptive capacity. Revising the water strategy pillars to reflect the importance of access to clean water and adequate sanitation for maintaining human health would be highly beneficial.

The water strategy has focused on the importance of engaging low-income households through the improvement of water and sanitation provision for people residing in informal settlements, as well as the use of free basic water access and subsidies to poor households. Extending this to think about the intersectoral water issues in these areas such as links to health would be important. Particular attention needs to be paid to the needs of low-income households and vulnerable groups.

The City of Cape Town's commitment to adopt a cross-sectoral, collaborative approach to addressing complex challenges is apparent from the development of the Cape Town Resilience Strategy. This commitment suggests that there may be opportunities to apply a cross-sectoral lens to the water strategy (City of Cape Town, 2019a). As laid out in the resilience strategy, the city aspires to be a resilient hub. Core to this aspiration is an increased understanding of the interdependencies between multiple shocks and stressors in the city. Longer-term, the City of Cape Town could complement the water strategy by developing a city-wide climate change and health adaptation strategy. A broader strategy using a system-wide approach should explicitly consider health, climate change, and water as interconnected issues rather than isolated challenges. While a climate change and health adaptation strategy exists at the national level in South Africa, an equivalent approach at the municipal or provincial level is lacking (Department of Health, 2014; Godsmark et al., 2019).

According to the water strategy implementation and monitoring framework, the water strategy is reviewed regularly under the Water Services Development Plan annual review procedure (City of Cape Town, 2019b). The next review cycle would be an opportune time to consider potential amendments in light of the COVID-19 pandemic. The current health crisis has exposed the stark reality of water scarcity and inadequate sanitation provision for low-income households in the city and the associated burden of disease.

It is critical for water issues to be addressed through cross-sectoral approaches to mitigate against further health and climate-sensitive crises which will likely arise in the future. Implementation of the water strategy should be monitored closely through the three implementation plans to ensure the core goals set out in the strategy are realised on the ground. However, as experienced during this research process, the fractured implementation approach may make it difficult to monitor progress against the vision of the strategy, particularly for non-state actors. As raised by Enwereji and Uwizeyimana (2019), robust implementation of the water strategy may be unrealistic regardless of the channels used. As a minimum standard, it would be beneficial for all the implementation plans for the water strategy to be published in the public domain. A clear breakdown of lines of responsibility for each implementation approach would provide more space for public scrutiny and feedback. From the information available publicly, it is currently unclear whether sufficient funds have been allocated for the implementation of the strategy.

As summarised by Phillips et al., (2020), further interdisciplinary, cross-sectoral solutions are required to respond to future global health and climatic threats in South Africa. The water strategy should not be an exception. Moreover, the COVID-19 crisis offers an opportunity to remind governments and water authorities of the imperative to improve clean water access to vulnerable populations (Anim and Ofori-Asenso, 2020).

The analysis used in this section of the study was limited by the inability to scrutinise the water strategy's implementation channels. As mentioned, there is no information on the timelines to develop the Cape Town Water Transition Plan and the Collaborative Resilience Action Plan, or indeed a clear indication of when the Water Services Development Plan will be updated and publicly available. It is unclear whether these documents already exist and are just unavailable in the public domain. It was beyond the scope of this research to attempt to access these implementation plans through other channels and

conduct further analysis. The document review of the water strategy was instead used as a proxy to understand how health and climatic risk factors are reflected by the City of Cape Town.

5.4 Opportunities for further research

Further research which explores the health impacts of water shocks and stressors in South Africa and assesses the adaptive capacity and coping methods in low-income households, would be particularly beneficial. This study has contributed initial findings which confirm there is an important relationship between poor water services, water scarcity, flooding, droughts, and adverse health outcomes in the Cape Town context, yet key gaps in understanding remain. This study did not explore the adaptive capacity and coping methods that low-income households adopt to mitigate against the negative health effects of climate-induced flooding, droughts, and water scarcity. Without an in-depth understanding of possible adaptation options for low-income households in South Africa, the most vulnerable groups will continue to be disproportionately affected by the impacts of climate change (Paz et al., 2016). For future studies, including poverty in a nexus approach could help to enhance understanding of additional causality and interdependencies between variables.

Further research in low-income settings (using a larger sample size), should apply a vulnerability risk lens. Key indicators should include pre-existing co-morbidities, gender, age and disability, to explore the correlation between disparities in water and health access, (a topic that has been initially explored in this study). The utility of the climate-water-health nexus would be a relevant conceptual framing for such a study. Further research could increase understanding of the barriers for vulnerable groups, and the extent to which these variables impede water access and affect health outcomes.

Moreover, further research in understanding how vulnerable groups, particularly women, older people, and people with disabilities, are impacted by climate change, and water and sanitation insecurity simultaneously, would be valuable. This is particularly valid as the impacts of climate change grow, and climate change risks widen gender-based health disparities (Sorensen et al., 2018). To build on the findings from this study, Cape Town could be a relevant study site to conduct further research. Focusing on a municipal level has merit as adaptation policy and practice at the city level can significantly reduce the vulnerability of low-income groups (Hunt and Watkiss, 2011).

5.5 Limitations

There are several limitations to this study. Firstly, in the research design, the data collection plans were significantly affected by the COVID-19 outbreak. The public health pandemic made it challenging to triangulate and validate sources from the SenseMaker dataset and other secondary sources with in-person interviews and focus group discussions. However, this initial barrier enabled the researcher to take a more creative approach and utilise several relevant secondary datasets and benefit from using larger, pre-existing data sets.

Secondly, the secondary datasets used (SenseMaker, Asivikelane, and Drought Learning library) were not designed to explicitly document health risks, and as such, the data did not focus on health specifically. Another key limitation is that the target groups interviewed were very disparate. One dataset focused on decision-makers and their response to the drought and water crisis, while other datasets were low-income households and their personal experiences of water-related challenges. This difference made it challenging to find synergies and compare the findings.

The absence of specific health data was both a limiting and advantageous factor. It was limiting because examples of health concerns relating to water were often not detailed and informants rarely provided a granular account of the health issue they faced. It was, therefore, more challenging to explore correlations and patterns in the data. The advantage of the approach was that it minimised researcher bias. Participants raised health issues related to water scarcity, drought, and flooding without prompt, which suggests that they are primary concerns of the respondents and bolster this research's validity.

Another limitation of the study is the small sample size of some of the data sets, particularly the interviews. They did, however, provide a useful snapshot of water-related health issues facing low-income households across multiple suburbs in Cape Town and the complications of compound risks during the COVID-19 crisis. It was beyond the scope and timeline of this study, (and unfeasible during the COVID-19 outbreak), to undertake a more comprehensive primary research project with a representative sample. That being said, the preliminary findings of this study provide a basis from which larger-scale projects can be undertaken.

5.6. Final synthesis of findings

COVID-19 has significantly impacted low-income households in Cape Town through multiple direct and indirect pathways. The findings from this study and other recent research should serve as a catalyst for the City of Cape Town to reflect on the sectoral water implementation channels, break down silos, and broaden their approach to encompass risks at the climate-water-health nexus.

Amin and Ofori-Asenso (2020) call for strengthening policy, regulatory and institutional frameworks, in response to COVID-19. Such reforms in policy should include a shift towards a more holistic and inclusive concept of water security. Furthermore, the pandemic has highlighted the stark realities facing low-income communities across sub-Saharan Africa and the importance of improving access to clean water for vulnerable populations. Improving water access in low-income contexts should be considered a key priority, with climate change expected to increase water scarcity and drought risk in sub-Saharan Africa. (Amin and Ofori-Asenso, 2020).

A study by Godsmark et al., (2019) which focused on the Western Cape, found that the intersection of health and climate change at the sub-national level is often under-represented in strategies. Research by Ziervogel et al. (2014), found that inter-sectoral perspectives on health and climate change are lacking. The links between climate change, food security, health and nutrition are also poorly understood in the context of South Africa (Ziervogel et al. 2014). While this thesis has only referenced food security in the context of COVID-19 and related-economic hardship, both are acknowledged as indirect health risk factors linked to climate change (Godsmark et al., 2019).

Findings by Bowen and Ebi (2015) suggest that it is critical to apply a multi-sectoral, systems-based approach to addressing the health risks of climate change. The approach must be centred around strong collaboration and coordination. Responding to health issues through a fragmented, siloed approach does not consider the multiple pathways where climate change and health intersect. This thesis acknowledges that operationalising a multi-sectoral approach would likely be challenging, particularly without strong governance structures in place. Indeed, findings from Pasquini, Cowling and Ziervogel (2013) highlighted that the Western Cape government faced individual, institutional and socio-cultural challenges in attempting to implement a sub-national climate change adaptation strategy.

6. Conclusion

This study uses the climate-water-health nexus as a lens to explore water-related health risks across a temporal scale from multiple vantage points. It considers how the COVID-19 crisis and mounting pressure from climate change have compounded pre-existing health and water issues for low-income households in Cape Town. In addition, the research outlines key considerations for the Cape Town water sector, which take into account the volatile and evolving public health pandemic and findings from the drought and water crisis.

This thesis utilises the nexus conceptual framework to contribute to an emerging evidence base on the interactions between health, water, and climate change in the context of Cape Town, South Africa. The study findings offer a broader conceptualisation of the pre-conceived nexus framework. The study findings do not draw out significant evidence on the direct pathways through which climate change impacts health, albeit with limited exceptions. Instead, the research found that the joint pressures of climate change and COVID-19 emerged as key stressors on health and water. In contrast, non-climate-related water scarcity, inadequate sanitation, and water service delivery challenges were frequently cited as direct risk factors for disease and psychological ill-health, suggesting a clearer link between the nexus nodes of health and water.

The study offers a number of relevant contributions. Firstly, the results show that inadequate sanitation and wastewater exposure are key hazards that directly lead to physical and psychological health risks. Secondly, anecdotal evidence suggests there may be a connection between health co-morbidities, gender and disability, and reduced access to clean water and health services. This is particularly apparent in areas characterised by high levels of informality. Thirdly, results from this study suggest that the COVID-19 pandemic has greatly impeded the ability of low-income households to cope with additional stressors. Fourthly, the thesis offers practical reflections which could be actioned by the City of Cape Town to reform policy and practice, following a comprehensive review of the water strategy. Short term considerations include mainstreaming health into the water strategy and adjusting the core pillars to improve water security to low-income groups. Longer-term opportunities include complementing the water strategy with a broader cross-sectoral strategy or policy such as a city-level climate change and health adaptation strategy.

Moreover, the study outlines several opportunities for further research. Some of the results must be interpreted circumspectly for claiming interactions due to the limited sample size, yet key factors to include in future research should consider the importance of social mediators such as poverty.

As this study shows, challenges in accessing clean water and sanitation services in South Africa have been amplified during the COVID-19 crisis. The pandemic has exposed critical gaps in the provision of essential services and drawn attention to the important relationship between climate change, water and health. Crucially, access to water resources is decreasing from the accelerating impacts of climate change across significant parts of sub-Saharan Africa (Armitage and Nellums, 2020). Climate-resilient water resource management strategies are urgently required to respond to the current COVID-19 crisis and in light of the uncertainty around future infectious disease outbreaks (Amin and Ofori-Asenso, 2020). The health crisis that has resulted from COVID-19 offers a key opportunity to review sectoral strategies and assess possibilities for a more integrated climate-centred approach to water and health in Cape Town.

The compound risk of COVID-19 and the real threat of further, prolonged drought and flooding from climate variability mean the City of Cape Town should take a cross-sectoral, collaborative approach to

manage future risks at the climate-water-health nexus. This approach needs to be context-specific and focus on local preventative and adaptive interventions which are reflective of the resource-constrained realities and poverty implications in Cape Town. Indeed, it is critical to gain a clearer understanding of the links between climate change, and health in South Africa as climate policy thus far have primarily overlooked the health sector (Myers and Rother, 2013).

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