FACTORS AFFECTING SUSTAINABLE WATER USE IN SOUTH AFRICA: A CASEOF CAPE TOWN

by

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DECLARATION

I, **YEUKAI MUSARIRI,** because of this, declare that this dissertation, "Factors affecting sustainable water use in South Africa. A case of Cape Town is my unaided work which has not been submitted before for any degree or examination at any other University. It is being submitted in partial fulfilment of the requirements for the master's degree in environmental management. I declare that all sources that are used or quoted have been indicated and acknowledged as complete references.

Student's Signature: Musariri YR…… **Date: 31 January 23**

DEDICATION

Initially, I would like to thank the Almighty God for guiding me in my studies. I want to express special gratitude to my family for their strong support throughout the course.

AKNOWLEDMENTS

I owe a huge appreciation to my academic institution, UNISA, for granting me an opportunity to undertake my studies. Many thanks to the lecturers in the department of Environmental Science, especially supervisor Dr I Kamika. Thank you for guiding and assisting me throughout the compilation of this document. I also want to thank my family for their moral and emotional support throughout my studies. Ultimately, my gratitude goes to God the Almighty for the gift of life, wisdom, and strength to pull through.

ABSTRACT

Cape Town's water shortages continue unabated, with most residents resorting to unsafe water sources. The continuation of the water shortages has reached crisis level, which signals challenges in the provision of clean, potable water in the city and the need for effective strategies to manage the crisis. To this end, the current study sought to establish the factors affecting sustainable water use and the causes of the failure of sustainable water use inCape Town. The study's main aim was to ascertain the factors affecting sustainable water use in Cape Town, South Africa. The philosophy adopted in the study was pragmatism, with deductive research being the preferred approach and a descriptive case study design being used. The study's target population comprised the total number of Cape Town residents and water management officials from the municipality who were sampled through a combination of systematic and typical case purposive sampling. Research instrumentation for the study included 362 semi-structured research questionnaires and 20 key informant interviews. It wasestablished that the most critical factors leading to the water crisis in Cape Town include the failure to invest in water services (mean of 4.36), increased water consumption arising from urbanisation (mean of 4.81) and increasing demand for water from various user sectors like agriculture, mining, and industry (4.91 mean response). The findings also suggest that such climate change-related issues as rainfall variability (mean response of 4.6) and flooding (4.7 means) have negatively contributed to Cape Town's water crisis. The significant challengesin the sustainable use of water in Cape Town were found to include the lack of knowledge onthe importance of water (mean 4.18), cost burdens (4.35 mean), political and administrative bottlenecks (4.09 mean) as well as weak institutional capacities in dealing with the water crisis (mean 4.73). The study also showed that only the use of boreholes (mean 4.22) and water rationing (mean 4.46) are effective coping strategies in managing the crisis. The causes of the water crisis significantly and negatively affected the effectiveness of the coping strategies employed, and there is no significant relationship between the challenges experienced in sustainable water use and the effectiveness of the coping strategies employed in Cape Town, as established by the R2 coefficients of 0.748 and 0.068, respectively. Sustainable water use in Cape Town can be achieved through a multiplicity of strategies which include attending to water networks and pipelines (mean 3.16), using potable water (mean 3.66), fixing the water reticulation systems (mean 2.78) and enhancing accountability in water governance (mean 2.79).

LIST OF ACRONYMS

Acronym	Meaning
COVID-19	Corona Virus Disease
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EU	European Union
GIS	Geographical information systems
GONU	Government of National Unity
IUWM	Integrated Urban Water Management
IWRM	Integrated Water Resource Management
m^3	Cubic metres
Mm	millimetres
PPP	Public-private partnerships
R^2	Regression coefficient
SD	Standard deviation
SDG(s)	Sustainable Development Goals (SDGs)
SPSS	Statistical Package for Social Science
UNDESA	United Nations-Department of Economic and Social Affairs
UNECA	United Nations Economic Commission for Africa
UNEP	United Nations Environmental Programme
UNICEF	United Nations International Children's Emergency Fund
USAID	United States Agency for International Development
WCWSS	Western Cape Water Supply System
WHO	World Health Organisation

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CHAPTER ONE: GENERAL INTRODUCTION

1.1 INTRODUCTION

With increased droughts in Africa, communities rely more on the sustainable use of the little water available to them (Dube *et al*., 2020). However, sustainable water management in most sub-Saharan African countries, including South Africa, remains a critical challenge, as evidenced by recurrent or prolonged water crises (Psomas *et al.* 2016). One such locality in which there is poor sustainable water use is Cape Town (South Africa), which is the focus of the present study. This chapter contains the background and statement of the water crisis problem in Cape Town, the research objectives, and its significance, among other aspects.

1.2 BACKGROUND

The issue of access to clean and safe drinking water is still essential in many developing countries, including South Africa (Psomas *et al*., 2016). Globally, more than two-thirds (67 per cent) of the world's population are expected to be dehydrated and will face various formsof water-related weakness by 2025 if current trends continue (United States Agency for International Development (USAID), 2013). The water issue will pass the present 3.2 billion people (approximately 46% of the world's population) who already face the threat of water insecurity (United Nations-Water Task Force on Water Security, 2013; United Nations,2015). Sub-Saharan Africa has made headlines for its insecurity over the past few decades. The region is unsafe, vulnerable, and struggling to provide drinking water to about 320 million people (United Nations -Water Task Force on Water Security, 2013; United Nations, 2015). For the same reasons connected and interdependent, the United Nations Sustainable Development Goals (SGG) focus on various water issues to achieve human well-being and a healthy ecosystem (Molinos-senante & Donoso, 2016). Goal 6 (universal water and sanitation) is critical to achieving the desired results by 2030 (Agudelo-vera *et al.,* 2011). Health protection in sub-Saharan Africa depends heavily on water resources, especiallyamong smallholder farmers.

Increased urbanisation, economic development, and agricultural activities, coupled with limited rainfall, contribute to the depletion of quantitative and elevated levels of water resources (Richley *et al*., 2015). Therefore, water security is one of the most challenging development goals to be achieved (World Bank, 2006; Bliss, 2009; Bakker, 2010; United Nations-Water Task Force on Water Security, 2013; United Nations, 2015; Peprah *et al*., 2015). Urban migration, agricultural flows, industrial dumping, and sanitation have affected water quality worldwide and

made them unsuitable for domestic purposes (Chatterjeeet *et al.,*2010; Choudhary *et al*., 2011; Ullah *et al.,* 2013). However, water remains one of the few, if not the only, sources of natural resources widely distributed worldwide. It also serves as an essential tool for human survival and ecosystem and national development engine (Janerette & Larsen, 2008; Richley *et al*., 2015). Due to water scarcity and surface water treatment challenges, sustainable water use is an alternative, as described by Yesah *et al.* (2013). Michalopoulos and Dimitriou (2018) argue that protecting and preserving good water quality is paramount worldwide. To achieve basic water security, harnessing the power of water production and reducing its destructive effects has become a primary public concern (Rosegrant & Cai, 2002).

In South Africa, one of the problems that can be mentioned is the shortage and the minimal amount of water available (approximately 495 mm annual rainfall) (Dube *et al*., 2020). The water shortages to some extent make the country rather a water scarce country. With only 1200 m3 of clean water available per person per year for an estimated 49 99million people, South Africa is close to the international definition of water stress (Savenije& Van der Zaag, 2000). Despite this, South Africa recently experienced a severe drought between 2014 and 2016, worsening the current situation. Donnenfeld *et al.* (2018) said the 2014-2016 droughts did not cause water shortages but created a national debate on watersafety and policy by highlighting the existing risks. These authors point out that for several years however, South Africa has been a water-stressed nation, and the management of this resource needs to be improved. These water shortages have led to a much higher demandthan available natural water.

Cape Town is one of the provinces most affected by water shortages in South Africa. Cape Town has been experiencing water shortages over the past few years, and the situation has worsened (Nkambule, ND). A water crisis occurs when available drinking water is below the need (Kumpel & Nelson, 2016). In 2015, problems arose when it was noted that dam levels continued to decline after below-average winter rainfall in 2014-2015 (South African Department of Water Affairs and Forestry, 2017).Although much of Cape Town's water comes from small arid rain-fed areas, forecasts for

2010 indicates that low rainfall was one of the problems. Increased water use was equally important. Given this alarming water crisis in Cape Town, the Department of Water and sanitation has decided to address the seriousness of water use inefficiencies, especially in irrigation agriculture, and improve water quality. The water crisis is due to overuse, which seems even more worrying as water demand is predicted to rise sharply by 2035 (Donnenfeld*et al*., 2018). Recently, a severe water crisis was reported in South Africa and Cape Town as asource of problems leading the city government to set a "Day of Friday", 12 April 2018, the day the water supply will run out. It has also been said that when this ends, Cape Town will be the first big city in the world to face water problems as dams go down drastically to supplyliquids (Maxmen, 2018).

The Western Cape is experiencing a drought that could be the result of climate change. Climate change could change the existing water resources in South Africa and put additional pressure on the sustainability of water resources. The water crisis caused by the drought underscores the regulation of water supply in Cape Town, leading to a response to thedemand side (Donnenfeld *et al*., 2018). A water management system was introduced to ensure that the existing water supply system meets the growing water demand. Some activities will be appropriate to address future shortcomings caused by climate change. There is a need to focus on conserving conservation areas to ensure the sustainability of wetlands and river ecosystems. South Africa is a desert, but the well-known Cape Town province, captures coastal warm air from the warm ocean waters, Table Mountain, traps, coming from rainwater that energises rivers and fills beneath groundwater (Walter *et al*., 2011).

This study focuses on Cape Town as it has a severe and continuous water crisis compared to other cities such as Durban and Johannesburg. Cape Town was particularly interested in this study since it is a big tourist city with high water use as tourists perform activities in tourist resorts. The Integrated Urban Water Management (IUWM) framework was used as a tool through which to understand how sustainable water use in Cape Town could beachieved.

1.2 RESEARCH AIM

The present study sought to ascertain the factors affecting sustainable water use in Cape Town, South Africa.

1.3 RESEARCH OBJECTIVES

The study sought to achieve the following objectives.

1. To explore the causes of the water crisis in Cape Town.
2. To establish the challenges encountered in the sustainable use of water in Cape Town.
3. To investigate the effectiveness of the existing copying strategies employed in dealing with theCape Town water crisis.
4. To develop effective strategies to Cape Town municipality for promoting sustainable water use.

1.4 RESEARCH QUESTIONS

The study sought to provide answers to the following questions.

1. What are the underlying causes of the water crisis in Cape Town?
2. What are the core challenges encountered in the sustainable use of water in Cape Town?
3. How effective are the copying strategies employed by Cape Town municipality in dealing with the water crises inCape Town?
4. How can the sustainable use of water in Cape Town be promoted?

1.5 STATEMENT OF THE PROBLEM

Demand for drinking water in Cape Town has grown in the past two years since 2015, when the country recorded its lowest rainfall (403mm) (Dube *et al*., 2020). Despite the prevailing water crisis, the core problem is inadequate management of the limited water resources available. The situation is further compounded by the fact that Cape Town's climate is expected to change, reducing the annual yield of dams to 30%-50% below average rainfall (Ibid, 2020). In addition to rains becoming erratic, the situation is aggravated by several factors, which include improper land use, untreated raw sewage, and pollution, which makes the already-limited water hazardous for individuals and households. Cape Town' water supply system has not been competent enough to provide adequate water and withstandadverse environmental challenges,

evidenced by poor water quality, unavailability, unreliability, and inadequacy (City of Cape Town, 2020). There is, therefore, a need for detailed studies to investigate the core factors affecting the sustainable use of water in South Africa to deal with the water crisis. Water access is critical to the livelihoods and well-being of the citizenry and the country's sustainable development. This is echoed in the National Development Plan (NDP) or Vision (2030). As the world enters the final decade of action to achieve the sustainable development goals (SDGs) and the NDP, this issue has become more crucial to building back better.

1.6 SIGNIFICANCE OF THE STUDY

The study was necessary since current water management practices in Cape Town need to achieve desired results despite the clear need for sustainable water use in the face of natural resource scarcity. The importance of the study could be to identify the primary reasons leading to water scarcity in Cape Town, which could help develop techniques to minimize and control water use. With varying public concerns that it is polluted, it is on such basis that a reliable management system is required for effective water use (Dube *et al*., 2020). The study could provide insights into sustainable water use to avert or manage the water crises in Cape Town, particularly highlighting the role of the IUWM framework for municipalities.

1.7 DELIMITATION

The study focused only on Cape Town city of South Africa. The rationale behind this focus was the extent of the water crisis in this city, particularly given its high population, economic importance and easier accessibility to the researcher. The study within Cape Town focusedon Camps Bay, Parrow, Constantia, Bishops Court, Wallacedene, Fairfield estate, CapriVillage, Platte-kloof and Woodstock since they were the most high-lying areas where the problem of water scarcity is greatest. The time emphasised in the study spanned the last decade (2009-2019), with the most recent five years (2014-2019) selected for the understanding of the current water crisis in Cape Town.

Moreover, the other five years (2009-2014) were selected to provide background insights into the origination and causal pathways of the current crisis. Theoretically, the study was delimited to the IUWM framework since it was one of the recent main currently leading frameworks for analysing upon which to understand sustainable water use interventions in urban settings like Cape Town (Dube *et al*., 2020). In terms of the participants' delimitation, the study engaged

Cape Town residents and professionals in the form of the Council, Department of Water and Sanitation and municipality officials and academics from the Urbanplanning faculty at the university.

1.8 STRUCTURE OF THE STUDY

The study comprises laid down has five related chapters. The first introduces the study and its background, focusing on such aspects as the statement of the problem, the objectives and research questions and the significance of the study. The second chapter reviews related literature, including theoretical literature on the IUWM framework and empirical literature from within South Africa and from other countries. The third chapter is on the research methodology, including the philosophy, design, population, sampling, data collection and analysis approaches of the study. The study's findings are laid out in line with the research objectives in the fourth chapter, while the fifth and final chapter presents the study's conclusions and recommendations.

1.9 CHAPTER SUMMARY

This chapter focused on introducing the study through discussions of such aspects as the background, problem statement, objectives, research questions and the significance of the study. Delimitations and the structure of the study were also presented. This water crisis in Cape Town and the failure to sustainably use the limited available water were identified and discussed as the problems necessitating the research. The proceeding and the next chapter present, and review literature related to this problem. It is presented and reviewed.

CHAPTER TWO: LITERATURE REVIEW

2.1 INTRODUCTION

This chapter focuses on the literature review of the study comprising the theoretical framework, the sources of groundwater pollution, water source vulnerability, methods of vulnerability assessment and water quality modelling.

2.2 THEORATICAL FRAMEWORK: THE INTERGRATED URBAN WATER MANAGEMENT (IUWM)

The study's theoretical framework hinged on the Integrated Water Resource Management (IWRM) framework, Integrated Water Resource Management (IWRM) is a holistic approach to managing water resources in a sustainable and equitable manner (Lüthi, C., & Matsebe, G. 2018). It aims to address the complex and interconnected nature of water systems by considering the social, economic, and environmental aspects of water management. IWRM promotes the integrated planning and management of water resources, considering the various competing demands and interests.

In the case of Cape Town, South Africa, IWRM theory plays a crucial role in ensuring the sustainable use of water resources (City of Cape Town. 2019). Cape Town is in a water-stressed region characterized by periodic droughts and limited water availability. The city faced a severe water crisis in recent years, with the threat of Day Zero a day when the city would have to shut off the municipal water supply looming in 2018. To address this crisis and promote sustainable water use, the City of Cape Town adopted an IWRM approach.

The IWRM strategy for Cape Town focuses on several key principles (City of Cape Town. 2019):

Demand management: The city has implemented strict water restrictions and awareness campaigns to reduce water consumption. This includes measures such as reducing leakages, promoting water-efficient practices, and implementing water-saving technologies.

Water conservation and reuse: Cape Town has emphasized the importance of conserving water and has implemented initiatives to promote water reuse, such as treating and recycling wastewater for non-potable uses (Department of Water Affairs and Forestry. 2004).

Catchment management: The city recognizes the significance of managing water resources at

the catchment level. This involves protecting and restoring natural ecosystems, managing land use practices, and implementing measures to enhance water quality and quantity in the catchment areas.

Stakeholder engagement: IWRM theory emphasizes the importance of involving all stakeholders in water management decisions. Cape Town has adopted a participatory approach, engaging with various stakeholders, including communities, businesses, and government agencies, to ensure that diverse perspectives are considered in decision-making processes.

This framework has been proposed to guide the planning and management of urban water systems by urban authorities, reduce the adverse effects on the environment, and enhance sustainable resource use. The framework is also envisaged to strengthen the contribution of water use to economic and social goals and the development ofcommunities (Kumpel & Nelson, 2016). This framework is necessary because it is a critical component of natural ecosystems and a vital resource for social and economic development.

The advantages of IWRM theory on sustainable use of water are numerous and include: IWRM promotes the efficient use of water by encouraging the adoption of water-saving technologies and practices, such as drip irrigation, rainwater harvesting, and wastewater reuse (El *et al*., 2016). This can lead to significant water savings, particularly in water-scarce regions. IWRM considers the potential impacts of climate change on water resources and helps to develop strategies to adapt to changing conditions, such as water storage, water demand management, and drought planning. IWRM aims to protect water quality by reducing pollution from various sources, including industry, agriculture, and domestic wastewater (Nazemi & Madani, 2018). This can help to safeguard human health and aquatic ecosystems. IWRM emphasizes the importance of stakeholder participation in decision-making processes related to water management (El et al., 2016). This can lead to more informed and inclusive decision-making, as well as greater acceptance and ownership of water management plans (Psomas *et al*., 2016). IWRM can contribute to increased economic benefits by promoting sustainable water use practices that support agriculture, industry, and tourism, among other sectors.

2.3 WATER AVAILABILITY AND SCARCITY

2.3.1 Water availability in the world

Water is an important resource whose availability is related to food, economies, and livelihoods across the world. Despite this importance, most of the countries worldwide arenot water safe as demand continues to be greater than supply (Grey & Sadoff, 2007). The failure by most countries to properly invest in water services and infrastructure because of giving little importance to the resource is one of the factors leading to, and worsening, water scarcity. The United Nations Environmental Programme (UNEP) believes that the global demand for water will continue to be above the supply within the next 20 years. Rises inwater demand have been related to urbanisation, poor water management and investment, water pollution and climate change's effects.

The availability of water for hygiene purposes remains low in sub-Saharan Africa and in southern Asia, with 41% and 30% coverage rates, respectively (Davies, 2012). In the case of southern Asia, as much as 692 million inhabitants continue to make use of open evacuation, which shows a high rate of people without access to fresh water (Schnoor, 2008). This isan even more serious case in sub-Saharan Africa as much as 33 million continue to use open withdrawal (Abrams, 1996). Most of the people in sub-Saharan Africa continue to have poor sanitation and the demand for clean water is on the rise.

As compared to people in urban areas, people in rural areas are at a disadvantage in as much as access to water and decent sanitation is concerned. Gaunt (2010) mentions that the WHO believes as much as 79% of urban dwellers have access to fresh water as compared to 47% pf the rural people. Further, as much as 96% of the people in urban areas have access to well-planned water systems as compared to 81% in the rural areas (Gaunt, 2010). However, within increasing populations, the situation of water supply on a global scale is expected to worsen especially due to the additional effects of urbanisation, specialised economic sectors, poor water infrastructure investments, climate change and water pollution.

2.3.2 African perspectives of water availability

Africa is a continent endowed with vast water resources including over 160 lakes that are within half of the continent's eastern part (World Commission for Water, Vision 2025).There are also many rivers within Africa including the Nile, the Congo, and the Niger (World Commission for Water, Vision 2025). Most African countries also receive relatively high rainfall of over

670 mm per year and the continent is also characterised by low levels ofwater extraction for water supply, industrials and agricultural uses, accounting for about 3.8%of the continent's water resources (Abrams, 1996). However, the supply of fresh water sources is unequally distributed in Africa, with the central and western regions having higher precipitation levels as compared to the northern, southern and the Horn of Africa (Parssons, 2000).

A lot more than 75% of people are dependent on groundwater as their main source of freshwater, mainly so in North African countries, such as Tunisia and Libya, as well as areas of Morocco and Algeria, and in Southern African countries like Botswana, Zimbabwe, and Namibia. According to Davies (2012), there are some sub-regions and countries in Africa going through increasing water scarcity and, unless suitable and timely involvements are made, the situation will degrade. In addition, compounding the problem is the landform's expanding population and inexorable urbanisation, which will apply increased tension on cities and towns' water resources. The United Nations Economic Commission for Africa (UNECA) estimated that, by 2020, the continent will have 11 megacities with five-million or more residents and more than 700 cities with populations of uphill of 100 000 (Angin, 2007).

2.4 CAUSES OF WATER SCARCITY

Water pollution is one of the significant causes of water scarcity. Even though pollution is a slow process, its effects are dire (Baghvand *et al.* 2010). Despite the nature of the pollution, such as physical, chemical, organic, or bacteriological, most of Africa's aquifers are polluted (Schijven *et al*. 2010; Attoui *et al.* 2012). The prevention of water pollution is one of the critical strategies for the sustainable management of freshwater sources in Africa, as advocated by the IUWM. This makes the prevention of water pollution one of the keyways through which to ensure sustainable water use in Africa.

2.4.1 Urban and population growth

Rapid urban and population growth causes water insecurity and vulnerability in sub-Saharan Africa (K'Akumu, 2006; WaterAid, 2011). However, the population sizes of towns and the functions they provide for their residents, such as administrative, political, economic, social, and cultural, are essential indicators for defining urban centers in the urbanization literature (Brunn *et al.,* 2008; Yeboah *et al.*, 2013; McGranahan & Satterthwaite, 2014). Available statistics indicate that about 54 per cent of the world's population resides in urban centers,and it is projected to reach over 66 per cent by 2050 if current urbanization trends persist (United Nations-Department of Economic and Social Affairs (UN-DESA, 2014). Using ecological

footprint methods, Jenerette & Larsen (2008) project that about 82 and 57 per cent of the global core and periphery populations are likely to reside in urban centers by the year 2030. This will undoubtedly increase domestic water consumption levels and will likely impact the sustainability of both urban and rural water supply systems (Foster *et al.* 2011; UN, 2015).

2.4.2 Water supply and distribution systems

WaterAid (2012) explains that an efficient water distribution system is critical for promoting the human right to safe and sound quality water for all people. Water supply and distribution systems refer to the layout of distribution networks of pipelines and the methods by which potable water is made available and accessible in needed quantities to consumers (Government of National Unity (GONU), 2009; WaterAid, 2012). The layout of distribution networks can be radial, dead-end, gridiron or ring. In contrast, the distribution methods are usually based on gravity, pumping, or a combination of both systems (WaterAid, 2012). GONU (2009) argues that adopting any of the layouts and networks of distribution primarily reflects the planning and growth patterns of urban localities and cities. Also, the adoption of either the gravity or the pumping method to supply water depends on several critical factors like the topography of an area, cost burden and the reliability of power supply in a country (Foster *et al*., 2011).

Therefore, the measurement of the efficiency of water supply and distribution systems and their vulnerabilities are shaped mainly by prevailing local conditions (GONU, 2009). According to Baker (2010), urban water managers' political and administrative decisions describe the efficiency of an urban water supply system. This often leads to urban water politics between urban water managers and residents about water security and vulnerabilities.

2.4.3 Water politics

The concept of water politics is a primary concern in water insecurity and vulnerability in sub-Saharan Africa (Ainuson, 2011). There is no consensus on what water politics stands for due to the varying ways it is used. Household water politics refers to the conflicts and interactions between urban residents and institutions responsible for water provision, water systems, and water services. It also entails the roles these actors play in the water decision- making process and who has rights to water (Leftus, 2015). Thus, the politics of water is thought of as a function of the socio-economic class status of urban residents or water managers.

2.4.4 Water governance

Water governance invariably revolves around the political, social, economic, and administrative

systems of water decision-making aimed at managing water resources and delivering water services and functions in a country, city, or locality (Bakker, 2010; WaterAid2012; UN-Water Task Force on Water Security, 2013). One core issue of water governance in relation to water security and vulnerability is the capacities of water sector institutions and specific institutional arrangements in place to manage water supply systems (WaterAid2011; Petersen-Perlman *et al*., 2012; UN-Water Task Force on Water Security, 2013). Petersen-Perlman *et al*. (2012) argue that weak capacities of water sector institutions at all scales to effectively manage water supply systems seriously impede the attainment of water security and eradication of vulnerabilities. In addition, inadequate financial resources to fully cover the costs of operations, provision and maintenance of infrastructure are also essential (Bliss 2009, WaterAid 2012; UN-Water Task Force on WaterSecurity, 2013)

2.4.5 Climate change

Rainfall variability, drought, unexpected prolong downpours are major concerns to the water security and vulnerability (Jenerette & Larsen, 2008; UN-Water Task Force on Water Security, 2013). Climate change is a major issue in the analysis of water security andvulnerability in sub-Saharan Africa. Rainfall is essential for urban water security since most urban households depend on rainfall for their water. Yet, rainfall variability and declining precipitation levels in the sub-region are making households vulnerable and water secure. WaterAid (2012) points out that rainfall variability remains a major challenge to urban watersecurity in sub-Saharan Africa due to low rainfall patterns and prolonged droughts. These lower precipitation levels in the sub-region make water supply difficult (World Bank, 2006).

The World Bank (2006) argues that climate change has driven millions of both urban and rural households into extreme poverty in sub-Saharan Africa due to the difficulties they encounter in accessing water. This is especially so since the economic activities of most ofthe people in the sub-region predominantly depend on availability of water. However increased temperatures and hydrological variability also impact the water cycle and water infrastructure in sub-Saharan Africa (UN-Water Task Force on Water Security, 2013). This intensifies water insecurity and vulnerabilities, despite the sub-region's barely significant contribution to global climate change (Tadesse, 2010).

2.5 OVERVIEW OF WATER CRISIS IN SOUTH AFRICA

2.5.1 Water demand and accessibility in South Africa

South Africa faces increasing openness between water demand and service delivery. Apractical solution will be provided to the country's various districts, specifically domestic,agricultural, and industrial needs. South Africa has an annual rainfall of 500mm, combined with high annual yearly fluctuations and volatility (43% of the rainfall in 13% of the world), and about 60% of the country is dry (Too *et al*. 2016). Before 1994 accountability for water supply was unequal, with no national government department accountable for its administration. Lack of accountability has created various levels of resources between Black and white communities. In addition, covering the issue is the absence of any national water law or support system (Dube *et al.,* 2020). Kumpel & Nelson (2016) noted that the Department's policies and activities in The Department of Water Affairs and Forestry (DWAF) were prohibited from irrigation and forestry. It had a significant impact on the waterand ecosystems. The demand for housing, industry and city is driven by rising income and population growth, as well as a national drive to improve primary living conditions (for example, the widespread use of toilets, and residential planning).

South Africa needs general yearly precipitation of 500mm, encompassed. Previously, in addition, aggravating the issue might have been the nonattendance from claiming at whatever sound national water enactment alternately help supportive network (Muller What's more path 2002). However, tests that need aid are selective of the investment exercises predominant in that range. The basins that supply those fundamental urban areas (Johannesburg, Durban, cape Town, and what's more, Pretoria) are foreseen to face extreme openings achieved by the enhanced family unit.

Once the cost-effective methods have been established, another solution to the problem, i.e., demand management, will be required. An effective measure at the household level includes flexible costs in residential patterns (such as small building size) and leakage control in standard municipal distribution networks to help with domestic water efficiency (Dube *et al*. 2020). In addition, industrial water use is difficult to control. The policy that the industrymust protect all costs of making water available helps decision-makers to focus on water options and performs well with other areas where water barriers are less exposed. It has also led to many support systems where industries become more comfortable and reuse municipal wastewater in their designs.

When the low-evaluated supply alternatives have been established, the elective approach should resolve that required. An effective measureduring those family levels incorporates levy growths that depress and vacillates made settlement patterns, for example, minor plot sizes and spill control in the general metropolitanconveyance networks that aid families (City of Cape Town 2020). These latest methodologiescould be compelling in massive networks. Various interest management exercises could commence, from superfamily water fixtures to amending the water utilization ability for provincial appliances, such as washing machines. Furthermore, water utilisation in those streamlined levels will be fragile and should control the evacuation from claiming wastewater will accomplish these targets. The approachability for water and consistency of supply, instead of prices, are the principal drivers for available industry (Lang, 2015). To huge first industries, however, the approach that the industry ought to cover those expenses about making sensory water needs aided choice makers to focus on water effectiveness alternatives. It needs likewise brought about a steady game plan that place commercial enterprises extravagance. Furthermore, reuse urban wastewater in its forms. Agriculture, which is still the prime water user, is often a possibility for considerable developments in the competence of water use. For instance, the technologies for refining irrigation competence are well known.

2.5.2 Water demand and accessibility in Cape Town

The rapidly growing population in the Western Cape and nearby towns as well as economic growth is causing such a big tension on the province's water supply that the DWA has calledfor the application of a WC and WDM program. According to the department, the margin amongst available water and that used was about 8%, which could be totally utilised within the following years (Cape Town, 2011). Western Cape Water Supply System (WCWSS) users includes the City of Cape Town and the municipalities of Stellenbosch, Swartland, Drakenstein, and Saldanha, as well as the farming community (Davies, 2012). The DWA noted that the WCWSS can securely supply 556-million cubic meters a year (Dube *et al.* 2020). According to research by the department, only a few surface water development options are offered for enlarging the water supply to the City of Cape Town and neighboring towns.

However, the Department is finding other ways to ensure enough water is available for future use, including a large desalination area in seawater, which was surveyed also plans toconduct a feasibility study on recycling on a large scale. Other research conducted by the cityon the potential for groundwater development and the use of the Table Mountain Group aquifer as a

sustainable water source is ongoing. The DWA also considers two types of surface water, one of which involves pumping winter rain from the Berg River to theVoelvlei dam. The other consists of diverting water from Dwarsriver, Mitchell's Pass, near Ceres, into the Sabarrier dam. In 2000, water demand reached 499Mm3 /year, while winter rainfall fell below that level (Kumpel & Nelson, 2016). Then there was a shortage, and water restrictions were imposed to prevent water shortages. These water restrictions resulted in a temporary reduction in water demand, followed by a free return to water use of approximately 476Mm3 / year in 2004 (Gray & Sadoff, 2007). In the same year (2004), there was a severe drought, and water restrictions were resumed. In addition, other water restrictions were re-introduced in 2006, reducing water demand to 465Mm3 / year (DWA, 2007a).

2.5.3 Cape Town water challenges

The Western Cape Water Supply System (WCWSS) allocates 399Mm^3 of water per year at a 90% pledge. The bulk pipeline network is used to transport water, providing more than 1.1 million homes (CoCT, 2015). According to the Department of Water Services Sector Plan (2015), the City of Cape Town aims to make water services more affordable for poorhouseholds. As a result, 6kl unlimited essential water is provided to all citizens every month (García-Betancourt et al., 2015). In addition, the first 4.2kl sewage is transported to wastewater treatment plants and stored free of charge for all users. Most of the green water comes from the Department of Water Affairs' water projects which account for about 73% of all water supplies (City of Cape Town 2020). The City of Cape Town receives 27% of its water resources. Storage can be improved by building new dams that will store water during the rainy season to be used during the dry season and using rainwater in the dry season.

However, there is a limit to this approach, as it is helpful to build dams only if there is enough rain to fill them. South Africa's final capacity is well developed, with a total of more than 32 billion m³, equating to about two-thirds of the annual flow across all its rivers (Cityof Cape Town, 2020). The Western Cape is an arid region, which in many areas, relies heavily on water for its economy. Although the higher education sector may be less water- intensive, most of the resources provided are linked to the agricultural industry in the province. Also, the quality and certainty of service delivery should be improved as opposedto agriculture.

According to Dube *et al*. (2020), climate change is a known risk factor for water progression. Infinite impact estimates also mean that the planning required to ensure adequate water supply

for fifteen to twenty years is challenging to implement. Sensible data on the characteristics of water sources and rainfall monitoring and flow are maintained, so that yield estimates are accurate, allowing for adaptation to the planning area. In addition, investing in developing existing infrastructure is necessary since significant investments are made. Many buildings are therefore nearing the end of their vital life span, which means that financial support will be needed to replenish these structures (Davies, 2012). The water management sector is facing a shortage of science, engineering, technical fields, and artisan skills, which are classified as rare and essential. It is strongly associated with a lack of skills base and intense competition in the field of skilled workers. In addition, there are concerns about declining water levels in dams and rivers due to pollution and reduced land use management and its impact on the environment and the economy. Examples of the economic effects include the costs incurred by Eskom because the water level does not meet the designrequirements for its power stations and the loss of income in the agricultural sector because the water level does not meet EU prices. Social outcomes include adverse health impacts and side effects such as death and functioning (Diouf *et al*. 2014). Environmental influence sects include groundwater pollution and eutrophication. Causes of pollution include industrial andagricultural activities, poorly managed wastewater treatment plants and human settlements.

2.5.4 Sustainable use of water in South Africa

The level of illegal water use, especially upstream of the Vaal River, especially by irrigators, is a significant problem as it has caused the available water to be out of current needs. In addition, pollution of water resources in the river system because of mining operations causes eutrophication (lack of oxygen in the water). Therefore, the water Department's position is to stop the illegal use of water in the Vaal River system and to control pollution levels by ensuring law enforcement and monitoring. Irrigation agriculture receives 62% of the distributed water and has recently been released from certain water costs (Healy et al., 2016). The Water Department understands that the sector wishes to participate in the processes and maintenance of state- owned irrigation infrastructure. The code of conduct used in this sector recommends that water be economically charged. The Department also remembers other issues, including water trade, water redistribution reform, and developing strategies to improve water efficiency in the sector.

As agriculture is the most widely used water sector in South Africa; it uses about 60% of the accessible water resources (Edokpayi et al. 2014). The test is to harvest more food with the same

or less water. Improving water production is essential, which furthers agriculture's competitive advantage in the global economy. Agriculture is also facing increasing competition from industrial and domestic consumers. Department of Agriculture's new irrigation system recommends irrigating 600,000 hectares of wastewater and improving irrigation efficiency, including restoring existing irrigation schemes in the former homeland, and using water that has already been distributed in agriculture but has not been usedrecently.

2.6 PREVIOUS STUDIES

Suangkiattikun (2003) used DUFLOW-modelling studio to analyse the solute balance of the lake in long-term and short-term periods. The result of the model simulation showed a very good correlation between observed and simulated lake level with an $R^2 = 0.923$. Therefore, the model can explain 92% of the real situation of the lake level with a sum square difference of $155m^2$. According to his result in the water quality analysis, the Malewa water contains a predominance of bicarbonate. Sodium and calcium are the major cations. The result of the tributary's water analysis shows that almost all water quality parameters are high values indicating that the tributaries contain more solute than the main river. He noticed that the presence of carbonate and bicarbonate alkalinity in lake water mainly comes from the weathering process of laucustrine deposits. The level of nutrients during the study period in the lake is relatively higher than in the river. A decrease in nitrate has been observed in the upstream of the Malewa river and it gradually increased downstream and rapidly went up to the peak of 1.2 mg/l at the constructed dam for the pumping station of a private orchard spatially located after a worker` village that might have been polluted from the fertilizers used.

Donia (2006) used DMS for modelling the water flow and water quality of the major rivers (Malewa, Gilgil) flowing into Lake Naivasha. He made a spatial analysis of water quality by drawing the profile of different water quality parameters. He noticed that the overall conductivity increases gradually from 80 to 130. µs/cm when the Malewa River enters the swamp towards the lake. In general, most of the water quality parameters increase from upstream to downstream of the river. From the analysis of the Lake Naivasha profile, he concluded that the major problem of the lake water quality is its susceptibility to eutrophication due to substantial algal growth. The growth of algae is facilitated by the amount of nutrients supplied to the lake from the basin. Several studies on the use ofagrochemicals in the area have been carried out.

The quality of ground water in some areas of South Africa deteriorated by high nitrate levels from agriculture, which contribute to the reduction of potable water in the region (Morgan,

2006). Different mathematical modelling packages have been tested and used by Anil Upendra da Silva (2012) to simulate the fate of pesticides and fertilizers in the vadose zone. He explained that the potential risk of pesticides and fertilizers leaching was found to be relatively low due to relatively low rainfall and great soil depth where the experiments were undertaken. This indicates that the pollutant loading process is high in surface runoff due the soil depth and soil particle distribution in the basin.

The potential pollution of agrochemicals used around the lake has been identified and evaluated by Xu (2015). The researcher analysed that water quality parameters measured from agricultural effluents discharging into the lake exceeded the discharge guidelines of Kenya. According to the analysis, the sandy loam area around the lake was the most susceptible soil for pesticide leaching.

2.7 CHAPTER SUMMARY

The focus of this chapter was the review of related literature. In particular, the chapter contained reviews of literature on the theoretical framework of the study which involved the inclusion of the Integrated Urban Water Management (IUWM).

CHAPTER THREE: METHODOLOGY

3.1 INTRODUCTION

The focus of the present chapter is to present the study's methodology. This includes discussions of such aspects as the description of the research site, Cape Town, the research philosophy, approach, and design, as well as the population and sampling procedures adoptedin the study. Also contained in the chapter are discussions of the data collection and analysis methods and the ethical considerations adhered to in the research.

3.2 RESEARCH PHILOSOPHY

Research philosophy is the theoretical viewpoint behind a particular study (Cresswell, 2011). From the perspective of Saunders et al. (2009), it relates to how knowledge on a particular subject of study is developed. The two significant philosophies which exist in scientific research include positivism and phenomenology. This is in addition to other philosophies, which include critical realism and interpretivism (Johnson & Clarke, 2006). This study, however, used a mixture of positivism and phenomenology, often called pragmatism. Whilst positivism was primarily objective and scientific, phenomenology was predominantly subjective and reliant on the participant's empathy (Cresswell, 2011). It is the view of Saunders *et al.* (2015) that pragmatism is a more helpful approach since it considers the philosophical points of both positivism and phenomenology in studying a research subject. This often enriches the data and generalisations of research, which was one key aspect of pragmatism that this study sought.

3.3 RESEARCH APPROACH

A research approach has been defined to collect data for a study (Cresswell, 2007). The practical approaches in scientific research are deductive and inductive. Deductive research is based on the formulation and testing of a hypothesis, while inductive studies focus ondeveloping a theory that can help inform a new study area (Cresswell, 2007; Robson, 2002). In the present study, therefore, a deductive approach was used. The relevance and applicability of deductive research arose from the need to use an existing theory, the IUWM, to understand the existence and causality of the phenomenon of the water crisis in Cape Town. The deductive approach was also selected for this study as it provides more valid and reliable findings through hypothesis testing. It was highly informative of the extent to which the IUWM framework was applicable in explaining Cape Town's water crisis.

3.4 RESEARCH DESIGN

The study adopted a descriptive case study design and mixed methods. The descriptive type proves most suitable as it fits with the overall study purpose of adding to the understanding of the water crisis in Cape Town. The study mainly focuses on Cape Town to find the reasons behind the droughts and find out where the real problem lies. The case study will enable concentration on a small geographical area to which emphasis will be on the depth of data gathered from a limited number of individuals. Bless and Higson-Smith (2002) said that qualitative methodology gathers more descriptive and explanatory data, while quantitative research gathers numeric data. Increased runoff decreases groundwater recharge, thus decreasing the water table and worsening droughts. This methodology will contribute to a deeper meaning ofsocial reality by Captonians on issues about the water crisis.

3.5 POPULATION AND SAMPLING

Having discussed the study's design, the methods of collecting and analysing data became critical. However, a description of the participants in the study was also essential. This section contains a description of the research population and the sampling methods.

3.5.1 Target Population

The population is defined as the totality of research subjects (Saunders et al., 2015). It may also be understood as the complete or aggregate measure of a study's participants or subjects in each area of research interest (Cresswell, 2011). In the context of the present study, the population was the total number of Cape Town residents and water management officials from the municipality.

3.5.2 Sampling

It is explained that a sample is a study's representative with characteristics that are similar and exemplary of a larger group from which they are derived (Silverman, 2006). Patton (2005) states that the sample and the associated process of sampling are necessary topractically study or measure the characteristics that are of interest in each study. This was the rationale for sampling in this study, and due to the pragmatic philosophy adopted, both probability and non-probability sampling methods were used. Some of the joint probability and non-probability sampling methods are presented in Figure 1 below.

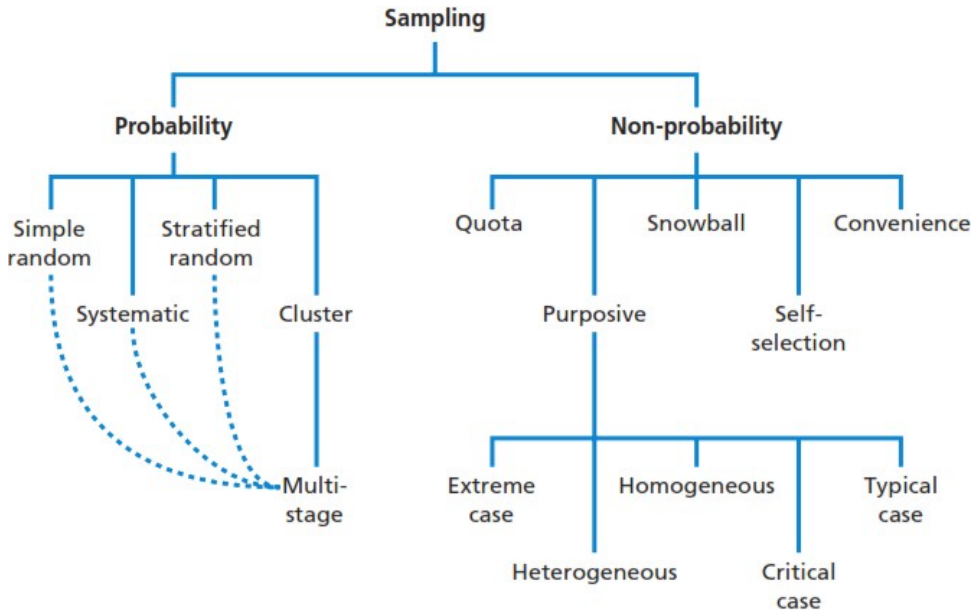


Figure 1 Common types of probability and non-probability sampling.

In terms of the probability sampling methods, the study used systematic sampling. This method was preferred for its high level of generalizability and its simplicity of application, asstated by Cresswell (2011). Households from nine suburbs of interest in Cape Town were selected, namely Camps Bay, Parrow, Constantia, Bishops Court, Wallacedene, Fairfield estate, Capri Village, Platte-kloof and Woodstock. These suburbs were preferred owing to their high-lying topography and geography since they were among the worst affected by the water crisis in the city. From the Microsoft Excel database file for the households in these nine suburbs, 362 participants were selected through a simple random selection of the 20th household listed on the database file. These participants were given the research questionnaires.

In the non-probability sampling, typical case purposive sampling was used to select municipality officials who would participate in the interviews. Typical case purposive sampling is a method that relies on the inclusion or exclusion of archetypal research participants based on criteria of interest, such as knowledge, expertise, availability, and willingness, among other motivations (Bless & Higson-Smith, 2002). The sampling purposes in this study included.

- being an official in the municipality,
- possessing knowledge of the water management system in Cape Town, and
- having experience in dealing with the water crisis in the town.

This was a deliberate choice given that the researcher wants to expose causes, challenges, coping strategies, and strategies for promoting sustainable uses of water. To this end, 20 officials from the Cape Town municipality were identified and included in the study, becoming interviewees.

3.6 DATA COLLECTION

Two key instruments were used to collect data for this study. These were a semi-structured research questionnaire and a critical informant interview. The application of these instruments in this study is discussed in the sub-sections below.

3.6.1 Research Questionnaire

In this study, a semi-structured research questionnaire was used. The questionnaire is described as a method of data collection based on a list of pre-designed questions forsoliciting information necessary to answer a particular study's objectives (Babbie, 2004). In the present study, a total of 362 questionnaires were distributed. These included open-ended and close-ended, Likert scale-type questions, which were answered by ticking the appropriate responses. The questionnaires were printed and hand-distributed to the participants in 2022.

This study preferred questionnaires due to their cost-effectiveness and ability to provide quick, timely responses. Questionnaires reach many people easily; they provide quantifiable answers, and the answers are relatively easy to analyze. They were convenient and appropriate for use in this study as there was a requirement for integrating both quantitative and qualitative tools in the data collection process in line with the pragmatic philosophy adopted in the study, of which the questionnaires served as part of the former class of research tools. Questionnaires were also preferred as they could contain much information in a summarized form and since the responses from the participants could be standardized, which made data analysis easier. They were also helpful for removing or mitigating bias inthe research (Cresswell, 2011).

Nevertheless, the use of questionnaires in this study was challenging. These included the inability to probe any emergent issues within the data collection process, as responses were only limited to pre-determined choices, particularly for the close-ended questions. To make up for this challenge, the questionnaire included open-ended questions. This was also the rationale for integrating key informant interviews (Section 3.6.2) as a second tool for the research.

3.6.2 Key Informant Interviews

Experiences were discussed using key informant interviews. An interview collects information or data that involves asking various questions (Lamnek, 2005). In-depth interviews were used as these are regarded to be experts with knowledge and information about the study matter (Bless & Higson-Smith, 2002). Interviews were advantageous in this study as the respondents could properly articulate their views on the issues under study. Interviews were vital because they drew upon respondents' attitudes and experiences feasibly and obtained detailed information while saving time and money simultaneously. Interviews were also crucial as they helped connect the respondent and the researcher and provided a deeper understanding of what was being discussed. Considering this, the causes of a water crisis in Cape Town, challenges faced in an endeavour to use water sustainably, copying strategies employed in trying to use water sustainably and strategies of promoting sustainableuses of water were best captured through interviews (Agnin, 2007).

The researcher used twenty key informant interviews with participants drawn mainly from the Council, Department of Water and Sanitation officials and Municipality authorities. Each interview comprised a statistically significant number of respondents selected through purposive sampling. In total, there were twenty interview participants. Appointments with these were made well ahead of time. In addition, meteorological, socioeconomic and water utilization data were also collected from respective authorities.

However, using key-informant interviews in this study also had disadvantages. These are time-consuming and often come with high costs associated with the logistics and recording ofthe data (Lamnek, 2005). However, these challenges were counterbalanced using the research questionnaires in the study, which was a form of research instrument triangulation.

3.6.3 Focus group discussions

The study also made use of focus group discussions. Focus group discussions are a qualitative research tool that helps gain in-depth knowledge of a particular social issue by purposively selecting a group of individuals (Nyumba et al., 2018). The researcher will assemble a group of individuals to discuss a topic to understand personal experiences, perceptions, beliefs, and attitudes through moderated interaction (Scheelbeek et al., 2020). In so doing, focus groups allow for an in-depth understanding of the research phenomenon by linking people's perceptions

to their sociocultural situations since most people obtain their notions, interpretations and mental constructions of reality based on their surroundings.

Focus group discussions were undertaken with residents from Cape Town. In this study, two focus group discussions were held, each consisting of 10 and 15 participants. As such, there were 25 participants in the focus groups. The focus groups were undertaken in the localitiesof the participants and at community halls. Each discussion lasted between 20 to 30 minutes. The discussions began with explaining the ethical principles binding the research, including information on the participants' informed consent, anonymity, confidentiality, and freedoms. The audio recording was done in the discussions, as well as note taking.

Focus group discussions were selected in this study since they are essentially a participatory approach to data collection. They emphasize the facilitative role of the researcher and relationships between individuals (Nyumba et al., 2018). Focus groups were selected in this study by allowing the researcher to play a facilitative role in the process since the researcher aimed to take a peripheral role to avoid researcher bias.

3.7 DATA PRESENTATION AND ANALYSIS

Data analysis is a crucial part of the research process and includes the sorting, comparison, examination, and synthesis of data (Neuman, 2011). In this study, descriptive analysis was used for data. This includes gathering data aimed at providing descriptions of the research phenomena using such visual aids as charts, tables, and graphs to sort and present the distribution of data. Such descriptive statistics as the mean, mode, standard deviation, percentage, variation, and correlation among the variables studied were done.

The researcher gathered data using questionnaires and observations. The presentation was done using pictures, tables, and figures in line with the thematic areas presented in the research questions. In analyzing quantitative data from the questionnaires,the SPSS computer package was used version 23. This package allowed for descriptive statistics analyses, including means, standard deviations, variance, skewness, and minimum and maximum value analysis, among others. The SPSS package also allowed for the undertaking of correlational and regression analyses in line with the studying of crucial relationships in the study.

For qualitative data from the interviews, a thematic analysis was done. This included sorting data, identifying themes and their discussion, and noting key areas of convergence and

divergence within the data (Gray, 2014). The computer package used for the thematic analysis was the NVivo software programme, version 11. The identification and discussion ofthematic strands were made to enrich the quantitative findings contained in the study, particularly to establish new ideas and explanations for the observed phenomena. For the presentation of qualitative data, verbatim quotes were used.

3.8 ETHICAL CONSIDERATIONS

The study also adhered to a solid ethical code. According to Wren (1998), research ethics entails using fundamental pillars like morality and legitimacy in a study. Including such principles helps ensure integrity and moral reasoning, which enhances the study's findings (Punch, 2005). According to Saunders et al. (2009) and Fisher (2010), research ethics is necessitated by the fact that academic research should not bring or cause any harm to people. This study upheld the following ethical principles in their respective ways.

Permission: The study sought the permission of participants. Management from included organizations was requested permission to use resources, staff time and other organizational resources.

Confidentiality: All individual rights to confidentiality and privacy were upheld. The study committed to upholding the confidentiality of the participants by not requesting or disclosing their names, identification particulars, photographs, addresses, and contact details. Where names of participants were a necessity, the study made use of pseudonyms to protect the participants' anonymity.

Participant consent: All forms included a consent section, which was explained to the participant before completing any research material. This section included all risks andbenefits of participating in the research. Only participants who consented to participate in the study were included, while those who did not consent were excluded.

Dignity: All participants were treated with dignity, i.e., with due care not to harm, cause discomfort, or embarrass them during the research or recording of facts. The dignity of the participants formed the basis for the style of conduct displayed by the researcher, which included the avoidance of quarrelling, displaying anger towards, laughing at, or showing disrespect to the participants in the study. General professional ethics guided the researcher in the research undertaking and relationships with the participants.

Non-Discrimination: There was no discrimination based on race, ethnicity, sex, intellect, or any other factors related to the well-being of the participants. As such, the study was inclusive of all genders, and participants were not segregated on any basis whatsoever, with only the results

of the systematic sampling being used to select participants.

Legality: All statutes, by-laws and ethics were withheld during the research.

Honesty: The research was conducted honestly in collecting, fabricating, and reporting data with due care taken not to misinterpret the data. This was duly accredited through proper referencing when data from other sources were used.

Table 1 provides some of the essential ethical principles used in this study and the factors leading to their inclusion.

Table 1 Rationale for inclusion of ethical principles.

Ethical principle	Rationale for inclusion
Informed consent	To manage and mitigate risks to the participants.
Confidentiality	To protect any secret data or avoid disclosure of sensitive information.
Participants' anonymity	To provide indistinctiveness which reduces participants' prejudices.
Approval	To enhance participants' welfare by upholding their rights.

In general, the study did not, in any case, conduct tests on humans or animals; however, human participants were interviewed. All ethical codes of conduct were followed during this research according to the university's requirements.

3.9 CHAPTER SUMMARY

The aspects discussed in this chapter comprised the methodology of the study. Regarding the philosophy, the study used pragmatism, whilst the research approach was deductive. The descriptive case study research design was adopted. The study's target population comprises the total number of Cape Town residents and water management officials from the municipality who were sampled through a combination of systematic and typical case purposive sampling. Data for the study was collected using 362 semi-structured research questionnaires and 20 key informant interviews. This chapter also detailed the data analysis methods and the considerations undertaken to ensure ethical adherence in the study. The following chapter is chapter four which

details the findings of the study.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 INTRODUCTION

The present chapter focuses on the presentation and analysis of the results from the study. This includes the analysis of the demographics of the participants as well as the findings on the objectives of the study. As such, findings on the causes of the water crisis in Cape Town, the challenges encountered in the sustainable use of water in Cape Town, effectiveness of copying strategies employed in dealing with the Cape Town water crisis and the strategies of promoting sustainable uses of water are presented. A section on the discussion of findings is also presented towards the end of the chapter.

4.2 RESEARCH ANALYSIS

In this section, an analysis of some aspects of the study is presented including analysing the response rate and the reliability of the research tool and the findings presented below.

4.2.1 Response rate analysis

The findings of the analysis of the responses received in the study are as presented in Table 2.

Table 2 Response rate findings.

Instrument	**Total Dispatched**	**Total returned**	**Percentage response**
Questionnaire	362	318	88
Interview	20	13	60

The findings in Table 2 show that 88% was the response rate for the questionnaires whilst 60% was that for the interviews. The findings show that there was a relatively high response rate for the questionnaires as compared to that for interviews. The high response rate for questionnaires is explained by the fact that the researcher used self-distributed and self- collected questionnaires which were filled and collected with minimal chances ofquestionnaire damage or loss. For the

interviews, the response rate was significantly low because the interviews were done during the COVID-19 pandemic where most participants were unavailable for interviewing due to the national lockdown in South Africa.

4.2.2 Reliability analysis

The analysis of the reliability of the questionnaire is an important part of the researchprocess. Establishing the reliability of the instrument as informed by the Cronbach Alpha coefficient was of importance to establish the level of reliability of the data within the questionnaire, which would impact on the validity and reliability of the research findings. In Table 3, the findings on the reliability of the research questionnaire are presented.

Table 3 Reliability analysis findings

Cronbach's Alpha	N of Items
.632	48

As the findings in Table 3 show, there was a Cronbach Alpha coefficient of 0.632 in the study. This was a relatively low level of reliability of the research instrument used in the study.

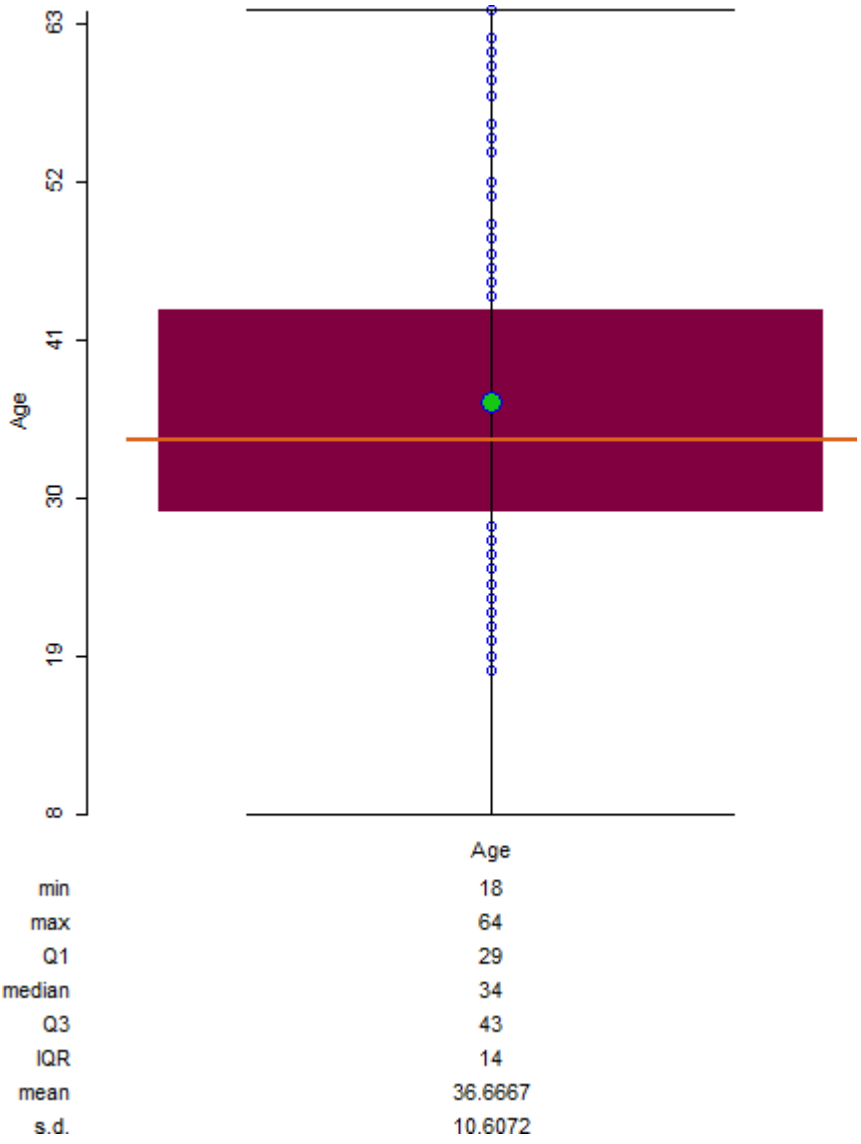
4.4 ANALYSIS OF PARTICIPANT DEMOGRAPHICS

In the present section, the findings on the analysis of the participant demographics are presented. This includes such findings as on the participants' age, gender, and highest academic qualification.

4.4.1 Age

The age of the participants made an important demographic as it relates to the willingness of the participants to participate in the study as well as to their level of knowledge and experience with regards to the water crisis in Cape Town. This made it crucial to understand the age of the participants to relate it to the nature of the findings made. The findings on the analysis of the participants' age group are presented in Figure 2.

Figure 2 Participants' age group findings



As presented in Figure 2, the age variable had a mean of 36.7 with a standard deviation of 10.6. The minimum age was 18 whilst the maximum was 64 for the participants in the study. Accordingly, the findings show that most of the participants in the study were middle-aged people.

4.4.2 Gender

The gender of the participants was also an important demographic that was studied in the study. The relevance of the gender as a demographic variable has been informed by its influence on the

nature of researcher-participant relations and, ultimately, to the reliability of the findings made in the study. As such, the study of the gender of the participants was infused as a key part of the research process. Table 4 contains the findings made on the analysis of the participants' gender.

Table 1 Participants' gender

Gender	Frequency	Percent	Cumulative Percent
Female	157	49.4	49.4
Male	161	50.6	100.0
Total	318	100.0	

As presented in Table 4, there were 49.4% female and 50.6% male participants in the study. Whilst males were slightly higher than females, there was an almost equal gender distribution which was useful in the study to avoid the effects of gender on the reliability of the findings.

4.4.3 Highest academic qualification

In most academic studies, understanding the academic level of the participants is of importance as it relates to their understanding of the topic issues in the study, as well as to their ability to effectively response to research questionnaires. As such, this study sought to establish the highest academic qualifications of the participants to understand how it impacted on the reliability of the findings made. The findings of the analysis of participants' highest academic qualification are presented in Table 5.

Table 2 Participants' highest academic qualification.

Qualification	Frequency	Percent	Cumulative Percent
Graduate	23	7.2	7.2
Undergraduate Degree	116	36.5	43.7
Diploma	87	27.4	71.1
Postgrad	74	23.3	94.3
Certificate	18	5.6	100.0
Total	318	100.0	

The findings presented in Table 5 show that most of the participants, being 36.5% of the total, possessed undergraduate degrees. A significant number of the participants possessed academic Diplomas, and these made up 27.4% of the total participants. Participants who reported having postgraduate degrees were 23.3% of the total participants in the study whilst those with graduate degrees were 7.2%. The least reported academic qualifications were certificates, which were possessed by 5.6% of the participants in the study. These findings, therefore, suggest that most of the participants were people with academic degrees, showing a high level of education amongst the participants. This was of importance in the study as the educational level was necessary for one to properly understand and articulate the research issues on the shortages of water in Cape Town, as well as to properly answer the research questionnaires which were used in the study.

4.4.4 Demographic data of interview and focus group participants

The demographic data of interview and focus group participants were also gathered in the study. Interviews were conducted with different participants such as the head of company or operations manager, wine farm owners as well as residents from the study areas. The findingsof this are as

presented in Table 6.

Table 3 Interview and focus group participants' demographics

Instrument	Participant Code	Age	Gender	Position	Date	Duration (minutes)
Interview	I1	44	Female	Owner	17.04.21	16
	I2	38	Male	Company head	20.04.21	23
	I3	51	Male	Operations Manager	21.04.21	31
Focus groups	F1	33	Female	Resident	17.05.21	26
	F2	40	Female	Resident	17.05.21	26
	F3	25	Male	Resident	17.05.21	26
	F4	36	Male	Resident	17.05.21	31
	F5	55	Female	Resident	17.05.21	26
	F6	42	Male	Resident	17.05.21	31
	F7	26	Male	Resident	17.05.21	26
	F8	23	Female	Resident	17.05.21	31
	F9	37	Male	Resident	17.05.21	31
	F10	50	Female	Resident	17.05.21	31

The findings in Table 6 show that there were three participants for the interviews, two of whom were male aged 38 and 51 whilst one was a female aged 44. The focus groups had a There were 10 participants, five of whom were female and another five males. The minimum age for the focus group participants was 23, whilst the maximum was 55.

4.5 CAUSES OF THE WATER CRISIS IN CAPE TOWN

The study's first objective required an assessment of the causes of the Cape Town water crisis. To this end, various causes were identified in the literature, and participants were questioned on the extent to which each factor exists or applies to the case of Cape Town. The fundamental causes investigated in the study included the failure to invest in water services effectively, failure to treat, collect and reuse water, increased domestic water consumption due to urbanisation, increasing demand from user sectors and low investment ininfrastructure. The findings of the analysis of the causes of the water crisis in Cape Town are presented in Table 7.

As seen in Table 7, the mean response for the role played by the failure to invest in water services leading to the water crisis in Cape Town was noted to be 4.36. The mean responses for the relevance of the failure to treat, collect and reuse water as a determinant factor was 1.78, whilst 4.81, 4.91 and 2.82 were the means for such factors as the increased domestic water consumption resulting from rapid urbanisation, the increasing demand from user sectors and the deficiency to invest in infrastructure, respectively. For the study's relevance ofsuch factors as weakening water quality, water pollution, climate change and high-water use from economic and social activities, means of 2.74, 3.07, 3.71 and 3.45 were obtained in the study. These findings suggest that the most critical factors leading to the water crisis in Cape Town include the failure to invest in water services, increased water consumption arising from urbanisation and increasing demand for water from various user sectors like agriculture,mining, and industry.

Table 4 Causes of water crisis in Cape Town

Cause	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
Investing	318	1.00	5.00	4.3585	1.27970	-.332	.137
Reuse	318	1.00	5.00	1.7799	1.29131	.505	.137
Urbanisation	318	1.00	5.00	4.8145	1.17284	.188	.137
Demand	318	1.00	5.00	4.9088	1.24879	.262	.137
Infrastructure	318	1.00	5.00	2.8176	1.26768	-.242	.137
Quality	318	1.00	5.00	2.7453	1.26387	-.020	.137
Pollution	318	1.00	5.00	3.0723	1.39550	-.368	.137
Climate	318	1.00	5.00	3.7075	1.17251	-.832	.137
Economic	318	1.00	5.00	3.4497	1.23908	-.355	.137
Valid N (listwise)	318						

Where, Investing = Failure to effectively invest in water services; Reuse = Failure to treat, collect and reuse water; Urbanisation = Increased domestic water consumption due to urbanisation; Demand = Increasing demand from user sectors eg. Agriculture; Infrastructure = Deficiency of investment in infrastructure; Quality = Weakening water quality; Pollution = Water pollution; Climate = Climate change, and Economic = Economic and social activities.

In the interviews, participants concur on two significant factors leading to the water crisis in Cape Town, namely the lack of prioritisation of water as reflected in such aspects as poor infrastructural investment, as well as the rapidity in the growth of water users. For instance, regarding the lack of investment, Participant F3, a resident, said.

> "The challenges we have are a result of the continued lack of investment in water issues in Cape Town, which I believe is also a problem in other cities in this country. As the population grew, the rate at which water systems have been developed has not been equal, leading to a high demand and a poor supply. The obvious result is shortages of

water."

Participant F3's response found support from Participant I3, who said.

> "Cape Town cannot store as much water as it would require, especially for periods between the rainy seasons. That, coupled with other problems like the rapid growth of the population and little financial resources to expand on current water supply mechanisms, is responsible for this crisis we now have."

As such, the interviews revealed the causal factors of the water crisis in Cape Town, with participants reiterating the roles of little regard for the importance of water planning and infrastructural investment.

Climate change-related factors formed a major causal factor leading to water shortages. As such, it was also imperative to investigate the extent to which selected aspects of climate change caused Cape Town's water crisis. Table 8 presents the findings on the extent to whichclimate change factors cause the water crisis in Cape Town.

Table 5 Climate change factors causing water crisis in Cape Town

Factor	**N**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**	**Skewness**	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
Variability	318	1.00	5.00	4.6415	.93500	-.487	.137
Drought	318	1.00	5.00	2.6006	1.07492	-.991	.137
Floods	318	1.00	5.00	4.7233	1.04118	-.540	.137
Precipitation	318	1.00	5.00	1.6069	1.14537	-.531	.137
Temperature	318	1.00	5.00	3.5157	1.17736	-.761	.137
Valid N (listwise)	318						

Where, Variability = Rainfall variability; Drought = Drought; Floods = Unexpected prolonged downpours or flooding; Precipitation = Declining precipitation levels and Temperature = Increased temperatures.

As presented in Table 8, the mean response for the role of the variability variable causing the water crisis in Cape Town was 4.6, and that for the drought variable was 2.6. The mean response for the relevance of the flood variable was 4.7, while those for the precipitation and temperature variables were 1.6 and 3.5, respectively. According to these findings, among the climate change variables, floods and rainfall variability formed the primary causal factors to the water crisis in Cape Town, with increased temperatures and drought playing high and fair roles, respectively.

4.6 CHALLENGES ENCOUNTERED IN THE SUSTAINABLE USE OF WATER INCAPE TOWN

The study's second objective required the identification and analysis of the challenges encountered by the Cape Town community in the sustainable use of water. This objective was relevant to later informing people of the solution to the town's water crisis. The findings on the challenges encountered in the sustainable use of water in Cape Town are presented in Table 9.

As presented in Table 9, there was a mean response of 4.18 which suggested to a great extent to which the challenge of the failure by officials to value the importance of water fully contributes to the water crisis in Cape Town. Also, means of 2.29, 4.35, 1.88 and 4.09 were obtained for the relevance of the factors of the topographical difficulties negating water supply, cost burdens, the unreliability of power supplies and political and administrative decision bottlenecks, respectively. For the impact of socioeconomic class and weak institutional capacities, means of 1.74 and 4.73 were obtained.

Interview responses on the challenges affecting the sustainable use of water in Cape Town revealed various points of interest, with most participants highlighting the negative impact of administrative and institutional issues. For example, Participant F5 had the following to say.

“Yes, we understand that there are some issues which complicate water delivery to households, but you will find that human issues have overtaken these genuine issues. In particular, the failure of office-bearers and their institutions to be accountable contributes immensely to the rise of the crisis and frustrates any efforts to end it. If you enter this office, they will say there is nothing we can do, go, and see so and so. Ifyou do so and so, they will say we are not responsible, go and see someone else. Moreover, the cycle continues.”

Table 6 Challenges in sustainable use of water in Cape Town

Challenge		Importance	Topography	Cost	Power	Administrative	Status	Institutional
	Valid	318	318	318	318	318	318	318
	Missing	0	0	0	0	0	0	0
Mean		4.1761	2.2925	4.3459	1.8805	4.0943	1.7358	4.7327
Std. Error of Mean		.07454	.05135	.04979	.07234	.06525	.07385	.06988
Mode		5.00	5.00	5.00	5.00	2.00	3.00	3.00
Std. Deviation		1.32928	.91569	.88797	1.28993	1.16355	1.31697	1.24617
Variance		1.767	.838	.788	1.664	1.354	1.734	1.553
Skewness		-1.316	-1.357	-1.227	-.663	.226	.005	-.043
Std. Errorof Skewness		.137	.137	.137	.137	.137	.137	.137

Where, Importance = Officials do not fully value importance of water; Topography = Topography of an area; Cost = Cost burden; Power = Unreliability of power supply; Administrative = Political and administrative decision bottlenecks; Status = Socio-economic class of residents or water managers; and, Institutional = Weak capacities and institutions to manage water supply systems.

This response blamed the failure to provide water sustainably on office-bearers and their institutions. It suggested the politicisation of water delivery in Cape Town, which wasconfirmed in later discussions with some of the officials interviewed in the study. Forinstance, Participant F9 said.

"Even though we are tasked with formulating water delivery programmes for our community, we are not alone in this task. Other stakeholders often let us down. For instance, are the providers of electricity who often do their load shedding without firstadvising us on our water delivery timelines, which often complicates our programmesas our services are not independent of theirs."

Further analyses of the politicisation of sustainable water delivery revealed more blame games among the concerned stakeholders. Participants highlighted how this was at the forefront of other water management problems and strategies. This, according to Participant F1, is what leads to failure.

“Because each stakeholder wants to appear as if they are doing their job well but is rather disturbed by others, they then use this as the chief excuse for their failure. Suchscapegoats is the order of the day, and even though we have well-known strategies to manage the water crisis, this big obstacle continues to stand in the way.”

These findings, as such, suggest that the most critical challenges in the sustainable use of water in Cape Town include the lack of knowledge on the importance of water, cost burdens, political and administrative bottlenecks, as well as weak institutional capacities in dealing with the water crisis. Of these, the role of administrative bottlenecks and politicisation of water issues take precedence, serving as a critical milestone in managing the causes of the water crisis and the effectiveness of management strategies.

4.7 EFFECTIVENESS OF COPYING STRATEGIES EMPLOYED IN DEALINGWITH THE CAPE TOWN WATER CRISIS

The effectiveness of coping strategies used in the management of the water crisis in Cape Town was also studied. The findings on the effectiveness of the coping strategies used in Cape Town are presented in Table 10. As the findings in Table 10 show, there was a mean response of 4.22 for the effectiveness ofboreholes as a coping strategy. A mean response of 1.28 was obtained for wells, suggesting that the effectiveness was inferior. Means of 2.39, 1.37, 1.21 and 3.23 were presented in these findings, there are only two effective strategies for coping with the water crisis in Cape Town. These include using boreholes and water rationing, which hadhigh effectiveness, as suggested by mean responses of 4.22 and 4.46.

Table 7 Effectiveness of coping strategies used in Cape Town

Cause	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
Investing	318	1.00	5.00	4.3585	1.27970	-.332	.137
Reuse	318	1.00	5.00	1.7799	1.29131	.505	.137
Urbanisation	318	1.00	5.00	4.8145	1.17284	.188	.137
Demand	318	1.00	5.00	4.9088	1.24879	.262	.137
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Quality	318	1.00	5.00	2.7453	1.26387	-.020	.137
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Climate	318	1.00	5.00	3.7075	1.17251	-.832	.137
Economic	318	1.00	5.00	3.4497	1.23908	-.355	.137
Valid N (listwise)	318						

Where, investing = Failure to effectively invest in water services; Reuse = Failure to treat, collect and reuse water; Urbanisation = Increased domestic water consumption due to urbanisation; Demand = Increasing demand from user sectors, e.g., Agriculture; Infrastructure = Deficiency of investment in infrastructure; Quality = Weakening waterquality; Pollution = Water pollution; Climate = Climate change, and Economic = Economic and social activities.

Interview findings on the effectiveness of the coping strategies used in dealing with the water crisis in Cape Town showed that most of these strategies have yet to be effective as they are on an individual level. It seemed agreed among the interview participants that most coping strategies currently in use are ineffective but are born out of necessity rather than efficacy. For instance, Participant F6 had this to say about the effectiveness of copingstrategies.

"We have resorted to using boreholes, even though not many houses have one around here. We normally go to our neighbor's and ask for water to use, especially for cooking and drinking. This is not as effective because a normal household would require water on a 24-hour basis, but at least it is useful because we get to access water as and when we need it."

In reiterating the position held by Participant F6, Participant F2 stated that they only use the strategies to avoid further disasters that can come from the unavailability of water in their houses.

"It does not make sense to sit at home and wait for municipal water. That water is hardly restored on time; some households have even been known to go for weeks without water around here. This makes it important for us to use other sources of water, of which borehole water is the commonest around here. Whilst it is not whatwe would desire, it at least helps keep our houses habitable and free from diseaseslike cholera, typhoid, and dysentery."

The study also evaluated the extent to which the effectiveness of coping strategies used in managing the water crisis in Cape Town is impacted by water challenges. To this end, a second data set was used in the study. This dataset contained such variables as the means for the causes of the water crisis in Cape Town, means for the challenges encountered in the management of the crisis and the effectiveness of the coping mechanisms used in the town. The descriptive statistics of the second data set used in the study are as presented in Table 11.

Table 11 Descriptive statistics for dataset 2

Statistic		**Causes**	**Challenges**	**Effectiveness**
N	Valid	9	7	8
	Missing	0	2	1
Mean		3.5171	3.3225	2.5672
Std. Error of Mean		.34700	.48839	.45815
Std. Deviation		1.04100	1.29217	1.29585
Variance		1.084	1.670	1.679
Skewness		-.093	-.338	.460
Std. Error of Skewness		.717	.794	.752

As Table 11 shows, Dataset 2 is comprised of three variables, namely the causes of Cape Town's water crisis, the challenges experienced in ensuring sustainable water use and the effectiveness of coping strategies used. The mean for the cause's variable was 3.51 whilst those for the

challenges and effectiveness ones were 3.32 and 2.57, respectively. Dataset 2 was used to linear regression tests to establish the effect of water crisis causes and those ofthe challenges encountered in the sustainable use of water on the effectiveness of the coping strategies employed.

The regression findings of the impact of the water crisis causes (Model 1) and challenges (Model 2) on the effectiveness of coping strategies were analysed. The rationale behind the regression analysis was to understand the extent to which the causes of the water crisis led to the establishment of the coping strategies, as well as the effect that the challenges experienced in water management in Cape Town on the coping strategies that are used by people in the town. The findings of the analysis are summarised in Table 12.

Table 8 Regression findings for effect of causes and challenges on coping strategies.

Model	R	R^2	Std. Error	Durbin-Watson	F	Sig.	t	VIF
1	-.818	-.748	1.20707	2.187	.251	.638	.501	1.000
2	.260	.068	1.35153	1.337	.435	.534	.660	1.000

From the findings presented in Table 12, the R^2 coefficient for Model 1 was 0.748 whilst that for Model 2 was 0.068. The findings suggest that the causes of the water crisis significantly and negatively affected the effectiveness of the coping strategies employed. The findings alsoshow that there was no significant relationship between the challenges experienced in sustainable water use and the effectiveness of the coping strategies employed in Cape Town.

As per the fourth objective of the study, it was imperative to establish the strategies that can be used in promoting the sustainable use of water in Cape Town. In Table 13, the findings on the strategies that are being used in the promotion of sustainable use of water in Cape Town are presented.

According to the findings presented in Table 13, the mean response for the importance of attending to the layout of water distribution networks and pipelines as a strategy to deal with the water crisis in Cape Town was 3.16. Means of 3.66, 2.78, 2.79 and 2.89 were obtained forthe importance of integrating such strategies as other methods of availing potable water, attending to water distribution, reticulation, maintenance and consumption, water supply accountability

and using low-priced supply options, respectively. For the importance of such strategies as demand management, addressing settlement patterns, leak control in municipal distribution networks, control on the removal of wastewater and using water allocations, means of 2.83, 2.79, 3.04, 3.68 and 2.80 were obtained in the study, respectively. Also, mean responses of 2.82, 2.86, 2.83, 2.74, 3.04 and 3.68 were obtained for the relevance of using large-scale seawater desalination, large-scale recycle of water, large-scale groundwater development, use of winter rainfall, sewerage wastewater treatment and the construction of new dams to stock water. Lastly, a mean response of 3.39 was obtained for the relevance of managing the illegal use of water.

Table 9 Strategies of promoting sustainable water use in Cape Town.

Statistic		Layout	Potable	Distribution	Accountability	Price	DM	Settlement	Leak	Wastewater	Allocations	Desalination	Recycle	Groundwater	Winter	Sewerage	Dams	Illegal
N	Valid	318	318	318	318	318	318	318	318	318	318	318	318	318	318	318	318	318
	Missing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean		3.1604	3.6604	2.7799	2.7893	2.8931	2.7862	3.0377	3.6824	2.7987	2.8239	2.8648	2.8302	2.7484	3.0440	3.6792	3.3836	3.3931
Std. Error of Mean		.07746	.05575	.07282	.06703	.07073	.07383	.07978	.06835	.07354	.06756	.07135	.07119	.07264	.08014	.06691	.07135	.07345
Mode		4.00	4.00	2.00	2.00	2.00	3.00	4.00	4.00	2.00	2.00	2.00	4.00	3.00	4.00	4.00	4.00	4.00
Std. Deviation		1.38129	.99418	1.29862	1.19526	1.26137	1.31655	1.42261	1.21883	1.31134	1.20480	1.27235	1.26943	1.29531	1.42906	1.19315	1.27236	1.30983
Variance		1.908	.988	1.686	1.429	1.591	1.733	2.024	1.486	1.720	1.452	1.619	1.611	1.678	2.042	1.424	1.619	1.716
Skewness		-.305	-.479	.485	.190	.260	.024	-.285	-.803	.478	.179	.302	-.227	.039	-.293	-.828	-.352	-.367
Std. Error of Skewness		.137	.137	.137	.137	.137	.137	.137	.137	.137	.137	.137	.137	.137	.137	.137	.137	.137

Where; Layout = Layout of distribution networks of pipelines; Potable = Methods of availing potable water to consumers; Distribution =

Water distribution, reticulation, maintenance and consumption; Accountability = Water supply accountability; Price = Low-priced supply options; DM = Demand management; Settlement = Addressing settlement patterns; Leak = Leak control in municipal distribution networks; Waste water = Controls on the removal of wastewater; Allocations = Water allocations; Desalination = Large-scale seawater desalination; Recycle = Large-scale recycle of water; Groundwater = Large-scale groundwater development; Winter = Use of winter rainfall; Sewerage = Sewerage wastewater treatment; Dams = Constructing new dams to stock water; Illegal = Management of illegal water use.

Interview findings on the strategies that can be used to promote the sustainable use of waterin Cape Town showed that there must be increased funding for institutions dealing with the water situation in Cape Town. This was the basis of the response made by Participant I1, whosaid that.

"In most situations where the authorities tasked with the provision of clean andpotable water is failing, you will notice that the issue of finance plays the major role. This is particularly so given the subscription-based nature of the water deliverysystem, as most authorities rely on the payments made by households for their operations. Now that most households continue to default on payments, with even some new houses illegally connected to the water system, there are loopholes in the payments, which frustrates water delivery."

Adding to the statement by Participant I1 was Participant I2, who pointed out the need for a prepaid billing system to deal with the revenue leakages which compromise the financial viability of urban water authorities.

"If we use the prepaid system, people will be forced to pay for what they use and conserve this critical resource. In the end, financial and technical efficiency will be achieved in delivering water in the city, which is our goal."

Also, a significant number of the participants in the study pointed out the need to put the water situation on the national agenda. As argued by the participants, this is necessitated by current interventions and approaches only at household and community levels; the municipalities and other national organs need to give the crisis proper attention and emphasis. For example, Participant F10 said:

"It is important to treat the water crisis as a national issue. The problem with current interventions and solutions is that they are too much at the grassroots level and needto be more effective. To ensure a well-coordinated, top-down approach, there must be serious national concern and policies."

The view held by Participant F5 was confirmed in the response made by Participant H, who intimated that.

"Another critical challenge is that the current efforts to deal with the water crisis need to be coordinated, and there needs to be a better understanding and characterization ofit as a national crisis. This needs to stop by first giving the issue the status of anational crisis as it deserves."

As per these findings, success in managing the water crisis in Cape Town is hinged on the improvement of funding for water management programmes and the management of the problem through national or policy efforts.

4.8 DISCUSSION OF FINDINGS

The study's findings were in line with the objectives of the study. As a restatement, the objectives of the study included ascertaining the causes of the water crisis in Cape Town, establishing the challenges encountered in the sustainable use of water in Cape Town,identifying and ascertaining the effectiveness of coping strategies employed in dealing with the Cape Town water crisis and to establish the strategies of promoting sustainable uses of water.

With regards to the causes of the water crisis in Cape Town, the study's findings suggest that the most critical factors leading to the water crisis in Cape Town include the failure to invest in water services (mean of 4.36), increased water consumption arising from urbanization (mean of 4.81) and increasing demand for water from various user sectors like agriculture, mining and industry (4.91 mean response). To a large extent, the findings confirm thenegative effect of population growth and urban development on the sustainable provision of water in Cape Town, as suggested by Foster et al. (2011), Yeboah et al. (2013) and McGranahan and Satterwaite (2014), among others.

The findings also suggested that the water crisis in Cape Town is given less priority. As a result, there has been a marked decline in the investments made in constructing and maintaining such critical water infrastructure as dams and waterways. These findings seem contradictory with the position that the government of South Africa prioritizes water distribution and supply as evidenced in the formulation of such policies as the Water ServicesAct (No. 108 of 1997) and the National Water Act (No. 117 of 1998), as argued by the government (South Africa, 1998). However, the findings only seem relevant when it is considered that despite the existence of water policies in South Africa, there has been little translation of policy objectives into reality, as evidenced by general backwardness in the maintenance and development of water treatment,

storage, and distribution facilities and services associated with the sustainable use of water (Gaunt, 2010; Hidden and Cillier, 2014;). Hidden and Cillier (2014) agree that this lack of efficiency in translating policy objectives into praxis is one of the reasons for the water crisis in Cape Town. The failure to routinely and frequently "update" water policies, particularly about the activities of theDepartment of Water and Sanitation (DWS), has also been fingered as one of the factors leading to the crisis (Turpie et al., 2008; Hidden and Cillier, 2014;).

Added to the low prioritization of water issues, the findings also suggest that such climate change-related issues as rainfall variability (mean response of 4.6) and flooding (4.7 means) have negatively contributed to Cape Town's water crisis. These findings show that the issueof water pollution seems insignificant in leading to the water crisis in Cape Town, which is against the findings that physical, chemical, and bacterial pollution significantly contribute to water scarcity, as suggested elsewhere (Schijven et al*.,* 2010; Bagvand et al., 2010)

Relating to the challenges which are being encountered in the sustainable use of water in Cape Town, the study established the most significant challenges as being the lack of knowledge on the importance of water (mean 4.18), cost burdens (4.35 mean), political and administrative bottlenecks (4.09 mean) as well as weak institutional capacities in dealing withthe water crisis (mean 4.73). From these findings, the most crucial challenges to sustainable water use in Cape Town include administrative bottlenecks and water politicization. The issue of public accountability in water management is a leading cause for the current unsustainable use of water in Cape Town, serving both as a cause and an effect. Responsibilities for the delivery of water, and any associated problems in achieving it, needto be clarified amongst the various stakeholders involved. The roles and duties played by various stakeholders in the management of cases of water unavailability remain hazy. The findings on the issue of water administration bottlenecks and politics in decision-makingwere expected and substantiated earlier findings that these challenges are not only familiar but also lead to inefficiencies in water supply (Baker, 2010; Leftus, 2015).

Interviews were conducted with participants from different organizations. Some were company and farm owners, managers, and heads from companies. The existence of various types of conflicts involving a plurality of stakeholders was verified in this study and for the context of water services in Cape Town, confirming earlier positions that the decision-making processes among various stakeholders can be compromised or weakened (Ainuson, 2011; Leftus, 2015)

Findings on the effectiveness of coping strategies used in managing the water crisis in Cape Town

reveal that only the use of boreholes (mean 4.22) and water rationing (mean 4.46) are effective in the management of the crisis. While other strategies have been used, theireffectiveness in managing the water crisis remains limited. For example, the use of wells onlyhad a mean of 1.28, whilst that of using purchased water was 1.37. The lack of effectiveness in most of the coping strategies currently being used in Cape Town was related to the factthat most such strategies are only at a household level and are difficult to apply on a national scale. The regression findings of the impact of the water crisis causes (Model 1) and challenges (Model 2) on the effectiveness of coping strategies showed that the R2 coefficient for Model 1 was 0.748, whilst that for Model 2 was 0.068. This suggested that the causes of the water crisis significantly and negatively affected the effectiveness of the coping strategies employed and that there is no significant relationship between the challenges experienced in sustainable water use and the effectiveness of the coping strategies employed in Cape Town.

Lastly, apropos of the strategies which can be used to promote sustainable uses of water in Cape Town, the findings of the study were that a multiplicity of strategies could contribute to water sustainability. These include such strategies as attending to water networks and pipelines (mean 3.16), using potable water (mean 3.66), fixing the water reticulation systems (mean 2.78) and enhancing accountability in water governance (mean 2.79). Regarding the water supply and water distribution system, the findings confirm its critical need, as WaterAid noted (2012). On its part, WaterAid (2012) notes that there is a need for an effective and efficient water distribution system, particularly in terms of the layout of water distribution networks and pipelines which serve households and commercial enterprises (WaterAid, 2012). These systems can be based on pumping, gravity, or using both methods. Attending to such systems is one of the perspectives possessed in the IUWM framework, which emphasizes the sustainability of water service provision by attending to the engineering and functional aspects of the water system (Kattsov *2013*).

Also relevant, as established in the study, are such strategies as using low-priced water payments (mean 2.89), demand management (mean 2.83), settlement management (mean 2.79), the management of water leaks in municipal networks (mean 3.04) and wastewater control (mean 3.68). In terms of using low-priced water payments, it is recommended that theCape Town municipality uses strategies that can lower water prices, taking into considerationopportunity costs. Foster et al. (2011) suggests that the adoption of gravity mechanisms in water distribution, stead of pumping methods, has also been suggested to reduce costssignificantly. Even though

this is not the only strategy to reduce operational costs and, ultimately, the price of water, it is among the most effective strategies that can be used in Cape Town, especially for the area of high relief.

The findings also suggested a fair relevance for the use of such strategies as water allocations, sea-water desalination (mean 2.82), water recycling (mean 2.86), the development of groundwater sources (mean 2.83) and the use of winter rainfall (mean 2.74). The findings also suggested a fair relevance of sewerage treatment (mean 3.04), dam construction (mean 3.68) and the management of the illegal use of water (mean 3.39). It was also suggested that funding for water management programmes could be helpful in the management of Cape Town's water crisis. Part of the reasons why most of these strategies can only be partially effective in managing the water crisis in Cape Town could be because some of the most determinant factors leading to the rise of the water crisis are related to climate change. As such, it would make sense for most of the strategies to be hinged on managing the effects of climate change, which has been found to increase the vulnerabilities of households (Tadesse, 2010; Murthy, 2013). Cape Town can benefit from integrating a multiplicity of factors and strategies that can enhance both the quality and quantity of water delivered to households, which is in line with the IUWM framework. Integrating IUWM principles is one of the best approaches for the sustainable provision of clean water in Cape Town as both surface and sub-surface, as well as natural and artificial strategies, can be integrated into the planning and management of water systems in towns and cities (Kattsov *etal*., 2013).

4.9 CHAPTER SUMMARY

This chapter focused on the presentation and analysis of the study's findings. Initially presented in the chapter was a section on the analysis of the study, including the response ratefrom the use of questionnaires and the reliability analysis. The questionnaires had a percentage response of 65%, whilst a Cronbach Alpha coefficient of 0.632 was obtained in the reliability analysis. Findings on the demographic details of the participants were also presented, including their age, gender, and highest academic qualification. The chapter also contained the presentation of findings on the objectives of the study, and this included such aspects as the causes of the water crisis in Cape Town; the challenges encountered in the sustainable use of water in Cape Town; the effectiveness of coping strategies employed in dealing with the Cape Town water crisis, and the strategies of promoting sustainable uses of water. A section on the discussion of findings from the study was also presented. The next chapter focuses on the study's summary, conclusions, and

recommendations.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

As the previous chapter focused on the presentation and analysis of the study's results, the present chapter complements this process by providing the conclusions and recommendationsmade in the study. Initially presented in the present chapter, however, is a summary of the study's significant findings to provide an abridged overview of what the study managed to establish in line with its key objectives. The summary is followed by the conclusions of the study, which detail the deductions arrived at from the research. The recommendations of the study are presented after that, focusing on the significant suggestions that stakeholders should adopt to improve and achieve sustainable management of the water crisis in Cape Town. Afterwards, the chapter contains a section on areas identified for further research.

5.2 SUMMARY OF MAJOR FINDINGS

The study's findings were in line with the objectives of the study. As a restatement, the objectives of the study included ascertaining the causes of the water crisis in Cape Town, establishing the challenges encountered in the sustainable use of water in Cape Town,identifying and ascertaining the effectiveness of coping strategies employed in dealing with the Cape Town water crisis and to establish the strategies of promoting sustainable uses of water.

The study's findings suggest that the most critical factors leading to the water crisis in Cape Town include the failure to invest in water services (mean of 4.36), increased water consumption arising from urbanisation (mean of 4.81) and increasing demand for water from various user sectors like agriculture, mining, and industry (4.91 mean response). The findingsalso suggested that the water crisis in Cape Town is given less priority. As a result, there has been a marked decline in the investments made in constructing and maintaining such critical water infrastructure as dams and waterways. The findings also suggest that climate change- related issues like rainfall variability (mean response of 4.6) and flooding (4.7 means) have negatively contributed to Cape Town's water crisis.

Relating to the challenges which are being encountered in the sustainable use of water in Cape Town, the study established the most significant challenges as being the lack of knowledge on the importance of water (mean 4.18), cost burdens (4.35 mean), political and administrative bottlenecks (4.09 mean) as well as weak institutional capacities in dealing withthe water crisis (mean 4.73). From these findings, the most crucial challenges to sustainable water use in Cape Town include administrative bottlenecks and water politicisation. The issue of public accountability in water management is a leading cause for the current unsustainable use of water in Cape Town, serving both as a cause and an effect. Responsibilities for the delivery of water, and any associated problems in achieving it, are notclear-cut amongst the various stakeholders involved. The roles and duties played by various stakeholders in the management of cases of water unavailability remain hazy.

Findings on the effectiveness of coping strategies used in managing the water crisis in Cape Town reveal that only the use of boreholes (mean 4.22) and water rationing (mean 4.46) are effective in the management of the crisis. While other strategies have been used, theireffectiveness in managing the water crisis still needs to be improved. For example, the use of wells only had a mean of 1.28, whilst that of using purchased water was 1.37. The lack of effectiveness in most of the coping strategies currently being used in Cape Town was related to the fact that most such strategies are only at a household level and are difficult to apply ona national scale. The regression findings of the impact of the water crisis causes (Model 1)and challenges (Model 2) on the effectiveness of coping strategies showed that the R2 coefficient for Model 1 was 0.748, whilst that for Model 2 was 0.068. This suggested that the causes of the water crisis significantly and negatively affected the effectiveness of the coping strategies employed and that there is no significant relationship between the challengesexperienced in sustainable water use and the effectiveness of the coping strategies employed in Cape Town.

Lastly, apropos of the strategies which can be used to promote sustainable uses of water in Cape Town, the study's findings were that a multiplicity of strategies could contribute to water sustainability. These include such strategies as attending to water networks and pipelines (mean 3.16), using potable water (mean 3.66), fixing the water reticulation systems (mean 2.78) and enhancing accountability in water governance (mean 2.79). Also relevant aresuch strategies as using low-priced water payments (mean 2.89), demand management (mean 2.83), settlement management (mean 2.79), the management of water leaks in municipal networks (mean 3.04) and wastewater control (mean 3.68). The findings also suggested a fair relevance for the use of such

strategies as water allocations, sea-water desalination (mean 2.82), water recycling (mean 2.86), the development of groundwater sources (mean 2.83) andthe use of winter rainfall (mean 2.74). The findings also suggested a fair relevance ofsewerage treatment (mean 3.04), dam construction (mean 3.68) and the management of the illegal use of water (mean 3.39). It was also suggested that funding for water management programmes could be helpful in the management of Cape Town's water crisis.

5.3 CONCLUSIONS

In the present section, the conclusions made in the study are presented. These conclusions detail the significant inferences made after the data analysis on the study's research objectives.

5.3.1 Causes of Cape Town's water crisis

The water crisis in Cape Town has arisen mainly from the rise in water demand because of rapid urbanisation and the increasing demand for water in vital economic sectors like mining, agriculture, and industry. Also contributing to the city's water crisis is the authorities' failureto invest appropriately in water services and infrastructure. To a significant extent, the effectsof climate change have also led to a rise in the demand for potable water, mainly as there is now a high rainfall variability and the continued occurrence of floods.

5.3.2 Challenges to the sustainable use of water in Cape Town

The significant challenges which continue to frustrate efforts for the sustainable use of water in Cape Town include the need for knowledge on how water is a crucial resource, as well as high costs incurred in the smooth running of water delivery systems to both households and commercial customers. Added to these are problems in the administration and the politics of water governance, and poor public accountability in Cape Town, which can be related to the weak capacities of institutions tasked with water management in the city.

5.3.3 Effectiveness of water crisis copying strategies in Cape Town

Most of the coping strategies used in dealing with the water crisis in Cape Town could be more effective. Of these strategies, only boreholes and water rationing are dominant and influential. Other strategies, which include using shallow wells and purchasing water, could be more effective in leading to sustainable water use in Cape Town. The reason for the failureof most coping strategies is that they are hardly on the national level but are domestic or household

strategies whose efficacy and longevity are primarily limited and do not impact thesustainable management of water in the city.

Most of the coping strategies used in dealing with the water crisis in Cape Town could be more effective. Of these strategies, only boreholes and ratings are dominant and influential. Other methods, including using shallow wells and purchasing water, could be more effective in promoting sustainable water use. Most coping strategies fail because they are not on the national level but are domestic or household strategies whose efficacy and longevity are primarily limited and do not impact water in the city.

5.3.4 Strategies to promote sustainable water use in Cape Town

Multiple strategies can contribute towards the sustainable use of water in Cape Town. Theuse of such strategies as mending water infrastructure, providing potable water, being accountable in the management of water, using demand management systems like prepaid metres and developing groundwater sources can significantly promote the sustainable use of water in Cape Town. However, it is noteworthy that most of these strategies only relatively improve the capacity of Cape Town to use water sustainably and, as such, the strategies must be used or applied mutually or collectively.

5.4 RECOMMENDATIONS

This section contains the recommendations of the study. These recommendations detail the significant proposals and suggestions for managing the water crisis in Cape Town andachieving sustainable water use. Among the key recommendations made in the study is the need for investments in critical water infrastructure, educational programmes for the Cape Town community and for public officials tasked with water management to formulate a single, comprehensive water management authority for the use of prepaid metering demand management systems and the development of groundwater systems.

5.4.1 Invest in water infrastructure.

It is suggested that there must be a higher investment in water infrastructure in Cape Town. This suggestion is made on the backdrop of the findings that there is currently a poor level of investment in water infrastructure, which is one of the factors contributing to the rise of the water crisis in the city. The current infrastructure in the town needs to be updated, dilapidated and generally inadequate in serving the water requirements of the town, significantly since the water

demand is rising owing to urbanisation and the development of other economic sectors like agriculture, tourism, and industry. Investments in crucial water management infrastructure like dams, reservoirs, storage tanks, water treatment works, and waterways are necessary. Such investment must be made using national funds and engaging private investors and public-private partnerships (PPPs). Investments in crucial water infrastructure development should be made when funds are available but should be done urgently.

5.4.2 Educational programmes on the importance of water

The study also suggests community education programmes. These programmes should educate the water authorities and user communities on the importance of sustainable water use. The milieu leading to this recommendation is the findings that most of the public officials tasked with water management and the water users need to give higher regard towards the importance of water as a scarce resource. The net effect of this lack of knowledgeis the failure to conserve water and practice proper water management in the face of a crisis. The waste of water works against the goals of ensuring that every household in Cape Town obtains vital resources and contributes to water scarcity in the town. As such, education programmes should be put in place. These programmes should explain the perceived importance of water and practical water management techniques, such as avoiding household water leaks and strategies for limiting water usage in bathrooms, kitchens, and geysers,among other domestic purposes. For the water authorities, the education programmes should prioritise the communication of information and knowledge on the best practices in such topical issues as the distribution of water, attending to water faults, the treatment of water, efficient harvesting, and storage of rainwater, among others. Such educational programmes will help solve the challenges of water wastage leading to shortages and high-water delivery and management costs. These programmes should be done as a matter of urgency as the water crisis is currently ongoing in Cape Town.

5.4.3 Formulate a single, comprehensive water management authority.

For the sustainable management of water in Cape Town, it is also recommended that there must be systems that enhance public accountability in the governance of water. This study established that poor accountability, politics in administration and governance, and the weak capacities of institutions tasked with water management in the city are among the critical challenges leading to water shortages in Cape Town. The study also revealed that there needs to be a clear national coping strategy for managing localised water crises, as is currently the case in Cape Town. Some of the poor organisation's effects are reflected in the continued "blame games" that see concerned

water users unable to get practical assistance when needed.To this end, a single, comprehensive, and principal administrator should be formulated and mandated to manage Cape Town's water issues. Such an organisation should include officialsfrom the electricity service provider, water service providers, law enforcement agents, environmental agencies, and town planners, among other stakeholders. By being inclusive and comprehensive, the authority will at least be able to house all stakeholder concerns under one roof to quickly resolve water issues, which could also guide national coping strategies. The means through which this authority can be put in place is the Constitution of South Africa.

5.4.4 Prepaid metering demand management systems

It is also recommended that the Cape Town municipality use demand management systems to provide water in the city. The findings that there are high costs involved in the provision of clean water to residents, as well as that some of the households and commercial water users do not pay due regard to the importance of water, suggest the need for a system which helpsto limit unnecessary usage and wastages. To this effect, demand management systems are a possible solution. In particular, the use of the old, conventional metering system should be discarded and replaced with the use of prepaid metering systems. These are systems that usea smart meter that only dispenses the water that has been paid for by the user, limiting their usage to the amount they would have paid for. These emerging technologies have been successful in the developed parts of the world and could help regulate water use in both domestic and commercial systems. The use of prepaid meters is a capital-intensive programme that the Cape Town municipality should embark on step-by-step. However, pilot projects are encouraged first to establish the efficacy and feasibility of the systems beforethey are rolled out on a large-scale, city-wide basis.

5.4.5 Development of groundwater systems

The alleviation of the water crisis in Cape Town and the sustainable provision of water in the future also hinged on the development of groundwater sources, particularly boreholes. The study found that groundwater sources can significantly promote sustainable water use inCape Town. With the richness of groundwater sources in not only Cape Town but even the entire of South Africa, reliance on them for the provision of water could be an effective solution. This is the benefit of this source since it can be easily accessible from any point, which makes it suitable for use, especially by commercial enterprises like farms and mines.At the same time, with the high unreliability of surface water sources like dams and rivers owing to the continuing variability in rainfall and due to climate change, groundwater sourcescould be a more reliable source of

water in the future. As such, the development of groundwater sources should be the priority of households at the Cape Town municipality and national levels.

5.5 AREAS FOR FUTURE RESEARCH

Several areas must be taken into consideration in future studies. One of these is the need for larger research samples, which could enhance the validity and reliability of findings. The present study relied on a relatively small sample for a large city of Cape Town's size, which could limit the findings. Also, future studies can make use of advanced analytical techniques like the integration of statistical modelling, neural networks, and the integration of geographical information systems (GIS) and their related concepts. It would be helpful to perform a risk mapping of the levels of vulnerability of Cape Town suburbs to water scarcity as informed by both rainfall and municipal water distribution, as such a study will be highly informative by avoiding being overly generalising since not all Cape Town localities have the exact extent of water shortage. Geographical mapping can also be applied to studying groundwater sources as sustainable water resources to effectively understand the spatialdistribution patterns of underground water sources and relate them to the various locations within Cape Town.

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APPENDICES

Appendix A: Informed consent form

My name is Yeukai Musariri, and I am a master's student from The University of South Africa. The focus of this research is to establish the factors affecting sustainable water uses inCape Town. I selected you for participation in this study as you are among the key stakeholders in this research project.

Before we begin this interview, please note that:

(i). Your participation is strictly voluntary, and you are allowed to withdraw at any time you fell so, and you also reserve the right to answer or refrain from answering any question withinthe interview. However, it would be in the best interests of the study for you to answer all the questions.

(ii) Participation in this study comes with no repercussions on your personal or professional lives. Also, participation in the study comes with no financial or material benefits.

(iii) There are various processes which will be carried out as part of this research and the motive will purely be academic. This includes voice recording or this interview and the resulting sorting, analysis, and reporting (publishing) of the findings from this and other interviews.

(iv) Your consent to participate in this interview is hereby formally requested. By proceeding with the interview, your consent is regarded as affirmed.

Can we proceed with the interview? Yes _____

No _____

Appendix B: Research questionnaireResearch Questionnaire

Section A: Demographic details of participant

A1. Please provide your age. _____

A2. What is your gender?

Male	
Female	

A3. What is the highest academic qualification that you possess?

Certificate	
Diploma	
Undergraduate degree	
Graduate degree	
Postgraduate degree	

Section B: Causes of the water crisis in Cape Town

B1. The following are some of the common causes of water crises. Please rank the extent to which each of the stated causes applies in leading to the water crisis in your community.

Cause					
Failure to effectively invest in water services					
Failure to treat, collect and reuse water					
Increased domestic water consumption due to urbanisation					
Increasing demand from user sectors eg. agriculture					
Deficiency of investment in infrastructure					
Weakening water quality					
Water pollution					
Climate change					
Economic and social activities					

B2. Climate change has also been suggested as one of the major causal factors leading to water crises. Please rank the extent to which the following climate change aspects areresponsible for

the water crisis in your community.

Factor					
Rainfall variability					
Drought					
Unexpected prolong downpours or flooding					
Declining precipitation levels					
Increased temperatures					

Section C: Challenges encountered in the sustainable use of water in Cape Town

There are various challenges which continue to be met in the sustainable provision of water in Cape Town. Please rank the extent to which each of the challenges listed below apply to your community's context.

Challenge					
Officials do not fully value importance of water					
Topography of an area					
Cost burden					
Unreliability of power supply					
Political and administrative decision bottlenecks					
Socio-economic class of residents or water managers					
Weak capacities and institutions to manage water supply systems					
Inadequate financial resources to maintain infrastructure					

Section D: Effectiveness of coping strategies employed in dealing with the Cape Town water crisis.

To what extent have the following coping strategies been effective in dealing with the water crisis in Cape Town?

Strategy					
Use of boreholes					
Use of shallow wells					
Storage of water eg. water tanks					
Purchasing bulk water					
Accessing river water sources					
Limiting water consumption eg. Avoiding flush toilet systems					

Rainwater harvesting					
Water rationing					

Section E: Strategies of promoting sustainable uses of water

The sustainable use of water can be promoted using various strategies. Please rank the extent to which each of the strategies suggested below can be effective in promoting the sustainable use of water in Cape Town.

Strategy					
Layout of distribution networks of pipelines					
Methods of availing potable water to consumers					
Water distribution, reticulation, maintenance, and consumption					
Water supply accountability					
Low-priced supply options					
Demand management					
Addressing settlement patterns, such as minor plot sizes					
Leak control in municipal distribution networks					
Controls on the removal of wastewater					
Water allocations					
Large-scale seawater desalination plant					
Large-scale recycle of water					
Large-scale groundwater development					
Use of winter rainfall					
Sewerage wastewater treatment					
Constructing new dams to stock water					
Management of illegal water use, eg. by irrigators					

End of Questionnaire. Thank you.

Appendix C: Interview guide

1. What are the root causes of the water crisis in Cape Town?
2. Which challenges are being encountered in the sustainable use of water in Cape Town?
3. What copying strategies are being employed in dealing with the Cape Town water crisis, and how effective are they?
4. How can the sustainable use of water in Cape Town be promoted?

Appendix D: Model summaries

Model summary for effect of challenges on coping strategy effectiveness.

Model		R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change			Sig. F Change	
1		.748	.543	1.20707	.048	.251			.638	2.187

a. Predictors: (Constant), Challenges

b. Dependent Variable: Effectiveness

Model summary for effect of water challenge causes on effectiveness of coping strategies.

		R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change			Sig. F Change	
		.068	-.088	1.35153	.068	.435			.534	1.337

a. Predictors: (Constant), Causes

b. Dependent Variable: Effectiveness

Appendix E: Analysis of Variance (ANOVA) TablesANOVA for effect of water challenges on coping strategy effectiveness.

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	.365	1	.365	.251	.638[b]
Residual	7.285	5	1.457		
Total	7.650	6			

a. Dependent Variable: Effectiveness

b. Predictors: (Constant), Challenges

ANOVA for effect of water crisis causes on effectiveness of coping strategies.

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	.795	1	.795	.435	.534[b]
Residual	10.960	6	1.827		
Total	11.755	7			

a. Dependent Variable: Effectiveness

Appendix F: Residual coefficients

Residual coefficients for effect of water challenges on effectiveness of coping strategies

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	1.662	1.347	.218	1.234	.272		
Challenges	.191	.381		.501	.638	1.000	1.000

a. Dependent Variable: Effectiveness

Residual coefficients for effect of water crisis causes effectiveness of coping strategies.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	1.499	1.688	.260	.888	.409	1.000	1.000
Causes	.303	.459		.660	.534		

a. Dependent Variable: Effectiveness

Appendix G: Collinearity diagnostics

Collinearity diagnostics for effect of water challenges on effectiveness of coping strategies.

Model Dimension	Eigenvalue	Condition Index	Variance Proportions	
			(Constant)	Challenges
1	1.941	1.000	.03	.03
2	.059	5.729	.97	.97

a. Dependent Variable: Effectiveness

Collinearity diagnostics for effect of water crisis causes on effectiveness of coping strategies.

Model Dimension	Eigenvalue	Condition Index	Variance Proportions	
			(Constant)	Causes
1	1.959	1.000	.02	.02
2	.041	6.920	.98	.98

a. Dependent Variable: Effectiveness