A COMPARATIVE EVALUATION OF WATER SUPPLY PERCEPTIONS AND OVERALL WATER STEWARDSHIP IN HAMMANSKRAAL AND ATTERIDGEVILLE

by

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DEDICATION

This Dissertation is dedicated to my sweet, late grandmother Koko Refilwe Mabena, for encouraging me, always being interested in my research, listening to my ideas and being a true environmentalist at heart.

DECLARATION

I, Keitumetse Mthimunye hereby declare that the dissertation, with the title: *A Comparative Evaluation of Water Supply Perceptions and Overall Water Stewardship in Hammanskraal and Atteridgeville* which I hereby submit for the degree of Master of Science in Geography at the University of South Africa, is my own work and has not previously been submitted by me for a degree at this or any other institution.

I declare that the dissertation does not contain any written work presented by other persons whether written, pictures, graphs or data or any other information without acknowledging the source.

I declare that where words from a written source have been used the words have been paraphrased and referenced and where exact words from a source have been used the words have been placed inside quotation marks and referenced.

I declare that I have not copied and pasted any information from the Internet, without specifically acknowledging the source and have inserted appropriate references to these sources in the reference section of the dissertation.

I declare that during my study I adhered to the Research Ethics Policy of the University of South Africa, received ethics approval for the duration of my study prior to the commencement of data gathering, and have not acted outside the approval conditions.

I declare that the content of my dissertation has been submitted through an electronic plagiarism detection program before the final submission for examination.

Date: 09 December 2020

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SUMMARY

This research focused on evaluating and comparing the perceptions, water-use behaviour, water conservation awareness and overall water stewardship of participants residing in Hammanskraal and Atteridgeville who have experienced intermittent water supply in their domestic households – due to either water contamination incidents caused by dilapidated infrastructure or water restrictions implemented by the City of Tshwane Metropolitan Municipality during the 2016–2017 drought in the Gauteng Province. The research concluded that the municipality needs to implement proactive water conservation awareness initiatives on an ongoing basis to reduce high water demands and to create a culture of water stewardship, especially in Atteridgeville. Transparent communication is also required from the municipality to instil the necessary trust among the public. It is recommended that the municipality attends to water leaks and ongoing complaints from the public timeously to reduce the current apathy from the public against reporting water-related issues and to ultimately ensure compliance to water restrictions.

Key terms:

township water supply, water conservation awareness, non-revenue water, water leaks, water stewardship, water restrictions, water-use behaviour, water contamination, municipal water supply, Gauteng drought.

OPSOMMING

Hierdie navorsing fokus op die evaluering en vergelyking van deelnemers wat in Hammanskraal en Atteridgeville woon se persepsies, waterverbruiksgedrag, waterbewaringsbewustheid en algehele waterrentmeesterskap, wat onderbroke watervoorsiening in hulle huishoudings ervaar het – as gevolg van waterbesoedelingsvoorvalle wat deur vervalle infrastruktuur veroorsaak is en waterbeperkings wat deur die Stad Tshwane Metropolitaanse Munisipaliteit gedurende die 2016 tot 2017-droogte in Gauteng ingestel is. Die navorsing het tot die gevolgtrekking gekom dat die munisipaliteit proaktiewe waterbewaringsbewustheidsinisiatiewe op ’n deurlopende grondslag moet implementeer om hoë wateraanvraag te verminder en ’n kultuur van waterrentmeesterskap, veral in Atteridgeville, te skep. Deursigtige kommunikasie word ook van die munisipaliteit vereis om die nodige vertroue by die publiek te kweek. Daar word aanbeveel dat die munisipaliteit betyds aandag aan waterlekkasies en deurlopende klagtes van die publiek sal gee om die huidige onverskilligheid van die publiek by die aanmeld van waterverwante aangeleenthede te verminder en om uiteindelik te verseker dat die publiek die waterbeperkings eerbiedig.

Sleutelterme:

townshipwatervoorsiening, waterbewaringsbewustheid, water sonder inkomste, waterlekkasies, waterrentmeesterskap, waterbeperkings, waterverbruiksgedrag, waterbesoedeling, munisipalewatervoorsiening, Gauteng-droogte

KAKARETSO

Patlisiso ena e ne e tsepame hodima ho lekola le ho bapisa maikutlo, boitshwaro ba tshebediso ya metsi, tsebo ka poloko ya metsi le tlhokomelo e akaretsang ya metsi ke bankakarolo ba dulang Hammanskraal le Atteridgeville ba bileng le phepelo ya metsi e kgaohang malapeng a bona – e ka ba ka lebaka la diketsahalo tsa tshilafatso ya metsi e bakilweng ke dipeipi tse senyehileng kapa ho kgaolwa ha metsi ho kentsweng tshebetsong ke Masepala wa Motsemoholo wa Metropolitan wa Tshwane nakong ya komello ya 2016–2017 porofenseng ya Gauteng. Patlisiso e fumane hore masepala o hloka ho kenya tshebetsong matsholo a ho atisa tsebo ka poloko ya metsi ka mokgwa o tswellang e le ho fokotsa tlhokeho e phahameng ya metsi le ho theha ditlwaelo tsa tlhokomelo ya metsi, haholo ho la Atteridgeville. Ho boetse ho hlokeha puisano e hlakileng e nang le ponaletso ho tswa ho masepala e le hore setjhaba se be le tshepo ho ona. Ho kgothaletswa hore masepala a sebetsane le diketsahalo tsa ho dutla ha metsi le ditletlebo tse tswellang tse tswang ho setjhaba ka potlako e le ho fokotsa maikutlo a ho tsotelle a tswang ho setjhaba mabapi le ho tlaleha mathata a amanang le metsi le ho netefatsa hore batho ba latela melawana ya phokotso ya metsi.

Mantswe a bohlokwa:

phepelo ya metsi ya lekeishene, tsebo ka poloko ya metsi, metsi a sa tliseng tjhelete, ho dutla ha metsi, tlhokomelo ya metsi, ho fokotswa ha metsi, boitshwaro ba tshebediso ya metsi, tshilafatso ya metsi, phepelo ya metsi ya masepala, komello ya Gauteng.

ABSTRACT

This research evaluates and compares the perceptions on water supply, water-use behaviours, conservation awareness and overall water stewardship of participants from a rural township (Hammanskraal) and a peri-urban township (Atteridgeville) in Pretoria, South Africa. A case study research design approach was followed to investigate the intermittent water supply events in Hammanskraal and Atteridgeville following the implementation of water restrictions by the City of Tshwane Metropolitan Municipality on account of sewage effluent spillages which continually contaminate the drinking water resources for Hammanskraal and a drought which struck Atteridgeville and the entire Gauteng region in 2016-2017.

Using a mixed method research approach, four data collection instruments namely surveys (questionnaires), focus group discussions and observations were conducted in the respective research areas, while one-on-one interviews were conducted with officials from the Water Supply Division of the City of Tshwane Metropolitan Municipality.

The findings indicate that the participants from both research areas perceived that their water supply challenges were attributed to mismanagement and an overall lack of transparency from the municipality, which has caused distrust by the public. Furthermore, the municipality's delays in repairing water leakages and its challenges in timeously addressing complaints exacerbate the apathy of the public towards actively practising water conservation and notifying the municipality of water wastage in their communities. Nonetheless, water conservation awareness actions were practised in Hammanskraal and the participants in this area had an overall culture of water stewardship, despite having a perception that the tap water supplies in the area are of poor quality. In Atteridgeville however, participants neither conserved water nor demonstrated evidence of water stewardship on account of the residents in the area having open-access to alternative sources of water (fire hydrants) during restrictions, which in essence did not reduce the huge demand for water or encourage sustainable water usage during the drought. This research concludes that the use of a reactive approach and the heightened promotion of water conservation during a water-related crisis seldom mitigates the heavy demand for water and does not encourage water-saving behaviours on a long-term basis. Through the implementation of the recommendations in this research, the City of Tshwane Metropolitan Municipality and other water service providers could effectively ensure improved integrated water resource management, reduce the high water demands, achieve long-term water conservation actions and create future water stewardship in the domestic household sphere.

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CHAPTER 1: INTRODUCTION AND PROBLEM STATEMENT

1.1. Introduction

In recent years, water has become a scarce resource that must be used in a sustainable manner to ensure that both present and future generations adequately benefit from its use. Du Plessis (2017) states than an adequate water supply is a key element to ensuring good health in human beings and the wellbeing of the environment. Many developed and developing countries around the world are facing the challenge of providing the global population with safe and secure water supplies (Erickson et al., 2017). Water supply issues can be attributed to limited freshwater resource availability, poor water quality, malfunctioning and leaking pipeline infrastructure as well as climate variability (Simukonda et al., 2018). Overall, water is a scarce resource and its scarcity has resulted in the implementation of water restrictions and the ultimate intermittence of water supplies, which can be an inconvenience to water-users.

In South Africa, municipalities and other water service institutions are mandated by the South African Water Services Act (No. 108 of 1997) to supply the public with basic water supplies and sanitation services. Furthermore, Section 27(1)(b) of the Constitution (Constitution of the Republic of South Africa, 1996) clearly emphasises that everyone has the right to have access to adequate supplies of clean water.

Despite what is enshrined in the aforesaid law, South African municipalities continue to face challenges in providing adequate water supplies to domestic households. These municipal water supply challenges are exacerbated by *inter alia* infrastructural malfunctions at municipal water treatment plants and climate variability, as seen in the recent droughts (Distefano & Kelly, 2017; Simukonda et al., 2018). The prolonged droughts, coupled with the unsustainable consumption of water by domestic households have forced water suppliers to implement water restrictions in a quest to reduce the strain on declining dam and reservoir levels (Kenney et al., 2004).

This research therefore focuses on the water supply challenges faced by the residents of Hammanskraal and Atteridgeville in Pretoria, Gauteng. Both these research areas receive water supply services from the City of Tshwane Metropolitan Municipality.

Hammanskraal has been subject to water restrictions owing to failing infrastructure and systemic malfunctions at the Rooiwal Wastewater Treatment Plant. These infrastructural and systemic failures have resulted in sewage effluent spillages into the Apies River, the freshwater source for Hammanskraal (DWS, 2019). These water contamination

incidents ultimately resulted in the South African Human Rights Commission (SAHRC) deeming the drinking water in Hammanskraal to be unfit for human consumption (Mahlangu, 2019). In addition, the water contamination incidents in Hammanskraal forced the City of Tshwane Metropolitan Municipality to implement water restrictions and to supply tap water intermittently to households in the area while attempting to rectify the problem. The intermittent water supply challenges faced by Hammanskraal date as far back as 2015 and these issues have continued to date (Matsena, 2015; Maluti, 2020). On the other hand, Atteridgeville's water restrictions over recent years were imposed on the residents owing to the drought which struck Gauteng in the Spring season of 2016 and early 2017 (Tandwa, 2016).

This research sets out to investigate and compare the perceptions, water-use behaviours and conservation awareness of the Hammanskraal and Atteridgeville residents as to their water supply. Through this research, the researcher aims to establish the overall water stewardship in both research areas and offer suitable recommendations to address the water supply challenges faced by the residents therein. This research also aims to promote a future ethos of water conservation awareness as a coping mechanism during the times when there is a lack of water in the domestic households in the research areas. A description of the background to the research problem now follows.

1.2. Background to the Problem

In order to provide context to the research problem, reflections on some of the media coverage of the water-related challenges experienced by the residents in Hammanskraal and Atteridgeville will serve to highlight the problem which this particular research aims to investigate.

The Democratic Alliance (DA) (2015) raised important concerns on the system failures and infrastructure malfunctions at the Rooiwal Wastewater Treatment Plant in Hammanskraal that caused raw sewage sludge to overflow into the Apies River, which feeds into the Leeuwkraal Dam, the main source of the drinking water in Hammanskraal. This incident occurred in 2015 and has ensued on numerous occasions in subsequent years (DWS, 2019). Following these water contamination incidents, the City of Tshwane Metropolitan Municipality was forced to implement water restrictions on the tap water received by the Hammanskraal residents, while maintenance operations proceeded at the aforesaid water treatment plant. This water contamination incident further resulted in the water supply issue in Hammanskraal being dubbed a *"humanitarian crisis"* (DA, 2015). Moreover, what may have started off as mere water restrictions in Hammanskraal

attributed to the aforesaid water contamination incidents, eventually transitioned into a water supply crisis that has continued to date, with the residents receiving less of this resource to their households while maintenance operations at the Rooiwal Wastewater Treatment Plant continued (Maluti, 2020).

Further to the water contamination incidents that have occurred in Hammanskraal, Matsena (2015) stated that the water supply in the area had also been intermittent owing to cable theft and maintenance work on an Eskom transformer at the municipal water treatment plant which caused the water supply to be restricted. In essence, the water supply issues of Hammanskraal have continued and years later, they have not been resolved, all this while the residents in the area experience intermittent water supply on a regular basis in their households (Matsena, 2015).

According to Sono (2016), the Hammanskraal residents complained that they would go for up to a week without tap water supplies in their households. Some residents also mentioned that the municipality had failed to adequately communicate that there would be no water supply for a particular period of time (Sono, 2016). It was only in 2016, while the residents were planning a protest march to draw attention to their perception that the tap water in Hammanskraal was contaminated and that their water supply was inadequate, that the Executive Director of Water and Sanitation at the City of Tshwane Metropolitan Municipality finally responded. He explained that in addition to the dilapidated infrastructure at the Rooiwal Waste Water Treatment Plant, cable theft also contributed to system failures and the ultimate water contamination incidents of Hammanskraal's drinking water. Furthermore, he explained that the water supply in Hammanskraal would be intermittent until maintenance of all systems and infrastructure was completed (Legodi, 2016). In 2019 however, many civil rights groups still expressed concerns over the water-related issues in Hammanskraal, especially following the water sampling results for this area indicating that the water was unsafe for human consumption (Moatshe, 2019).

Quite evidently, the systems and infrastructural malfunctions at the Rooiwal Wastewater Treatment Plant are at the core of the water contamination incidents that forced the municipality to implement water restrictions in Hammanskraal and domestic households in the area receiving tap water supplies intermittently.

While the Hammanskraal residents have faced water restrictions on account of *inter alia* infrastructure failures and maintenance issues at the Rooiwal Wastewater Treatment Plant, the Atteridgeville residents faced water restrictions as a result of the Gauteng 2016-2017 drought, coupled with the unsustainable consumption of water by the residents in

the area at the time. These two factors caused a significant reduction in the water levels at the Vaal Dam and forced Rand Water and the City of Tshwane Metropolitan Municipality to implement water restrictions (Ntshidi, 2019). During the drought, the municipality provided water to the Atteridgeville residents through roaming and stationed water tankers while the residents in the area were advised to use water strictly for drinking, cooking and for the flushing of toilets (Tandwa, 2016). The reasoning behind the implementation of water restrictions during the drought was to ensure that people would use the limited available water supplies in an efficient and sustainable manner (Kenney et al., 2004). Quite evidently, although Hammanskraal and Atteridgeville have faced water restrictions for various reasons, the commonality shared by these two townships are the water restrictions implemented by the City of Tshwane Metropolitan Municipality with domestic households in the area receiving tap water supplies intermittently.

The issue of intermittent water supply is serious and affects many households in a water-thirsty South Africa and needs to be investigated. The researcher was of the opinion that such research was imperative and set out to obtain an in-depth understanding of how the residents of just two settlements, Hammanskraal, a small rural settlement, north of Pretoria and Atteridgeville, a large peri-urban township close to Pretoria's Central Business District (CBD), had adjusted and adapted to the intermittent supply of water to their homes.

A discussion related to the significance and justification of the research now follows.

1.3. Significance and Justification of the Research

The primary goal of this comparative research was to highlight the similarities and contrasts in the perceptions of the Hammanskraal and Atteridgeville residents towards their water supply and to explore their behaviour in respect of their consumption of water during the periods of intermittent supply in previous years and at the present time. It is important to note that the City of Tshwane Metropolitan Municipality has different motivations as to why water restrictions were implemented in Hammanskraal and Atteridgeville and why the household water supply in these areas had been intermittent (viz. systemic and infrastructural malfunctions at the municipal plant in the former research area and restrictions on account of the drought in Gauteng in the latter research area).

Holistically, a secure and constant water supply alleviates many challenges in a household because water is not only used for the purposes of bathing, cleaning and laundry. Water is most importantly used for cooking, drinking and the flushing of toilets

(Adams et al., 2018). Having this resource supplied only intermittently obviously interrupts a lot of the essential functions within the household. More so, the intermittent supply of water can be an inconvenience for many households and could influence the perceptions and behaviours of the residents towards water in one way or another (Syme et al., 2000).

According to Adams et al. (2018), the current status of water as a scarce resource is one of the most pressing environmental issues facing humanity in the 21st century, especially given the prevailing drought conditions caused by climate change and the constant pollution of freshwater resources. With the provision of water supply services being a challenge to those stakeholders mandated to make this resource accessible to people, it is of great importance that scholars conduct research to investigate the perceptions that the general public have towards water restrictions and to analyse their behaviour in respect of their usage of water when its supply is intermittent.

It is also important for scholars to engage in research in a holistic manner by comparing water supply challenges within different contexts. This will provide researchers with an opportunity to analyse trends and themes surrounding the perceptions, behaviour and awareness that people have of water conservation, especially in terms of their own experience of its sporadic supply to their homes.

In light of the above, this comparative research highlights the stark contrasts and similarities in the perceptions towards water supply issues in the chosen research areas. It also explores the behaviours of the residents living in rural townships (e.g. Hammanskraal) as opposed to those if residents living in peri-urban townships (e.g. Atteridgeville) in response to intermittent water supply challenges.

These perceptions and behaviours towards intermittent water supplies and water conservation when analysed through both quantitative and qualitative methods can give the researcher an in-depth understanding of how water supply challenges are being holistically managed by the general population. The particular scenarios investigated in this research involve such conditions as water supply challenges being caused by municipalities, either as a result of the lack of proper maintenance of their water treatment facilities, or of their implementation of water restrictions on account of droughts and the continued unsustainable use of water by the residents.

Through this comparative research, the contrasts or similarities of the perceptions, water conservation awareness and water-use behaviours that the Hammanskraal and Atteridgeville residents have towards their intermittent water supply issues over the past few years will highlight research gaps in this discourse and provide recommendations that

will fill in such gaps in existing research and ultimately contribute to the body of knowledge. This will be realised through the aim and objectives of the research being achieved. A brief discussion on the aim and objectives of the research now follows.

1.4. Aim and Objectives

The aim of this research was to establish and compare the perceptions on water supply, the water conservation awareness and the water-use behaviours of the affected parties, namely the Hammanskraal and Atteridgeville residents towards the challenge of their intermittent water supplies. By so doing, the researcher could establish the overall water stewardship in both research areas, provide suitable recommendations to address the water supply challenge and promote future water conservation awareness and appropriate pro-active responses to this problem.

The research aim presented above would be realised through the achievement of the following research objectives:

- Review the relevant literature to strengthen the researcher's understanding of the body of knowledge relating to: current water supply issues, current water availability, perceptions related to water supply and water conservation awareness in the global and South African local contexts.
- Establish the local contexts of Hammanskraal and Atteridgeville in terms of water supply specifically and consider these in terms of the current water-related issues and challenges in these areas.
- Establish and evaluate the current water-use behaviours and perceptions of the residents related to intermittent water supply by means of relevant semi-structured questionnaires and semi-structured focus group interviews targeting the Hammanskraal and Atteridgeville residents as well as semi-structured interviews with the relevant municipality.
- Evaluate current water conservation awareness, adaptations to water restrictions and the overall water stewardship in Hammanskraal and Atteridgeville.
- Compare the established water supply issues and related perceptions and behaviours around water usage, water conservation awareness and the overall water stewardship in Hammanskraal and Atteridgeville.
- Recommend suitable actions which should be taken or measures which could be implemented to address the identified water supply challenges and promote future water stewardship in Hammanskraal and Atteridgeville.

In essence, this research is a comparative analysis between Hammanskraal and Atteridgeville and aims to answer the following questions:

- *What are the perceptions of the Hammanskraal and Atteridgeville participants in respect of their water supply?*
- *What is the level of awareness related to water conservation of the Hammanskraal and Atteridgeville participants and have they adapted as to how to use water sustainably?*
- *How have the Hammanskraal and Atteridgeville participants behaved in respect of their water consumption during its intermittent supply phases, both previously and currently?*
- *Have the Hammanskraal and Atteridgeville participants adapted to water restrictions and have they developed a culture of water stewardship?*

Whether or not the aim and objectives of this research were achieved will be discussed in the chapters that follow. It is also imperative for the research questions and gaps in this discourse to be identified and filled by this research. A review of the literature to identify any gaps in the research topic now follows.

CHAPTER 2: LITERATURE REVIEW

The main aim of this research was to establish and compare the perceptions, behaviours and awareness of residents of Hammanskraal and Atteridgeville in respect of water conservation and stewardship. These two research areas were selected primarily on account of the water supply challenges that they both face. Households in Hammanskraal have been plagued by intermittent water supply issues, caused by service provision challenges as a result of the ongoing failure of the infrastructure at the Rooiwal Wastewater Treatment Plant which escalated significantly during 2015 (Matsena, 2015). On the other hand, Atteridgeville has been subjected to water restrictions that have been implemented primarily on account of the 2016-2017 drought. Currently, these water challenges are also being experienced by many of the households in residential areas across Gauteng. Overall, both research areas are finding the provision of water to their households to be challenging. As water is a scarce resource, it is important that adequate coping mechanisms and strategies be put in place to alleviate the stress on water resources and on water-users, who receive water only intermittently. Such measures could in turn reduce the demand for the resource, ensure that water is used sustainably and promote overall water conservation actions.

This chapter discusses water availability and challenges on a global scale and within the South African context. In addition, the primary causes of water scarcity on a global and national scale are also discussed. Lastly, this chapter also focuses on people's perceptions and behaviours towards water scarcity and water conservation. A brief description concerning the current availability of water on a global scale now follows.

2.1. Current Availability and Distribution of Water Globally

Water is described as a scarce resource which is essential for good health and for human life generally (Hunter et al., 2010). Water scarcity is a global phenomenon which has affected and is still affecting the developed and developing countries around the world. Annually, the security of global water is constantly being placed under pressure as the resource is generally used unsustainably and freshwater supplies are being significantly exploited. The Earth's water resources currently comprise of 97% of sea water and 2.5% of freshwater, which is frozen in glaciers and in the polar ice caps. The remaining 0.5% of freshwater that is available occurs in rivers, natural lakes, aquifers, reservoirs and rainfall (Figure 2.1) (Nayar, 2013).

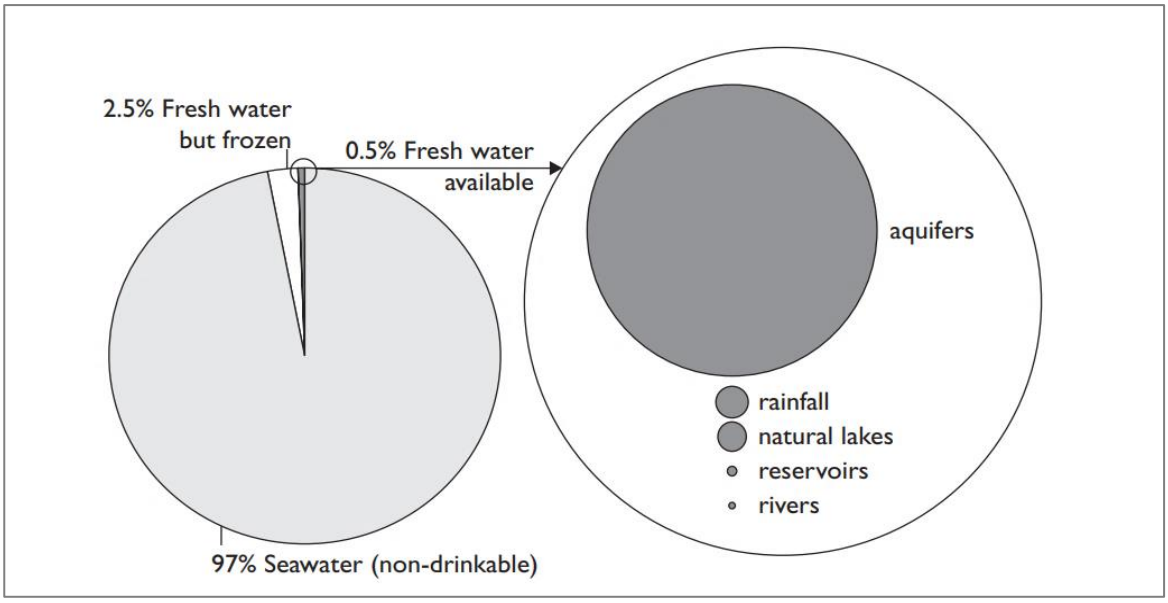

Figure 2.1: Distribution of the Earth's water resources (WBCSD, 2006; Nayar, 2013).

The limited availability of freshwater on Earth must be rationed across the globe in order to satisfy the global demands for water and food. In 2017, approximately 844 million people lacked a basic drinking-water service (UN, 2017). The unfortunate reality is that water supplies are unevenly distributed across the world, and furthermore, that some of the world's most water-stressed countries are densely populated (Hofste et al., 2019). Figure 2.2 presents the stress of varying intensities that is associated with accessing water across the globe.

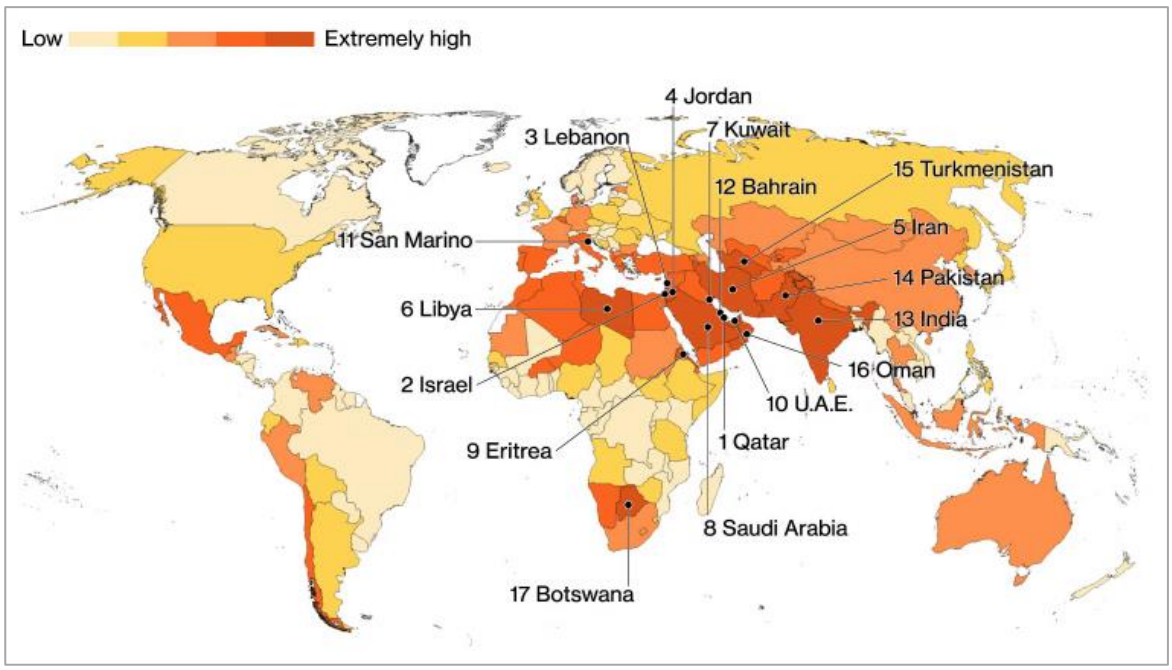

Figure 2.2: The 17 most water-stressed countries in the world (Dormido, 2019).

As shown in Figure 2.3, Qatar, Israel, Lebanon, Jordan, Iran, Libya, Kuwait, Saudi Arabia, Eritrea, the United Arab Emirates (UAE), San Marino, Bahrain, India, Pakistan, Turkmenistan, Oman and Botswana are the 17 most water-stressed countries in the world (Dormido, 2019; Hofste et al., 2019). Although these countries are water-stressed, together they accommodate one quarter of the world's population (Hofste et al., 2019). Furthermore, of all these 17 countries, India is the most water-stressed but has more than three times the population of the other countries combined. Quite evidently, water is indeed unevenly distributed as the countries that are severely water stressed do not necessarily have sufficient water resources that can cater to their increased populations (Hofste et al., 2019). Overall, further increases in population growth, coupled with impacts associated with climate variability and droughts tend to exacerbate the water stress levels faced in these water stressed countries. While some countries have limited water resources and are water stressed, others, such as the United States of America (USA) have low water stress levels and as a result they consume large quantities of water i.e. up to 2 842 cubic meters (m^3) per capita of water annually (Fischetti, 2012).

The uneven distribution of water is graphically presented in Figure 2.3, which shows that in 2015, estimates showed that the developed countries in North America and Europe had the highest level of safely-managed drinking water, while those in the sub-Saharan countries had the lowest of all global estimates of safely-managed water. The aforementioned are known as the Millennium Development Goal (MDG) regions (WHO & UNICEF, 2017).

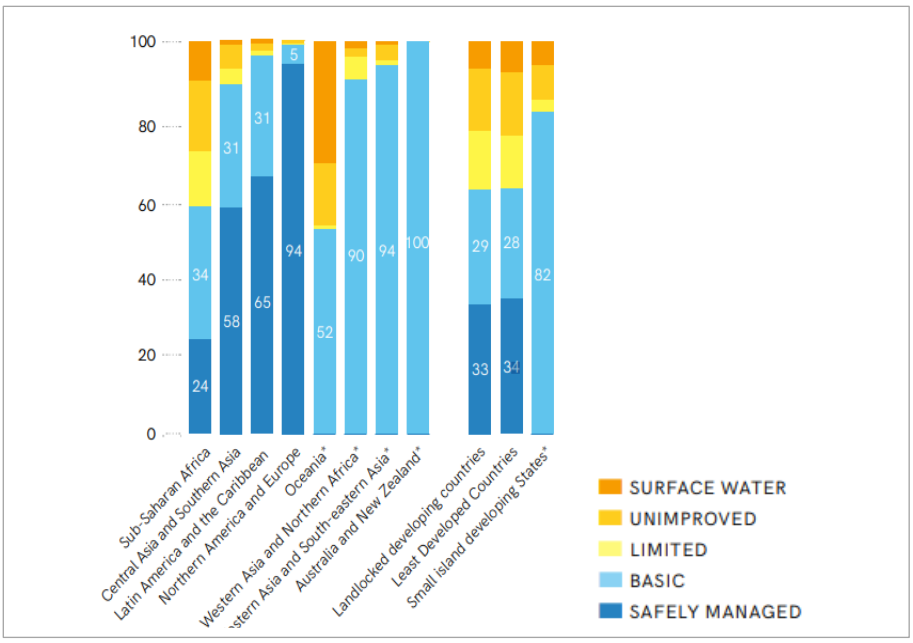

Figure 2.3: Estimates of safely-managed drinking water services for some of the MDG regions (WHO & UNICEF, 2017).

Figure 2.3: Estimates of safely-managed drinking water services for some of the MDG regions (WHO & UNICEF, 2017). Figure 2.3 shows that in 2015, access to safely-managed and basic water sources in sub-Saharan Africa and the least-developed countries ranged from 24% to 34%, which is low if compared to the developed nations such as Australia and New Zealand, both of which had 100% access to basic water sources (WHO and UNICEF, 2017).

To mitigate the problems associated with the uneven distribution of water on Earth and in an attempt to alleviate the water stress faced by many populations across the world, the World Health Organisation (WHO) has for many years tried to develop plans and policies which would ensure that people around the world have access to safe and secure supplies of clean drinking water, as well as to adequate sanitation. An example of such plans was the set of the Millennium Development Goals (MDGs), which included eight (8) development goals and targets developed by the WHO which many countries worldwide agreed to try to achieve by the year 2015. Of all the eight (8) targets of the MDGs, Target 7C aimed to halve the proportion of people without access to sustainable and safe drinking water and basic sanitation (WHO, 2013).

The United Nations (UN), in partnership with various stakeholders, put various strategies in place to ensure that the world would meet Target 7C and halve the proportion of people without access to satisfactorily clean sources of water globally. As a result, and in compliance with this target, by 2015, approximately 2.6 billion people across the world had gained access to improved drinking water sources, while 2.1 billion people were also enjoying access to improved sanitation (UN, 2019).

Although significant progress has been achieved globally in meeting the aims of Target 7C of the MDGs, only 58% of the sub-Saharan African countries had basic water services by 2015. This is graphically presented in Figure 2.4, which also shows that 89% of the global population had access to basic drinking water in 2015.

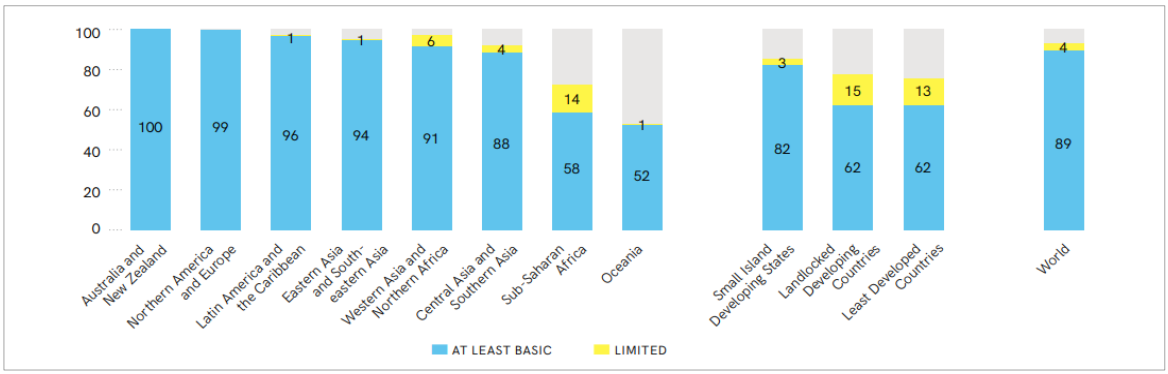

Figure 2.4: Estimates of global basic drinking water services in 2015 (WHO & UNICEF, 2017).

The countries in sub-Saharan Africa faced challenges in achieving the MDGs, particularly Target 7C, on account of the continuously high growth rates of their populations as compared to those of other countries around the world (UN and African Bank, 2015). This indicates that significant planning and management of water resources must take place in the developing countries in the light of the high population growth rates coupled with the large demand for water in the agricultural, industrial and other economic sectors. These statistics also highlight the fact that water security remains a challenge in many sub-Saharan countries as opposed to the situation in the developed countries across the world (WHO & UNICEF, 2017).

Overall, the high population growth rates in sub-Saharan Africa have exacerbated the lack of progress to achieving Target 7C of the MDGs, with many people still lacking water security and basic sanitation (UN & African Bank, 2015). In the light of Target 7C of the MDGs not being achieved to any great extent in sub-Saharan Africa particularly, where many people still experience challenges in gaining access to a safe and secure supply of drinking water and to sanitation, the WHO and the United Nations Children's Fund (UNICEF) introduced the 2030 Agenda for Sustainable Development, which enlists the Sustainable Development Goals (SDGs), a successor of the earlier MDGs (UN Women, 2016). Like the MDGs, the SDGs are comprised of targets and goals that have been put in place to deal with various global issues such as, *inter alia*, the lack of access to safe and secure drinking water supplies by the year 2030. Amongst the targets of the SDGs in alleviating the global challenge in respect of water supply and sanitation, specific attention can be paid to Goals 6.1; 6.3, 6.4, 6.5, 6.a and 6.b which read as follows:

"6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all;

6.3 *By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater, and by substantially increasing the recycling and safe re-use of water globally;*

6.4 *By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and the supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity;*

6.5 *By 2030, implement integrated water resources management at all levels, through inter alia transboundary cooperation as appropriate;*

6.a *By 2030, expand international cooperation and capacity-building support to developing countries in water and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and re-use technologies;*

6.b *Support and strengthen the participation of local communities in improving water and sanitation management"* (WHO & UNICEF, 2017).

In essence, the 2030 SDGs set out to reduce the imbalances associated with the global population not having adequate access to potable water resources (WHO & UNICEF, 2017). The challenging fact in reducing the aforesaid imbalances however, is that the global population is expected to increase by up to 10 billion people in 2050 which will in turn lead to a greater demand being made on water supplies and a further decline in the freshwater resources currently available (Lutz et al., 1997; Ringler et al., 2010; Rosegrant & Cline, 2003; FAO, 2018). Research also anticipates that most of this population growth is expected to occur in the developing countries, which are already water-stressed. It is thus imperative that water should be used sustainably to reduce the imbalances between the supply and demand of water globally (UNIDO, 2007).

A brief description of the current consumption of water and the demand for this vital and valuable resource in a global context now follows.

2.2. Current Global Water Consumption and Demand

The pressure on global water resources can be attributed to the fact that the available freshwater resources must be shared between various economic sectors and domestic consumption. Having access to only 0.5% of the shared freshwater resources for global consumption has led to increased scarcities being experienced in the global supply of water as water becomes scarcer and the demand for the resource exceeds its availability

(Zimmerman et al., 2018). The worldwide scarcity of water is further exacerbated by the variability of the climate, with higher temperatures, changes in the overall hydrological patterns, and the prevalence of drought (Gleick, 1998; Zimmerman et al., 2018). As a result, it is imperative that the Earth's water should be used sustainably in order to meet the current demand for water. It is also important that more efficient water conservation methods be put in place to ensure that water will be available for future generations. Quite evidently, the future availability of water resources depends on the current consumption of this resource globally. Further water scarcities will result in populations experiencing more water supply challenges (Zimmerman et al., 2018).

The demand for water is increasing and the various economic sectors and households in the domestic arena will continue to compete for it. The agricultural sector is regarded as the major consumer of water globally in that it uses up to 70% of the water available worldwide (Molden, 2007; Nayar, 2013). Apart from the fact that the agricultural sector is using up most of the Earth's available water, this sector plays a pivotal role in ensuring global food security. On the other hand, it also plays a major but negative role in the degradation of freshwater resources (Mateo-Sagasta et al., 2017). In addition, the industrial sector consumes 21% to 22% of the freshwater supply, while the domestic sector consumes eight percent (8%) and recreational use consumes one percent (1%) of the total global freshwater supplies (Kibona et al., 2009; Rosegrant et al., 2009; Cassardo & Jones, 2011; du Plessis, 2017).

Up until the year 2000, the industrial and municipal sectors consumed more water than the agricultural sector (Figure 2.5). However on account of the high population growth rate and the increased demand for food globally, the agricultural sector is currently the dominant consumer of water (Nayar, 2013).

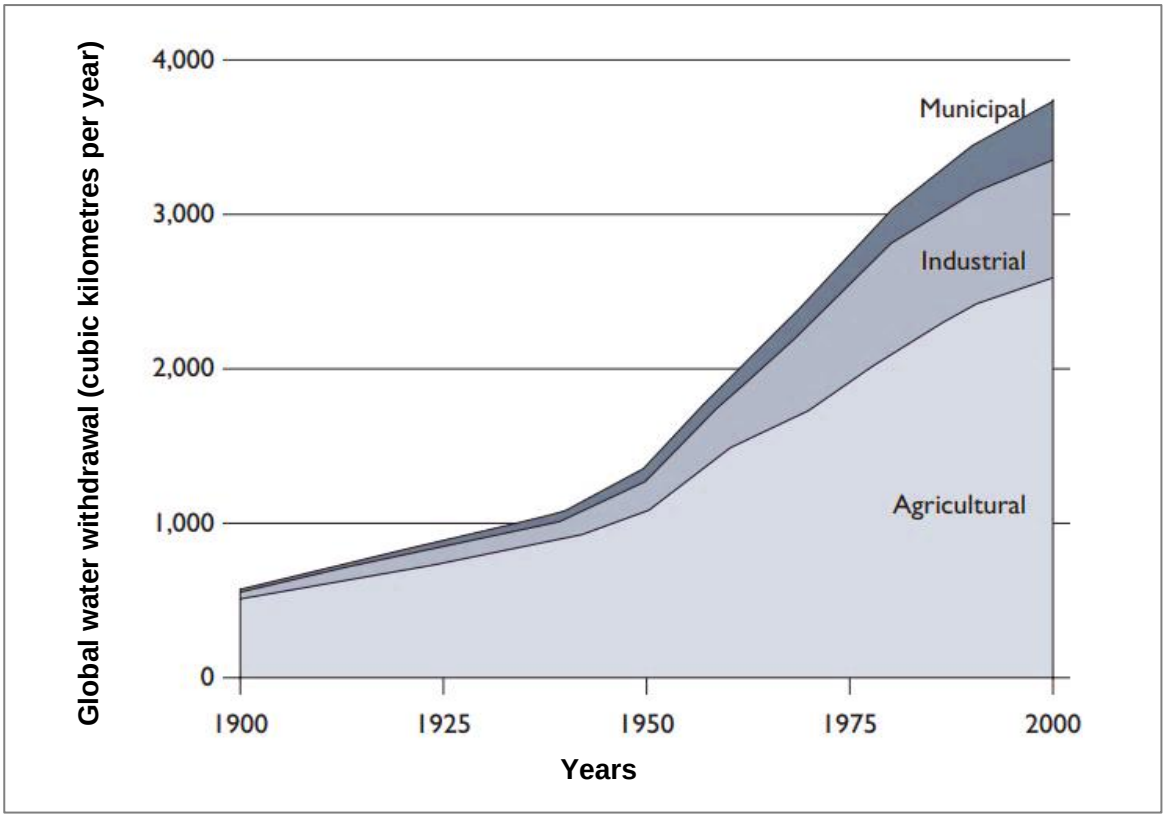

Figure 2.5: Sectoral withdrawal of water (Nayar, 2013).

Figure 2.5 shows that globally the demand for water in all of the aforesaid sectors has been constantly increasing, and that these sectors are continually competing for this resource, which is problematical in the light of its limited availability. As population growth has gradually increased from the year 2000, so also have the food and water demands, with the future demand for domestic household water supplies predicted to increase by 130% by 2050 (OECD, 2012; Guppy & Anderson, 2017). Further water demands are predicted to increase in other economic sectors that also consume high volumes of water in their respective ways. A brief discussion of the main global water-users, namely agricultural, industrial, domestic and recreational consumers now follows.

2.2.1. Agricultural Water Consumption

The persistent increase in the demand for water is significantly driven by continuous population growth. The accompanying increase in the demand for food security has placed increased pressure on the agricultural sector in that land needs to be cleared for crop cultivation, which in turn requires more water for irrigation, in a quest to meet the global food demands (Mateo-Sagasta et al., 2017). Currently, the agricultural sector is regarded as the major consumer of water globally and uses up to 70% of the water

available worldwide for, amongst other uses, irrigation, livestock farming and aquaculture (Molden, 2007; OECD, 2010; Mateo-Sagasta et al., 2017).

The continual changes in the climatic patterns have forced the agricultural sector to rely less on rainfall for the irrigation of crops. Consequently, farmers are using irrigation systems which entail the abstraction of freshwater from surface and groundwater sources and the application of the water to croplands in significant volumes for the enhancement of plant (crop) production (van Averbeke et al., 2011). Approximately 40% of the water that is used by irrigation systems is sourced from groundwater supplies (aquifers), while the remaining 60% of the water used for irrigation is acquired from surface water bodies (rivers, reservoirs, freshwater lakes and streams) and rainfall (Giordano, 2009; Rutledge et al., 2019). Irrigation is therefore a water-intensive agricultural practice and tends to consume surface and groundwater supplies rapidly beyond their replenishment rate. As a result, the exploitation of water resources, coupled with the increased climate variability, manifesting in high temperatures and low rainfall, serves to further exacerbate to varying degrees of water stress around the world (OECD, 2015).

In 2010, many developed countries, such as the USA and Australia, used groundwater to irrigate 23 million hectares of farmland in their semi-arid areas. In addition, the USA, Spain, Greece, Turkey, Italy and Mexico presented with the highest rates of groundwater abstraction for irrigation purposes in 2010 (Figure 2.6). In totality, the amount of water used for irrigation in the aforementioned developed countries accounted for approximately 20% of the global irrigation abstraction rates in 2010 and these high rates have continued to date (OECD, 2015).

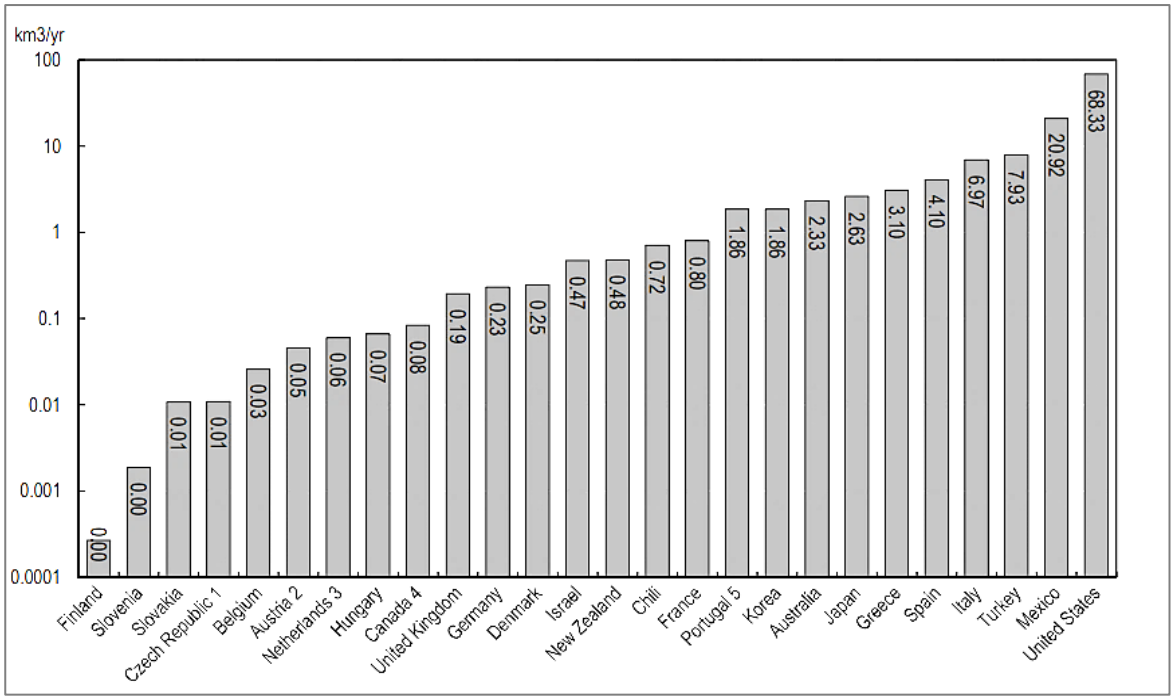

Figure 2.6: Estimated groundwater abstraction for agricultural irrigation (2010) (Margat & van der Gun, 2013; OECD, 2015).

Overexploited freshwater reserves are therefore at risk of being depleted as a result of the unrelenting increase in water abstraction for agricultural purposes. For instance, Lake Chad, located in central Africa, can be quoted as a good example. This lake was initially regarded as one of the world's largest freshwater lakes. However, owing to a combination of the extensive abstraction of its water for irrigation purposes, along with the extended drought conditions in the region during the period 1960 to 2001, the size of this lake has declined from an area of 25 750 square kilometres (km^2) to one of 2 150 km^2. By the year 2001, the volume of water in Lake Chad had decreased by approximately 90%. Today, Lake Chad still has a limited volume of water and has left many people in the central African region impoverished and hungry as the lake can no longer cater for the food demands of the region (Berner, 2017).

The Aral Sea, located in Central Asia, also serves as an example to illustrate the continued over-abstraction of water since it has been almost completely depleted of its waters through the irrigation of cotton, melon, and citrus crops in the Uzbekistan and Kazakhstan deserts (OECD, 2015). The shocking reality of the abovementioned global abstraction rates for the purpose of irrigation is that this method of farming will continue to consume and probably deplete the already limited freshwater reserves in tandem with the continued increase in the global demand for food security (Islam & Karim, 2019).

Despite irrigation proving to be water intensive and to have negative impacts on many freshwater resources (both surface and groundwater), livestock farming also contributes significantly to the unrelenting water stress issue. According to Deutsch et al. (2010), the livestock sector uses approximately 10% of the global freshwater reserves. Water used in farming is strongly associated with feed consumption and the processing of livestock products (e.g. slaughtering, cleaning, processing as well as finishing stages). Livestock requirements for water vary considerably depending on the animal species and their unique dietary requirements during the various stages of the animals' lives (e.g. pregnancy), where more water is consumed (FAO, 2018). In context, for every litre of milk produced, a dairy cow consumes 150 litres of water per day (Krauß et al., 2016). Furthermore, the consumption of water by animals is highly dependent on the climatic conditions of the country in question. As such, when it is extremely hot, the livestock consume more water; when the temperatures exceed 30°C, poultry drink 50% more water than is the case under normal conditions (OMAFRA, 2015; FAO, 2018).

Overall, the agricultural sector is highly dependent on freshwater systems for the health and growth of plants and animals to cater for the global food demands. Since the growth in population numbers is inevitable, it is imperative that more innovative agricultural methods be developed and implemented to reduce the strain that the irrigation of croplands and livestock farming has placed on water resources in a quest to satisfy the global demand for food. On account of the manner in which water is consumed, and its contribution to global water stress, the industrial sector is another large consumer of water globally. A brief discussion on industrial water consumption on a global scale now follows.

2.2.2. Industrial Water Consumption

Industries contribute positively to the growth of a country's economy but can in turn impose negative impacts on water supplies. Globally, the industrial sector consumes approximately 22% of the available global freshwater reserves and is placed second in terms of its consumption of water globally (Kibona et al., 2009; Rosegrant et al., 2009; Cassardo & Jones, 2011; du Plessis, 2017).

The largest industrial consumers of water include the textile industry, mining and energy sectors. Although the textile industry consumes large quantities of water during the farming of its basic material cotton, significant amounts of surface and groundwater are also used mainly in the processing of the cotton. For example, the production of a single pair of jeans requires 1 084 899 litres of water for the processing and dying of such an item of clothing (Manganello, 2019).

The mining industry primarily uses water for the processing of minerals, for dust suppression, slurry transportation as well as drinking and sanitation purposes (Mining Technology, 2013). The location of a mine is not always in an optimal area where suitable water conditions for the mining operation prevail as some mines are located in water-stressed areas and thus use water from sources such as boreholes, rivers, lakes and streams for their operations. As a result, the abstraction of water during the mining process reduces both the surface water and groundwater levels and could also pollute the surface water resources when the abstracted groundwater is pumped up to the surface and thereafter pumped in nearby water resources (Mining Technology, 2013). Furthermore, the withdrawal of water from underground sources places strain on the groundwater table and affects its capacity to be replenished (Hudson, 2012; Karmakar & Das, 2012; Jhariya et al., 2016).

Lastly, in the energy sector, large volumes of water are required in the power plants for cooling the machinery and equipment. In its power generation facilities, the USA uses four billion gallons of water in its cooling systems (GE Reports, 2017). In 2015, thermoelectric power accounted for 41% of the overall total for water abstraction in the USA. This not only indicates that the energy sector is water intensive but also confirms that countries that do not face severe water scarcities and stress tend to exploit this valuable resource (Fischetti, 2012).

As the world transitions into becoming more industrialised, the failure to manage water consumption in industries will have dire consequences for the world's water resources. In addition to the impacts of the industrial sector on the global water resources, more effective water management is also required in the municipal sector which supplies water to domestic households and for recreational use.

A brief discussion of global domestic and recreational water consumption now follows.

2.2.3. Domestic and Recreational Water Consumption

Domestic water consumption accounts for a third of global water-use and consumes up to eight percent (8%) of the available global water reserves, often supplied by the municipal sector. Domestic water consumption includes the water used for laundry, cooking, cleaning, bathing, gardening and sanitation (Adams et al., 2018). An individual on Earth could use approximately 50 litres of water per day for the aforesaid basic household requirements, and this would exclude garden irrigation (du Plessis, 2017). Of the aforesaid 50 litres for household use, each individual in a household uses approximately 10 litres for cooking, two (2) litres for drinking, 15 litres for bathing, and 20 litres for

sanitation (Gleick, 2006; Kibona et al., 2009; du Plessis, 2017). Nonetheless, the United Kingdom, the USA, and numerous countries in Asia exceed the global domestic water consumption estimates, and individuals per household in these countries consume 334 578 litres and 95 litres of water respectively on a daily basis (UNFPA, 2002).

Water is also the medium for recreational activities such as kayaking, fishing, rafting, boating, water-skiing and swimming (Kakoyannis & Stankey, 2002). Recreational water-use accounts for one percent (1%) of the water available globally and consumes the least amount of water on Earth. Although one percent (1%) may seem relatively low, with continued water stress, recreational activities tend to use water from reservoirs, which are mainly developed for specific purposes such as the provision of a reliable source of drinking water (Kakoyannis & Stankey, 2002). Recreational water activities could also add microbial, physical, and chemical contaminants to the drinking water from the reservoirs, ultimately contaminating the freshwater supplies meant for drinking purposes, or for use in the industrial and agricultural sectors (Fewtrell & Kay, 2015).

This section highlighted the fact that the agricultural, industrial and municipal sectors (which includes domestic and recreational water usages) are in constant competition for the Earth's limited freshwater supplies (both surface and groundwater). The aforementioned do not use water in a sustainable manner and the rate at which this resource is used does not allow for its natural replenishment to take place. Furthermore, the deterioration in water quality as a result of various forms of pollution in turn affects the availability of water (Nachiyunde et al., 2013; Simukonda et al., 2018). It is thus imperative that all water consumers in this regard should work as a collective in reducing their water consumption and use water sustainably through improved water management strategies, water stewardship and more innovative water-conserving technologies. Furthermore, domestic water-users should be encouraged to employ sustainable methods for using water in the household, failing which, the demand for water will skyrocket, which will in turn amplify the global issues of water scarcity and stress.

A discussion on global water scarcity and stress now follows.

2.3. Global Water Scarcity and Stress

Water scarcity can be described as freshwater supplies that are insufficient and not easily available - to such an extent that the demands of the people and the environment of the area in question cannot be met (Petruzzello, 2019). When water is scarce and the demand for the resource is high, the pressure on the limited water supplies that are available is amplified. Global water scarcity is not only caused in many countries by the

physical scarcity of the resource but also by the continued deterioration of the quality of the water which in turn reduces the quantity of water that is safe to use (Mateo-Sagasta et al., 2017).

Apart from the fact that water is unevenly distributed across the Earth, factors such as the exponential growth of the global population, together with the growth of the world economy, have placed more pressure on global water supplies. These factors have contributed to increased urbanisation and the subsequent development of informal human settlements on the outskirts of many urban areas in many countries as people converge on the cities to seek employment. The high population growth rate in such human settlements around the world has resulted in an increased demand for water which amplifies the issues of water scarcity and stress (Seetharam & Bridges, 2005; Le Blanc, 2008; Simukonda et al., 2018). According to the UN (2010), the world's urban population grows by two more people every second. This ultimately places additional stress on the Earth's water supplies. Currently, approximately 828 million people on Earth live in informal settlements that are scattered around the world's cities, and approximately 789 million people live without access to improved sanitation (UN, 2010). For instance, in south-central Asia and sub-Saharan Africa, those living in informal settlements constitute approximately 43% and 62% of the total populations respectively. In addition, India in particular, attributes the migration of rural dwellers to the urban areas as a contributing factor to its water scarcity problem (Vairavamoorthy et al., 2007). The pressing issue is that before 2025, the urban population in Asia is predicted to increase by 60% which will cause further demands for water and water stress issues on the continent (UN, 2010).

Overall, water supply in many human settlements globally is unsatisfactory as additional pressure is being placed on the capacity of the existing infrastructure. Ultimately, the large demand for water and in providing water services to such overpopulated human settlements amplifies the stress that the authorities and service providers in these countries are currently experiencing (Behailu et al., 2018).

On the other hand, globally, some informal settlements have been developed in close proximity to rivers and streams, which would then serve as their source of water. However, because of high population density, these water resources have become polluted by the human settlements and the local activities performed in the area (Hranova et al., 2006). For example, more than 60% of the Latin American population lives in coastal cities, where significant pollution is evident in the rivers and seas (UN, 2010).

In addition to the pollution of water resources by these informal settlements in the world's cities, these cities also experience water losses as a result of inadequate water

infrastructure which causes sewage effluent spillages into clean water resources. Moreover, the world's cities have also experienced water leaks with approximately 250 to 500 million cubic metres of drinking water lost in many mega cities annually as a result of failing pipeline infrastructure. These water losses holistically contribute to global water scarcity and stress (UN, 2010; Simukonda et al., 2018).

Globally, water stress is here to stay and will become an increased problem in the future, as is evident from Figure 2.7, which predicts that global water stress will increase significantly by the year 2040 (Maddocks et al., 2015).

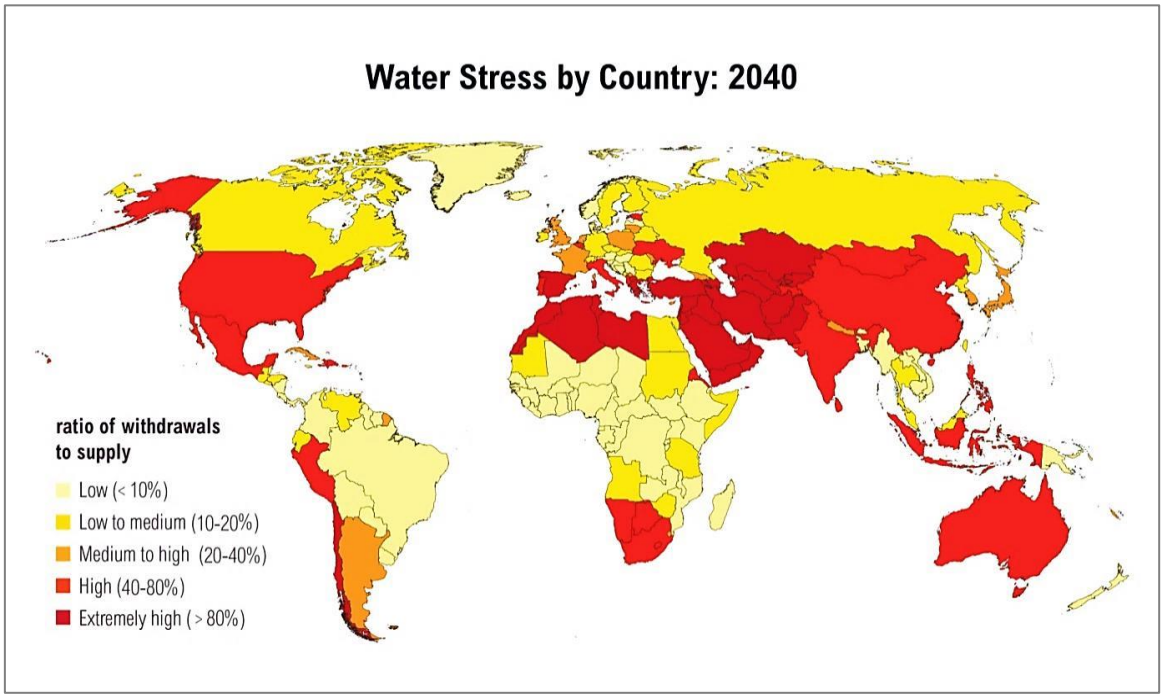

Figure 2.7: Global water stress predictions for 2040 (Maddocks et al., 2015).

Global water supplies are also deteriorating in quality due to pollution from industries such as mining activities which place increased threats on maintaining the current supply. The negative impacts of mining on water quality are a major concern globally (Hudson, 2012; Dasgupta, 2012). According to Qiu (2011) and Gui et al. (2015), 99% of the shallow groundwater table in China has been polluted by mining activities, while 37% of this polluted water cannot be treated to make it potable. It is evident that such pollution of freshwater resources amplifies water stress.

Further to the impacts of mining activities on the quality of fresh water, industries pollute water by discharging heavy metals, toxic sludge and other industrial waste into freshwater bodies (WWAP, 2017; Mateo-Sagasta et al., 2017). Many freshwater lakes in the USA and in Scandinavia are constantly polluted by sulfuric acid from coal-burning power plants

at the former and by nitric acid from the automotive industry at the latter (Berner, 2017). Overall, water contamination from industries also contributes to global water scarcity and stress. Furthermore, oil refineries and oil tankers have caused major oil spills in many of the world's freshwater bodies and seas. For instance, an oil spill in the Gulf of Mexico killed much of the aquatic life and polluted the sea and many of the nearby rivers and lakes in April 2010 (West, 2019). Furthermore, during March 2018, an oil well in northern Colombia burst and poured significant volumes of oil into the Magdalena River (Zachos, 2018). Oil spills from damaged tankers, pipelines and offshore oil rigs often result in the immediate and long-term contamination of water resources, the consequences of which last for decades (West, 2019).

Another contributor to global water stress is the municipal sector, which discharges sewage effluent into freshwater bodies. In Canada, 81% of the population is served by municipal wastewater treatment facilities. Sadly, effluent discharges from municipal wastewater treatment plants and stormwater sewers have caused many adverse impacts on the country's rivers, lakes and coastal waters (UN, 2010). The unfortunate reality in this regard is that further population growth and a greater demand for water will continue to overwhelm the existing rundown water infrastructure, thus leading to additional infrastructural failures and the further discharging of wastewater into freshwater bodies (Nayar, 2013).

Although many countries are working towards achieving the targets of the SDGs by 2030, particularly the targets relating to the supply of safely-managed drinking water services and sanitation, high population growth rates overall tend to increase the water stress levels on the existing freshwater supplies and weaken and prolong the realisation of the targets and objectives of such policies (Abughleleshal & Lateh, 2013).

Apart from the large demand for water as a result of the high population growth rate and the proliferation of industries contributing to water scarcity, cities such as Bombay and Madras in India and many other cities globally, have been struck with water scarcities and limited surface water supplies as a result also of the variability of their climates (Leichenko, 1993; Misra, 2014).

A brief discussion on the impacts of climatic variability and droughts on global water resources as water stressors and contributors to global water scarcity now follows.

2.4. Impacts of Climatic Variability and Droughts on Global Water Resources

The impacts of variations in climatic conditions and the prevalence of droughts exacerbate global water scarcity and stress, with increased pressure being placed on the already stressed hydrological systems and water sources which are meant to meet the current and future water demands. Climate variability which is associated with high temperatures and low precipitation patterns has had a significant effect on water supplies (Kahinda et al., 2010; Misra, 2014; Distefano & Kelly, 2017).

On a global scale, droughts have recently caused significant pressure on water sources, and this has in turn affected the well-being of humans, the environment and the overall ability of municipalities and the relevant stakeholders to make adequate provision for the resource to be supplied to the population (Rossi & Cancelliere, 2012). In the near future, further drought risks are anticipated as a result of the persistent temperature increases that cause high evaporation rates and reduced precipitation in many regions (IPCC, 2007; Rossi & Cancelliere, 2012; IPCC, 2014). Overall, climate variability and global warming are projected to reduce the replenishment ability of surface and groundwater sources in most of the subtropical regions around the world (IPCC, 2014). The persistent variations in climatic conditions, as well as the direct and indirect human impacts in the various economic sectors further exacerbate the global problem of water scarcity (Kummu et al., 2016; Rodell et al., 2018).

In essence, the lack of rainfall and the high evaporation rates generally reduce the replenishment capacity of the freshwater sources, which, as it is, are already being overexploited by the various economic sectors (agricultural, industrial and municipal), domestic household and recreational use. Freshwater resources are also being hugely affected by population increases. This highlights the fact that the natural water cycle has been significantly disturbed and rearranged. Holistically, climate variability, droughts, high water demands, and increased water pollution collectively contribute to water scarcity on a global scale (WWC, 2016).

The continued increase in human population numbers, economic growth, as well as the impacts of climate variability, have not only placed immense pressure on water as a resource, but have also contributed to water stress in many regions globally. Furthermore, water quality challenges also continually contribute to water stress and intensify the problem of water scarcity as water of a suitable quality is not readily available (Jorgensen et al., 2009).

A discussion on the global water quality challenges and major water contaminants now follows.

2.5. Global Water Quality Challenges

As the survival of humans, plants and animals depends on the quality of water, water is considered to be one of the most important resources on Earth. Despite the fact that this resource is essential to life, many people still do not have adequate access to clean and safe drinking water and, as such, they suffer from waterborne bacterial infections arising from their consumption of poor quality water (Cabral, 2010). The discharge of large quantities of organic matter, sediments, agro-chemicals and saline intrusions draining into both surface and groundwater sources is a pressing water quality challenge globally (UNEP, 2016).

It is therefore important to highlight the major contaminants negatively affecting water supplies globally as it contributes to further water stress. Major contaminants include nutrients, trace metals, human-produced organic chemicals and toxins, emerging contaminants that are discharged into the water body, sedimentation arising from soil erosion, thermal pollution by way of such agents in the vicinity (e.g. power stations) causing abnormally high water temperatures, acid rain, salinisation, and pathogenic organisms (du Plessis, 2017).

A brief discussion of the major water contaminants which affect water quality now follows.

Nutrients

Water pollution can be attributed to the discharge of nutrients and sediments into freshwater bodies. In agricultural regions, many of the farmlands discharge large quantities of organic matter, sediment, agro-chemicals and liquids with a high saline content into both the surface water and groundwater bodies (UNEP, 2016). In order to produce crop yields to satisfy the global demand for food, pesticides and fertilizers are used on farmlands to increase their productivity. Fertilizers enrich the soil with nutrients that enhance crop growth and ensure high crop yields. Pesticides on the other hand, are used either to control insects feeding on the crops or to prevent the growth of invasive weeds. Although the use of fertilizers and pesticides may result in higher crop yields, these products, coupled with significant inputs of irrigation water, which causes soil erosion, often result in the accumulation of soil sediments, nutrients and salts in lakes, rivers, coastal waters and aquifers (Mateo-Sagasta et al., 2017).

The accumulation of salts and nutrients leads to the growth of plants and the accumulation of algae in the aforementioned water bodies, a process which is known as eutrophication. Eutrophication is a major environmental issue affecting reservoirs, lakes, wetlands and other water resources globally (Schindler, 2006).

Nitrate accumulation in freshwater sources has resulted in the significant growth of plants in many surface freshwater bodies and the ultimate loss of aquatic life, and this has destroyed many wetlands. Overall, the agricultural sector is the main source of pollution in the USA, while 38% of the water resources in Europe have been affected by the agricultural sector (Mateo-Sagasta et al., 2017).

Sediments issuing from the process of soil erosion

As previously mentioned, nitrates and phosphates are the most common chemical contaminants in the Earth's groundwater aquifers and surface water bodies as runoff water erodes the topsoil which has often been enriched with nutrients, and deposits these sediments in freshwater bodies (WWAP, 2013; Mateo-Sagasta et al., 2017). These eroded soils settle in the water bodies and the process is called sedimentation. The sediments, coupled with the nutrients, the latter serving to enrich the water, cause rapid plant growth and the accumulation of algae in the water bodies (Rand Water, 2019a). The overgrowth of plants in the surface water bodies could cause the plants to take over the entire ecosystem which would then result in the demise of the aquatic fauna and the overall degradation of the quality of the water. Furthermore, the overgrowth of plants in water bodies such as wetlands could alter the entire biodiversity of such ecosystems. Eutrophication in this regard degrades the already scarce water resources and amplifies the problem of water scarcity (Mateo-Sagasta et al., 2017).

Thermal pollution

When humans alter the natural water temperature of freshwater habitats, the result is known as thermal pollution. Thermal pollution can be attributed to elevated temperatures in freshwater resources on account of industrial cooling processes when industrial manufacturers discharge heated water into freshwater bodies (Dodds & Whiles, 2019). The elevation of water temperatures in freshwater bodies could alter the biodiversity of an ecosystem in that the higher temperatures make it intolerable for the aquatic biota to survive under such conditions. Furthermore, thermal pollution increases microbial growth in the water (Vallero, 2019). Overall, the alteration of water temperatures changes the natural conditions of freshwater bodies, thus making the water unsafe for consumption

and use. Furthermore, thermal pollution also places increased stress on the aquatic organisms as the quality of the water is affected (Palmer et al., 2004).

Acidification

Acidification in fresh water can be caused by acid rain, which originates from emissions of sulphur and nitrogen oxides into the atmosphere. It has been mentioned that numerous freshwater lakes in the USA and in Scandinavia have been significantly polluted by sulfuric and nitric acid from coal-burning power plants and automotive plants respectively (Berner, 2017). Acidification degrades the quality of the freshwater body and makes it unsafe for human consumption. In addition, acidic water is also an unsuitable habitat for aquatic biota as the pH of an aquatic ecosystem determines the health and biological characteristics of that system (Peters & Meybeck, 2000; UNEP GEMS Water, 2009; du Plessis, 2017).

Salinisation

Increased salinity in surface and groundwater bodies limits access to freshwater. When water supplies are limited, economic growth and household activities are then affected. Although natural salts can be found in water without significantly affecting its quality, the salinity of freshwater resources is exacerbated by agricultural and mining activities which produce highly saline runoff that affects the quality of the water negatively (Barros et al., 2012). The effects of the salinisation of freshwater bodies could alter the functioning of many riparian ecosystems such as wetlands (Schulz et al., 2015; Cañedo-Argüelles et al., 2018). The impact of salinisation on wetlands contributes to greater water scarcities as, in spite of the large demand for water globally, highly saline water is not suitable for consumption. Once wetlands have been destroyed, they cannot replenish the aquifers, which play a vital role in the storage and circulation of water through the ecosystem. Overall, without wetlands, the environment cannot filter contaminants in water, ultimately leaving freshwater systems degraded and polluted (WWF-SA, 2016).

Pathogenic organisms

The discharge of wastewater into freshwater bodies is a major source for placing faecal microorganisms, including pathogens, in surface water bodies (Taylor, 2003; Cabral, 2010). Wastewater tends to contain large varieties of pathogenic organisms, including bacteria, viruses, fungi, and protozoa. The survival and growth of these pathogenic organisms is affected by the temperature of the water (Cabral, 2010). During high rainfall events, pathogenic organisms could be transported into freshwater bodies. According to

Molloy et al. (2017), humans may be exposed to water-borne diseases carried by pathogenic organisms when they drink contaminated water, eat seafood from contaminated water, eat fresh produce that has been irrigated by or processed with contaminated water, or from swimming in contaminated water.

The release of sewage effluent into a freshwater body meant for human consumption poses significant human health risks. In the long term, water resource management initiatives should focus on the prevention of pollution from wastewater effluents (Taylor, 2003). Furthermore, wastewater treatment facilities should be designed and built in such a way that they will contain the wastewater and prevent it from being discharged into the environment and freshwater bodies during rainfall events (WWF-SA, 2016). It is also important that a more effective infrastructure be put in place to further prevent the leakage of wastewater. In this regard, increased efforts should be made by municipalities to ensure there is adequate treatment of the drinking water and to prevent the spread of pathogens (Taylor, 2003).

Trace metals

The contamination of rivers by trace metals remains a global threat to biodiversity and humans (Edokpayi et al., 2016). Trace metals such as cadmium, iron, lead, nickel and zinc pose threats to human health and aquatic life. The water polluted with these metals that is used for irrigation purposes can cause significant crop losses. Apart from agriculture, mining and manufacturing, which add trace metals to water sources in their respective ways, the dumping of municipal waste into freshwater bodies also contributes significantly to trace metal pollution. Trace metal accumulation in water bodies, even in minute quantities, has negative impacts on human health, animals, the water and the overall environment (Shyam et al., 2008; Edokpayi et al., 2016).

Human-produced organic chemicals and toxins

There are many human-produced organic chemicals and toxins that could contaminate freshwater resources and impact upon the quality of the water. Chemicals developed by human technology for use in agriculture, manufacturing or in industrial processes have affected the quality of many of the freshwater bodies on Earth. Persistent organic pollutants (POPs) are those toxic chemicals that adversely affect human health, water and the environment around the world. An example of a POP is Dichlorodiphenyltrichloroethane, commonly known as DDT, which was extensively used in agriculture prior to its banning in many regions of the world (EPA, 2009). POPs can be deposited in freshwater bodies through the release of effluent and subsequent runoff.

They can also be transported by wind and water and most of the POPs generated in one country can affect the people and water resources in other countries far from their source. These human-produced chemicals and toxins can persist for long periods of time in the environment and in water bodies. Additionally, POPs tend to accumulate and to pass from one species to the next through the food chain (WHO, 2019). Furthermore, many of them evaporate from water or the land surface and ultimately return to Earth through snow, rain, or mist. Lastly, POPs travel through the oceans, rivers, lakes and have an overall effect on the quality of the limited available freshwater sources on Earth, and reduce their potential to be used (EPA, 2009).

Emerging contaminants

Emerging contaminants constitute a group of natural and synthetic chemicals occurring in water bodies throughout the Earth and are currently not being monitored in the environment despite the high potential that they have for causing environmental damage and adverse impacts on water ecosystems and human health (Geissen et al., 2015). Such emerging contaminants can be found in pharmaceutical products, pesticides, industrial chemicals, surfactants such as detergents, and various toilet products (Rosenfeld & Feng, 2011). There are still gaps in the research of emerging contaminants and this discourse has not been studied in any great detail. As such, the environmental and human impacts of these emerging contaminants have not yet been tested in municipal water systems despite the fact that they have passed through drinking water treatment systems, and have thereby generated by-products, which often go undetected (Rosenfeld & Feng, 2011).

Despite the new technologies and methods that have been implemented to reduce the negative impacts on the quality of the water, new contaminants continue to emerge, thus amplifying the water quality challenges. Furthermore, water contaminants are not always mutually exclusive as one contaminant can independently and significantly affect water quality, whereas a combination of contaminants can have cumulative impacts, which would in turn affect water supply. It is, therefore, essential for the quality of the water in freshwater bodies to be constantly monitored in order to prevent the limited available water supplies from further degradation. Should such efforts fail, the maintenance of an adequate water supply would ultimately be threatened globally and the result would be accelerated health risks. Furthermore, water quality challenges elsewhere in the world could have an impact on the quality of water in South Africa, which already faces water challenges of its own. A discussion on the state of South Africa's water resources in terms of quantity and quality now follows.

2.6. South Africa's Water Resources

South Africa has a semi-arid climate and is the 30th driest country in the world (Schreiner et al., 2010; Fanadzo & Ncube, 2018). The country is water-stressed and its paucity of water is caused by the variability of its climatic conditions, its high population growth rates and the large demands made on its water reserves by the agricultural, industrial and municipal sectors (Donnenfeld et al., 2018).

The municipal sector is legally mandated by South African law to cater for all of the water demands in the country and to distribute water particularly to domestic households (Murombo et al., 2009). However, water scarcity in South Africa and the increasing stress on the country's water reserves has made the supply of water a mammoth task for municipalities. Considering the limited water resources of the country, and the fact that the national demand for water in South Africa is projected to exceed the water supply by 2020, and that it will increase by a further 32% by the year 2030 as a result of increased population growth and further industrial development, South Africa is in a dire situation. Holistically, the greater demand for water will severely affect the limited available freshwater supply (Misra, 2014; WWF-SA, 2016; GreenCape, 2017).

A brief discussion on the current availability of water in South Africa now follows.

2.6.1. Water Availability in South Africa

South Africa is water stressed and has an annual rainfall of approximately 490 mm which amounts to almost half of the world average rainfall of 860 mm (Dennis & Dennis, 2012; WWF-SA, 2016). Rainfall in South Africa is variable and unevenly distributed as is evidenced in the fact that the provinces in the western portion of the country receive less rain than the provinces in the eastern portion of the country (Figure 2.8) (Rand Water, 2019b).

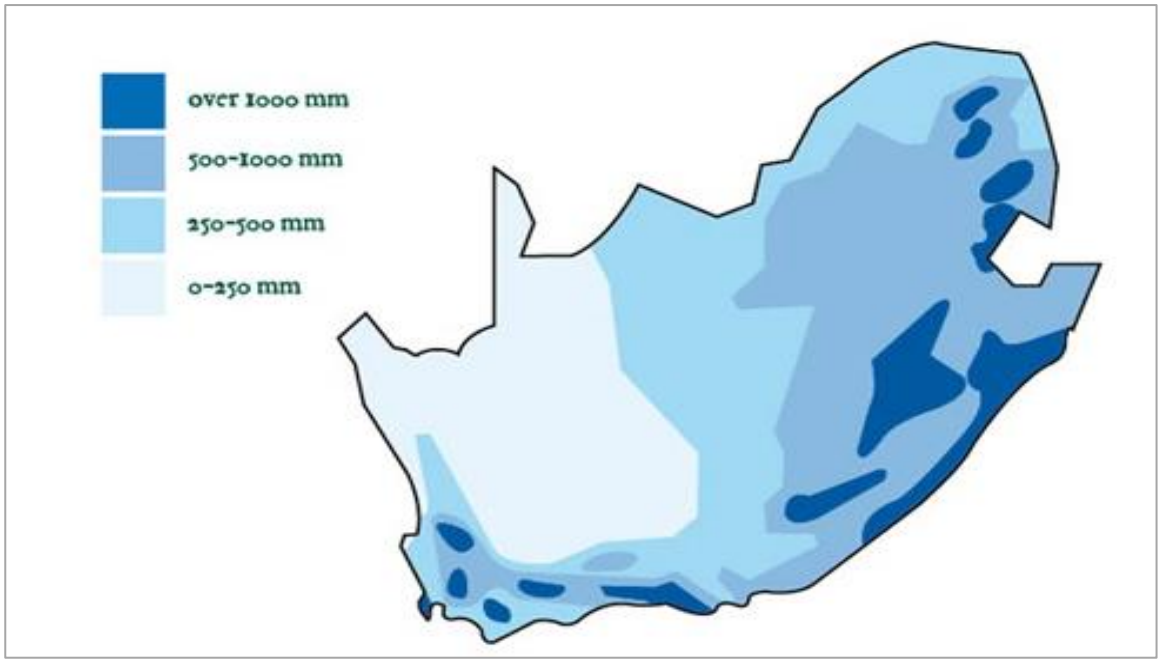

Figure 2.8: Distribution of mean annual rainfall in South Africa (Rand Water, 2019b).

The country's freshwater sources are in catchment areas, wetlands, rivers, estuaries, springs and aquifers which all serve as the foundation for the overall water supply in South Africa. The aforesaid water bodies are highly dependent on rainfall for their replenishment (WWF-SA, 2016). However, owing to the variability of the rainfall in the country, the reliance on rainfall as a water source has declined. The overall surface water resources in the country constitute 77% of the total available water supplies, while groundwater resources constitute nine percent (9%), and 14% of the water is drawn from re-used return flows (DWA, 2013; GreenCape, 2017). Furthermore, only eight percent (8%) of South Africa's land area produces runoff, which contributes 50% to the volume of water in the country's river systems. South Africa also has 223 rivers, 32% of which are critically endangered and 25% of which are threatened by various forms of pollution, which will be discussed later on in this chapter (WWF-SA, 2016).

Along with the natural surface and groundwater sources available in South Africa, the country has approximately 4 718 registered dams, which have been constructed nationwide over many decades. The most recent dam constructed in South Africa is the De Hoop Dam located in the Limpopo Province and was commissioned in March 2014 (WWF-SA, 2016). Overall, the dams in the country have a total capacity of approximately 32 billion cubic metres and capture 70% of the total mean annual runoff in the country (Muller et al., 2009).

Despite the fact that South Africa's dams are able to store large volumes of water, there has been a gradual reduction in the dam levels over time as excessive temperatures and the lack of rainfall have caused high average evaporation rates of approximately 1 800 mm (which is almost three times the amount of the country's average rainfall). Essentially, South Africa's water resources are threatened by changes in the hydrological patterns, the high temperatures, the high evaporation rates, as well as the anthropogenic overexploitation of water resources (WWF-SA, 2016).

It is important to note that 98% of the surface water reserves in South Africa have already been allocated to users in the various economic sectors (agricultural, industrial and municipal) (WWF-SA, 2017; Donnenfeld et al., 2018). The remaining two percent (2%) of the available water resources in South Africa has not been allocated as the water is deemed unsuitable and unreliable as a potable source (WWF-SA, 2016). Furthermore, the increased variability of the climatic conditions in South Africa has contributed to reduced dam levels and the prevalence and frequency of droughts (Muller et al., 2009).

Reduced dam levels are a contributing factor to the intermittent supply of water received by households. The Vaal Dam is a prime example of a dam that has presented with reduced water levels as a result of low rainfall and high temperatures, as well as the increased rate of consumption (Rand Water, 2019b). The lower dam levels of the Vaal Dam, coupled with the unsustainable use of water resources in the Gauteng Province, have resulted in the implementation of water restrictions in the province and the concomitant effect of intermittent water supplies (EWN, 2019).

It is thus imperative that the limited availability of water resources in the country be equally shared amongst all of the water-users and that water should be used sustainably, especially during the prevailing drought conditions in South Africa. This is unfortunately not the case in reality as the country's freshwater resources continue to be exploited as a result of the large demand for water. A discussion on the demand for and consumption of water in South Africa now follows.

2.6.2. Water Demand and Consumption in South Africa

The agricultural sector of South Africa is the largest consumer of water in the country (Donnenfeld et al., 2018). Owing to the variability of the climate and the low rainfall of South Africa, great reliance has been placed on the application of irrigation methods to sustain the growth of pastures for livestock and for crop farming, both of which cater for the demand for food in the country (van Averbeke et al., 2011). Such irrigation methods

have contaminated the freshwater supplies of South Africa and have caused a 30 to 40% loss of water in the country (Fanadzo & Ncube, 2018).

Figure 2.9 is a sectoral representation of the total consumption of water in South Africa and shows that the agricultural sector consumes 62.6% of the country's total available freshwater supply (Donnenfeld et al., 2018).

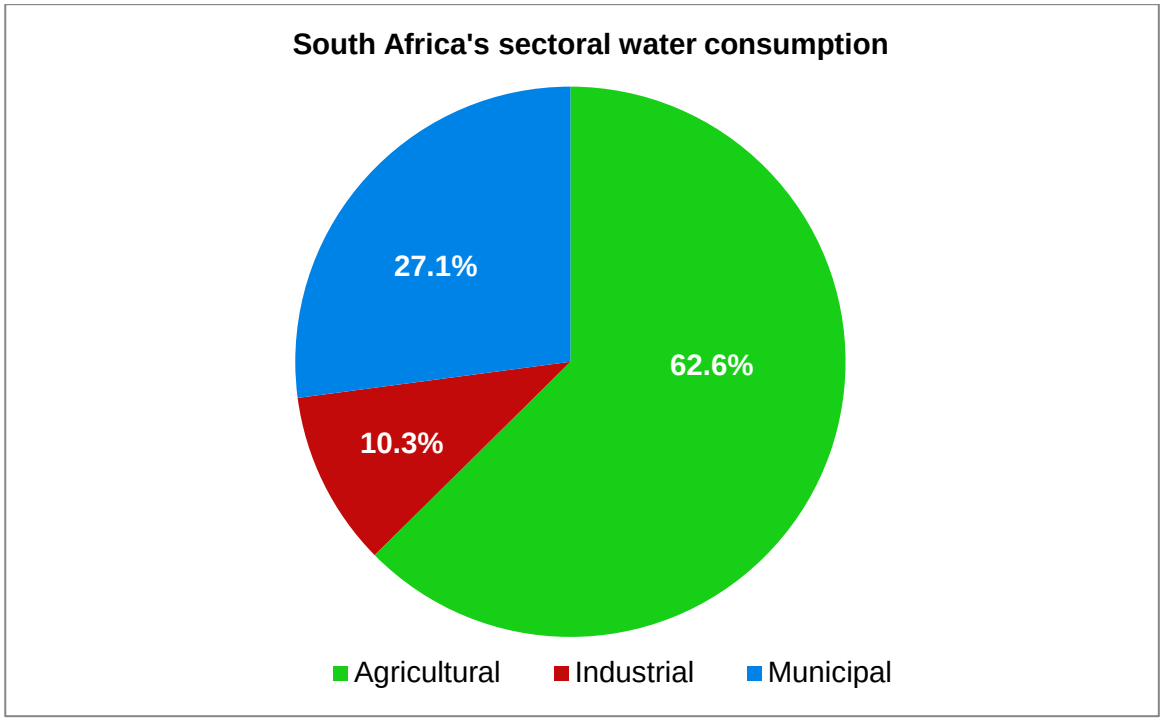

Figure 2.9: Total sectoral water consumption in South Africa (Redrawn from Donnenfeld et al., 2018).

The second-largest consumer of water in South Africa is the municipal sector, which consumes 27.1% of South Africa's freshwater supply (Donnenfeld et al., 2018). Approximately 70% of the fresh water used by the municipal sector is drawn from surface water bodies (rivers, streams, lakes, ponds and springs) to provide water for drinking, cleaning and sanitation purposes in the rural and urban areas nationwide (Ochieng et al., 2010; Donnenfeld et al., 2018). Urban and rural households consume approximately 84% of the water supply allocated to the municipal sector in South Africa (WWF-SA, 2017). These large demands on the water supply in rural settlements and urban areas contribute to South Africa's water stress as more water is abstracted in a quest to satisfy the increased water demands in these areas. This occurs concurrently with the variability of the rainfall which is a constant and impacts on the capacity of the country's freshwater reserves from replenishing. For instance, the Gauteng Province has the highest population in the country with a population size of approximately 15.2 million people and

the 2019 water consumption rates in the province having reached a staggering average of approximately 5 000 megalitres per day, as compared to the national average of approximately 4 400 megalitres, which is in itself also quite significant (StatsSA, 2019; Tshwane, 2019). Such a high water consumption level by the rural and urban populations of Gauteng contributes to the significant water stress levels that South Africa experiences, and intensifies the imbalance between the supply of and demand for water.

Another prime example of imbalances in water usage is in the Northern Cape Province, which is the largest province in South Africa but which has the lowest total population in the country of approximately 1 154 439 people. The Northern Cape is predominantly arid since 21% of the province receives less than 200 mm of rain per annum (WWF-SA, 2016). Despite the province's water scarcity, the Northern Cape is wealthy in terms of the area of arable land available to it, as well as the minerals found in its geological structures (e.g. iron ore and manganese). As such, the mining and agricultural sectors are the most important economic sectors in the Northern Cape. Furthermore, they stand out as being very demanding in terms of their water requirements (Young, 2017). Nonetheless, both of the aforesaid economic sectors consume significant amounts of the province's limited water supplies. They rely largely on the Orange River and the province's groundwater supplies for the irrigation of farmlands, the water used in the mines, and for drinking purposes in the province (DWS, 2014; WWF-SA, 2016).

Lastly, the industrial sector consumes 10.3% of South Africa's freshwater supplies (Donnenfeld et al., 2018). In the industrial sector, the manufacturing industry is the largest consumer of water, taking up approximately 53% for industrial use. These demands for water in the manufacturing industry are expected to grow to 70% in 2030 (WWF-SA, 2017).

Furthermore, South Africa is also well-endowed with gold, coal, platinum, and chrome deposits, and diamonds, as well as many other mineral resources (Minerals Council of South Africa, 2019). The mining industry is a major driver of South Africa's economy and contributed R351 billion (7.3%) to the country's gross domestic product (GDP) in 2018 (Minerals Council of South Africa, 2019). Despite the mining industry's contribution to economic growth in South Africa, the large demands that this industry places on its water supplies and its significant usage of this valuable resource have contributed to the overexploitation of water resources in this sector through over-withdrawals and pollution.

Moreover, many mining companies are using water resources without the relevant permits and licences, thus resulting in the exploitation of South Africa's water resources

(Olalde & Matikinca, 2019). Approximately 118 mines in the country are polluting rivers, while a staggering 115 of these mines have been observed to be operating without proper water permits (Olalde & Matikinca, 2019). In 2019, the Centre for Environmental Rights (CER) found that eight coal mines in the Mpumalanga Province of South Africa were not using water in compliance with the conditions of their water-use licences and had nevertheless not faced any consequences for any of their incidents of pollution that might have occurred in that regard (CER, 2019). Such a large demand for water, the misuse of the country's scarce water resources and the contamination of water in the industrial sector have exacerbated the issue of water scarcity and water stress in South Africa.

A discussion of South Africa's primary water challenges now follows.

2.7. South Africa's Primary Water Challenges

South Africa is a water-stressed country that is faced with water quality and quantity challenges. The country's freshwater resources are plagued by various forms of pollution, which has been identified as a major contributing factor affecting the quality of the water and water stress (Younger, 2001; Ochieng et al., 2010). In addition, the variability of the climate also contributes to the country's water stress levels as a result of the high temperatures and the low rainfall experienced (Dennis & Dennis, 2012). South Africa is faced with increasing demands for water, continued degradation in the quality of the water, as well as increased shortages in the supply of this valuable resource due to climate variability. In addition, high population growth rates are increasingly placing pressure on the available water resources of the country (Rand Water, 2019b).

The following section therefore describes the water challenges faced in South Africa in terms of increased water demands, persistent water degradation and increased water supply shortages respectively. A discussion on the primary water challenge associated with increased water demands in the country now follows.

2.7.1. Increased Water Demands

The population growth rates in South Africa increase by an estimated two percent (2%) per annum. Currently, the South African population comprises of approximately 58.8 million people (StatsSA, 2019). In context, 58.8 million people demand potable water for drinking and sanitation purposes, despite the limited water resources available in the country. Furthermore, South Africa's high water demands are expected to exceed the country's available water supplies by 2025 (Rand Water, 2019b). However, with the current looming droughts and the increased pressure on water resources, the imbalance

between water supply and demand is inevitable and water demands will exceed the supply by 2025 if more efficient water management strategies are not put in place. Additional water demands arise from the high urbanisation rate and as the population density in South Africa continues to significantly increase. South Africa's urban areas expand by 2.7% annually to accommodate the increasing population numbers in these areas (Department of Human Settlements, 2004).

The continued rise in the population growth rate in South Africa which has resulted in the inadequate provision of water to households for drinking and sanitation purposes has shown that South Africa is in fact one of the developing countries that was not able to achieve the objectives of the 2015 MDGs. The inadequate provision of water to domestic households in South Africa furthermore confirms that the targets of the 2030 SDGs need to be prioritised in the country. It is overall imperative that the limited water resources in the country be used sustainably for the benefit of the current and future generations. With the harsh impacts of increased climate variability and the prevalence of droughts in South Africa, there is no room for the unsustainable use of water. Therefore, it is essential that sustainability measures be included in long-term policies to significantly influence the way in which water is used in order to ensure that its quality and the amount made available to the population is prioritised and realised. The promotion of measures to promote water conservation should also be prioritised (Zimmerman et al., 2018).

Besides the problem of the increased population growth in the country contributing significantly to the larger demand for water, it should further be noted that freshwater resources in South Africa are continually being exposed to various forms of pollution.

A discussion of the phenomenon of the persistent degradation of water in South Africa now follows.

2.7.2. Persistent Water Degradation

As in the case of the water scarcity issue in the global context, South Africa's water resources are also affected by various forms of pollution. The pollution of the country's scarce water resources affects the quality of the water which then diminishes the availability of the water destined to supply households. The discharge of sewage effluents, toxic chemicals and other contaminants degrades the integrity of freshwater bodies prevents them from being naturally regulated and replenished (Rand Water, 2019b).

Some of the pollution sources in South Africa can be attributed to agro-chemical contamination, eutrophication, soil erosion and sedimentation, industrial effluent pollution, mining effluent pollution, acidification, sewage pollution, as well as the invasions of alien vegetation species (du Plessis, 2017). A brief discussion on the aforesaid water contaminants in South Africa now follows.

Agro-chemical contamination

The use of pesticides is a major contributor to water pollution in South Africa and poses health threats to the country's population by degrading the country's already limited and stressed water resource that is so much in demand (WWF-SA, 2016).

In a quest to satisfy the growing food demands in South Africa, fertilisers are used on many farmlands to enhance the potential of the soil for crop growth. The application of fertilisers in the correct manner can result in positive impacts on the soil and in high crop yields. However, the overuse of fertilisers can cause adverse effects on the environment and on the quality of the water when runoff erodes soils rich in nitrates and phosphates, drain into the surface and groundwater bodies, and cause sedimentation and eutrophication (WWF-SA, 2016; Mateo-Sagasta et al., 2017).

Eutrophication

Through the use of fertilisers and pesticides on farmlands and the highly intensive methods of irrigation, soils rich in nutrients can be eroded and deposited in freshwater bodies. Such soils would then settle in the freshwater bodies and promote plant growth and the accumulation of algae (Rand Water, 2019a). The accumulation of nutrients in water bodies is a major threat to the quality of the water in South Africa. Furthermore, the overgrowth of plants and algae in surface water bodies affects ecosystems such as wetlands and results in the demise of aquatic fauna and of the entire ecosystem (Griffin, 2017).

Eutrophication in this regard degrades the already scarce water resources in South Africa and exacerbates the paucity of water in the country. As in the global context, another major anthropogenic cause of eutrophication in South Africa is the disposal of sewage effluent in freshwater bodies. The increased nutrient levels of South Africa's rivers and effluent spillages into them have resulted in intensified eutrophication in the reservoirs of the country (Griffin, 2017). Because the reservoirs provide water for domestic purposes, the eutrophication process caused by sewage entering them has far-reaching consequences, such as dire health effects and an overall decline in the quality of the

water which in turn amplifies the water supply challenges that are faced in the domestic households nationwide (Harding, 2015).

Alien Invasive vegetation

Thirsty alien invasive vegetation consumes significant amounts of water and generally diminishes the availability of water in South Africa by four percent (4%) (WWF-SA, 2016). It has been estimated that alien invasive vegetation in South Africa consumes approximately three billion litres of water annually (Le Maitre et al., 2000; Dye & Jarmain, 2004; WWF-SA, 2016). If left unattended, alien invasive plants could use approximately 16% more of the country's water in the future as some of these plant species consume twice the amount of water that domestic vegetation does. As such, strict management measures to control alien invasive vegetation should be put in place to ensure that invader plants species do not take over South African ecosystems and consume more of the country's already limited water supply (Blignaut & van Heerden, 2009, WWF-SA, 2016).

Industrial effluent pollution

Many factories and industries in the manufacturing sector have contributed to the pollution of much of South Africa's surface water reserves. Such pollution incidents degrade the available water supplies, which are limited, and affect the amount of water that is dedicated to satisfying household demand and that required for animal drinking purposes. For example, in 2012, a cyanide spill from a synthetic rubber manufacturing factory polluted the Karbochem Spruit, which is a tributary of the Ingagane River in the KwaZulu-Natal (KZN) Province (Government of South Africa, 2012). This chemical spill affected the quality of the water and resulted in the demise of many cattle in the area. In addition, in August 2019, 1 600 cubic metres of fatty oil and caustic soda spilled from a factory in Pietermaritzburg and was discharged into the Umsunduzi River, KZN, resulting in the demise of many aquatic resources in the river, as well as of cattle. The spill in the Umsunduzi River affected the Inanda Dam, which supplies drinking water to the KZN population (Makhaye & Mkhize, 2019). The aforesaid freshwater contamination incidents are but a few of the prime examples of factories contributing to the degradation of the limited freshwater sources in South Africa. Likewise, the mining industry contributes to continued water degradation in South Africa.

Impacts of mining effluent pollution and acidification

Mine wastes comprise of waste rock, overburden, slurry, as well as tailings from the beneficiation plants (Szczepańska & Twardowska, 2004). The spillage of tailings that is precipitated by heavy rainfall events can result in surface and groundwater pollution. In addition, mining impacts in the form of acid mine drainage (AMD) is a challenge that plagues South Africa's water resources. Coal and gold mines significantly cause AMD and the shocking reality is that the effects of the contaminated water from these mines can be felt as far as 10 km or more beyond the source (Ochieng et al., 2010).

AMD is the most difficult mine waste problem to address and manage, especially at mines which were not adequately decommissioned and ultimately resulted in the decanting of mine water. For example, AMD at the coal mines in the Mpumalanga Province has caused severe pollution and dire consequences for the Loskop Dam and the Olifants River catchment (Naicker et al., 2003; Ochieng et al., 2010). Furthermore, the water quality of the Blesbok Spruit in the Gauteng Province has been negatively impacted upon by AMD associated with coal and gold mining operations in the province. In order to successfully mitigate the impacts of mining on the freshwater supplies, stricter policies should be developed and implemented for the mines to ensure the sustainable availability of water and to curb the contamination of water (Ochieng et al., 2010).

Sewage effluent pollution

Infrastructural malfunctions and high rainfall events could result in the discharge of wastewater and sewage into clean freshwater bodies such as dams and rivers. In severe cases in the Gauteng Province, the spillage of sewage into freshwater bodies used for drinking water has resulted in water restrictions being imposed on many of the human settlements in the region (Kings, 2015).

The Green Drop Report of 2013 noted that in South Africa, less than 10% of the 824 municipal wastewater plants in the country are releasing clean water that is suitable for potable use. Furthermore, approximately 50 000 litres of sewage effluent flowing into South Africa's rivers every second affect the water supplies meant for consumption (Kings, 2017). It is worth noting that the water in Hammanskraal is a focal element of this research as numerous wastewater spillages have occurred in the Apies River, which is a source of drinking water in the area. This can be attributed to the failing infrastructure at the Rooiwal Wastewater Treatment Plant that results in the release of sewage effluent and partially-treated water back into the river. In this regard, the sewage effluent pollution has resulted in the implementation of water restrictions in Hammanskraal, thus causing

the households in the area to experience an intermittent supply of water while the municipality attempts to resolve the issue (Ngqakamba, 2019). Such sewage effluent pollution incidents affect the quality of the fresh water and intensify the eutrophication process in freshwater bodies, thus contributing to increased water supply shortages (Kings, 2017).

A discussion on the challenge of increased water supply shortages now follows.

2.7.3. Increased Water Supply Shortages

Quite similar to Colombian Law in South America, South African legislation mandates municipalities to provide water to the population under their respective jurisdictions, and these laws further highlight the rights of people to have access to this resource (Rojas & Megerle, 2013). South Africa's waters are governed by the Water Services Act of 1997 (Act No. 108 of 1997) and the National Water Act (NWA) (Act No. 36 of 1998) (Kidd, 2011; WWF-SA, 2016). Although South Africa managed to build an impressive infrastructure for supplying water in the past, this infrastructure, together with the water network, is becoming rundown and cannot generally sustain the higher capacity for providing the volume of water that is in such great demand. The failing water infrastructure in turn leads to water leakages and the spillage of sewage effluent into freshwater bodies (WWF-SA, 2016). The deterioration in the water infrastructure, coupled with rapid urbanisation and increased population growth, continues to challenge municipalities in meeting the large demand for water in South Africa. Furthermore, the municipalities do not often have skilled personnel and the correct operational measures in place to timeously manage spills and provide adequate water services (Mothetha et al., 2013).

In the year 2000, the South African National Government introduced a policy for free basic services, stating that every household of eight people ought to receive 25 litres of water per person per day (WWF-SA, 2016). This measure has, however, proven to be inadequate, as many people in South Africa continue to be denied an adequate supply of water to their homes. Additionally, increased industrial and human settlement developments and high population growth rates, especially in the urban areas of the country, have proven to make household water supply an even greater challenge to municipalities. This indeed confirms the fact that the higher rates of population growth and urbanisation, in making increased demands on the water supply, are causing a situation which the current water infrastructure cannot sustain (Babel et al., 2010).

The pressure exerted on the water infrastructure has resulted in frequent leakages of potable water, which can be deemed as non-revenue water (NRW) losses. In simple terms, NRW losses can be defined as water that is unaccounted for in that it is lost through pipeline leaks, the theft of water from the distribution system, and unbilled water as a result of poor metering and poor customer records. In essence, NRW losses represent the difference between the amount of water placed in the distribution system and the amount that is billed to consumers (Baghirathan & Parker, 2017).

In Bangkok, approximately 81% of the country's total water losses arise from leakages in the distribution system as a result of broken pipes and the damaged water infrastructure (Babel et al., 2010). Similarly, the majority of NRW losses in South Africa are as a result of infrastructural failures. The NRW losses in South Africa average at approximately 41% of the total water loss (DWS, 2017; Ncube & Taigbenu, 2019), which is, relatively speaking, almost in line with the global average of NRW losses of 126 billion cubic meters per year (Al-Washali et al., 2019; Liemberger & Wyatt, 2019). Overall, the NRW losses in South Africa are significantly higher than in other water-stressed countries across the globe (Donnenfeld et al., 2018). Furthermore, NRW losses can be amplified by a large demand for water which places increased pressure on the already existing water infrastructure to supply water to the expanding human settlements and urban areas. The immense pressure placed on the existing and rundown water infrastructure leads to pipeline bursts and water leaks which often result in clean drinking water losses and sewage spillages (Babel et al., 2010).

Further NRW losses in South Africa are caused by unauthorised water connections. For instance, in 2012, approximately 1 700 illegal water connections were used for the irrigation of croplands, a process which consumes significant amounts of water (Seshoka et al., 2004; Jagals, 2012). Moreover, many local vendors often run informal businesses that are not regulated by the relevant authorities and the water used by these informal businesses is unaccounted for and can be regarded as NRW (Venkatachalam, 2015).

South Africa's water challenges are amplified when water losses are not timeously managed by the water service providers, that is, the municipalities (DWAF, 2004; McKenzie et al., 2012). Additional NRW losses occur as a result of the lack of coordination across the various departments of the South African municipalities. The overall lack of human resources in municipalities to manage leaks and ensure the proactive maintenance of the water infrastructure exacerbates the water losses of the already limited water reserves of South Africa (McKenzie et al., 2012).

The overexploitation of South Africa's water resources has resulted in the challenge facing the water service providers to adequately supply the general population with adequate quantities of drinking water. Despite all of the global and South African water challenges that have been discussed in this section, households continue to face water supply challenges on account of the effects of the variability of the climate, rapid urbanisation, increased population numbers, the large demand for water, the pollution of freshwater reserves and NRW losses in the country (Babel et al., 2010; McKenzie et al., 2012).

With population growth rates predicted to increase in the future, it is imperative for the perceptions, water-use behaviour and water conservation awareness of the South African population to be investigated to establish whether or not there is water stewardship in the country, despite the water challenges experienced in the country on a daily. Understanding the perceptions and behaviours of water-users could contribute to the development of more effective water management strategies and the promotion of water conservation awareness actions in the country. As such, the following section evaluates the literature relevant to the discourse on perceptions, behaviours and water conservation awareness in relation to water supply challenges. Thus, a discussion on the perceptions, behaviours and water conservation awareness of the South African population towards the challenges around water that are currently facing the country now follows.

2.8. Perceptions on Water Supply in South Africa

Munhall (2012) defines perceptions as the manner in which individuals comprehend reality through their senses, thus influencing their opinions, judgments, behaviours and actions in the world. By conducting research on the perceptions of individuals, it is possible to reflect on their subjectivity in respect of an aspect, and the fact that their perceptions could have an extremely powerful influence on their behaviour (Munhall, 2012). In many developed countries, research on water perceptions focuses on bottled water consumption, trust in the municipal water supply services, desalinated water, recycled water and private water supplies (Anadu & Harding, 2000; Turgeon, 2004; Jones et al., 2005; Doria, 2006; Hurlimann, 2008; Dolnicar & Schafer, 2009; Wright et al., 2012). In contrast, research in the developing countries is focused more on the perceptions of water quality and its ultimate safety for consumption. In essence, most of the research in the discourse on perceptions on water issues focuses more on the quality of household water rather than on the quantity of water supplied to the household (Anderson et al., 2007; Wright et al., 2012). Nonetheless, many scholars have indeed connected people's

perceptions to water quality and supply issues with their attitudes and behaviours towards using the resource (Ajzen, 2005; Adams et al., 2013).

Many South African communities face water supply and quality challenges in the domestic sphere. The increased climate variability has amplified the aforesaid water challenges as water resources become more limited, ultimately forcing water service providers to implement water restrictions. Such water restrictions cause intermittence in the supply of water to households. In turn, the dissatisfaction of community residents concerning their domestic water supply results in aggressive behaviours in the form of service delivery protests as a means of displaying their overall distrust of the municipal sector, which is responsible for providing water and sanitation services (Coetzee et al., 2016).

In a quest to address these challenges, a holistic understanding of the perceptions that the South African public has on the challenge of the household water supply must be investigated. In so doing, research on such perceptions could provide valuable insights into people's beliefs around water resources and determine their demands and behaviours around water-use in relation to the issue of the available supply of water (Coetzee et al., 2016).

Currently, the quality of water is affected by the overexploitation of the limited supply as well as the degradation of the water quality through various forms of contamination, such as *inter alia* sewage effluent spillages. Moreover, the quantity of the water made available is also a modern-day issue as the impacts of climate variability also affect the availability of water. These are but a few of the water challenges that are faced by many households in South Africa (Muller et al., 2009).

According to Hemson et al. (2002) and Kesharvazi et al. (2006), the common uses to which domestic water supplies include drinking, cooking, personal hygiene, as well as gardening. In this regard, research on the perceptions of households to their domestic water supply is paramount as it can highlight whether people's perceptions have an influence on their water-use behaviours and water conservation awareness in association with the water restrictions imposed by the municipality and the subsequent intermittent provision of water supplies that they are subjected to. Moreover, very little research has been conducted on the specific perceptions and behaviours of the residents of Hammanskraal and Atteridgeville in the Gauteng Province who have faced water supply challenges that have been highlighted since 2015 and 2016 respectively. These water challenges, experienced in amongst other areas in the Gauteng Province, Hammanskraal

and Atteridgeville, are related to water supply in the first instance and to climate variability impacts on the water supply in the second. A discussion on the perceptions of domestic households on municipal water supplies now follows.

2.9. Domestic Household Perceptions on Municipal Water Resources

According to Doria et al. (2009:5455), people's perceptions of the water supplied to their households are gauged by the taste, smell and appearance of the water, collectively called *"organoleptics"*, and such perceptions indeed have an influence on how people use the resource. For instance, in Sri Lankan households, research has found that people who perceive their water as contaminated either boil or filter their drinking water (Nauges & van den Berg, 2006; Wright et al., 2012). Similarly, in Bangkok, 71.8% of people boil or filter their tap water owing to the negative perception that tap water becomes contaminated subsequent to pipeline maintenance interventions and extended periods when no water is supplied to households (Biswas et al., 2005; Babel et al., 2010).

In South Africa, the water consumers in the North-West and Mpumalanga Provinces perceive that their water supplies are generally unreliable owing to the intermittent supply of water (WRC, 2016). In the North-West Province specifically, the organoleptic signs of residents drive the perception as to whether or not domestic tap water is safe for consumption (WRC, 2016). Hemson & Owusu-Amponah (2006) state that prolonged water interruptions can result in poor tap water quality once the supply again reaches the household. It should be noted that temporary water interruptions are important when the quality is compromised to prevent health issues (Vairavamoorthy et al., 2007). During such times, when water supplies are intermittent and when households have a negative perception towards the quality of tap water, they tend to purchase bottled water (WRC, 2016).

In Bangkok, however, extensive advertising by bottle-selling companies has had an effect on the perceptions of the public towards their water supply (Babel et al., 2010). Similarly, in South Africa, people purchase bottled water on account of their perception that the tap water is contaminated, while others resort to boiling or filtering their tap water (WRC, 2016). The poor, however, do not always have the luxury of purchasing bottled water despite their perceptions that their tap water is of a poor quality (Mothetha et al., 2013). Overall, it is imperative that alternative sources of water be made available when the tap water supplies are limited in households as a result of infrastructural maintenance or during droughts.

In many developing countries, water tankers deliver water to communities when the tap water supplies are not available (Srinivasan et al., 2010). For instance, in Chennai, India, water provision from water tankers peaked during the drought period 2003 to 2004, when piped-water supply services were ceased for a year. Research into the perceptions of households on the provision of water by informal tankers roaming around in Chennai revealed that the allocation of water was ineffective and the residents were also dissatisfied about having to purchase water in this manner (Baisa et al., 2008; Srinivasan et al., 2010).

In South Africa, however, there are limited research studies that investigate whether or not the provision of water by tankers is efficient and to the satisfaction of the consumers. Such a method should be undertaken in an efficient manner such that it would alleviate the household's sense of being deprived of a necessity of life. Should the residents have to pay for the water from the water tanker, this would be an additional expense to be incurred by them and would be even more of a burden to those who cannot afford to do so, thus exacerbating negative perceptions in this regard (Srinivasan et al., 2010).

By nature, the lack of water in a household would affect the daily functionalities in the home. It is therefore important to delve deeper into the reasons behind the domestic water interruptions which could ultimately affect the residents' perceptions of their water supply in a negative light.

A brief discussion on perceptions on water interruptions now follows.

2.10. Perceptions on Water Interruptions in the Domestic Sphere

In South Africa, poorly-treated sewage effluent from failing wastewater treatment facilities is one of the most prevalent water contamination sources affecting the quality of the water in the country (WWF-SA, 2016). When such water contamination incidents occur, municipalities are forced to implement water interruptions to terminate the supply of water, particularly to households, in order to obviate health impacts until the issue is resolved. Overall, the inadequate treatment of water and the failing wastewater treatment facilities in South Africa are an indication of the country's deteriorating water infrastructure, which requires urgent interventions (Donnenfeld et al., 2018). Moreover, climate variability in South Africa has proven to exacerbate water stress and water supply challenges by municipalities. Overall, these factors have contributed to the implementation of water interruptions and the intermittent supply of water to domestic households as continued unsustainable water-use prevails (Jorgensen et al., 2009; Muller et al., 2009). Wright et al. (2012) have therefore probed into people's perceptions regarding water interruptions,

water quality and the perceived overall safety of drinking water resources in South Africa. These authors also investigate the public opinions as to whether or not such water interruptions should be regulated by the water service providers. Such research on the perceptions of water-related issues (both in terms of water supply and quality) could assist water service providers in ensuring that an efficient and improved water supply service is afforded to communities (Wright et al., 2009).

Water interruptions (also known as water restrictions) are also temporarily implemented when the demands made on the water supply are great and the level of water consumption during droughts is unsustainable (Jorgensen et al., 2009). With the increased variability in climatic conditions, compulsory water restrictions have been implemented in countries such as Australia in a quest to limit water consumption during droughts (Cooper et al., 2019). Similar water restrictions have been implemented in South Africa, particularly in the Gauteng Province, which accommodates the relevant research areas, namely Hammanskraal and Atteridgeville. It is however worth noting that most research studies on water restrictions are undertaken during times of low rainfall and droughts, in essence, during a water crisis (Howe & Smith, 1994; Griffin & Mjelde, 2000; Gordon et al., 2001; Koss & Khawaja, 2001; Hensher et al., 2006; Cooper et al., 2019). However, the challenge of such research is that highlighting the importance of water scarcity and the necessary interventions to deal with the issue during a crisis (i.e. drought) does not necessarily promote the practice of water conservation on a routine basis (Syme et al., 2000; Rossi & Cancelliere, 2012).

In order to encourage the appropriate behaviours in terms of water conservation awareness, it is important that water restrictions be undertaken in a manner that will not result in the community being unresponsive and apathetic towards these restrictions which would defeat the purpose of reducing the high levels of water consumption. In essence, the affected parties' compliance with water interruptions or water restrictions could be optimal as long as the consumers trust the water service providers and water conservation awareness is raised to such levels that the severity of water scarcity is highlighted. Furthermore, compliance to water restrictions can be achieved when there is a common interest in the community to conserve water or when community members understand the need to do so (Atwood et al., 2007; Jorgensen et al., 2009).

Jorgensen et al. (2009) maintains that if people within a community believe that other community members are wasting water, it is likely that they will not save water themselves. As such, if water-users do not trust the water service providers (municipalities in South Africa's context) to enforce the restrictions, since the

aforementioned are at the forefront of water conservation initiatives, households will not be passionate about conserving water or about using the resource in a sustainable way (Jorgensen et al., 2009). This mentality can affect the behaviours of consumers in their usage of water.

A brief discussion on the behaviours of communities towards municipal water service provision now follows.

2.11. Behaviours of Communities towards Municipal Water Service Provision

South Africa has faced increased protests for the delivery of safe drinking water and of satisfactory sanitation services. The dissatisfaction of households regarding water services resulted in 71 protests being staged across South Africa in 2012 as a result of the challenges that municipalities were facing in their role of providing domestic water supplies (Tempelhoff, 2009, Coetzee et al., 2016; WRC, 2016).

In order to reduce the prevalence of protests, Babel et al. (2010) recommends that municipalities must ensure that they are completely transparent to the public by subjecting their water audit findings to public review and by submitting clear statements of their action plans for future water conservation and sustainable water-use. Ensuring complete transparency between the municipality and the public will mitigate any negative perceptions towards the municipality's operations (Babel et al., 2010). Wright et al. (2012) also maintains that through the provision of adequate information in this respect, the perceptions and behaviours of water-users on carefully managing water in their homes could be shaped. This would in turn justify the pressure placed on their water service providers to improve the quality of the water supplied to the domestic households (Wright et al., 2012).

In South Africa, the Blue Drop and Green Drop Reports are two of the public platforms that are being used to provide the country's population with information about the quality of South Africa's water in various regions (Wright et al., 2012; Kings, 2015). The pressing issue, however, is that the last Blue Drop and Green Drop Reports were published in 2013/2014 and that no updated reports have since been released. The failure of providing up-to-date information to the public could have an influence on their views and behaviours. Furthermore, if the public is not adequately informed about water issues, it will not take the initiative to report on the water issues that they might be facing (Wright et al., 2012; Kings, 2015).

The overall lack of adequate information on water quality and supply has been widely criticised by water-users in developed countries such as Canada, the USA and Italy, all of which have relatively safe water supplies at their disposal (Doria, 2010; Crampton & Ragusa, 2016). Evidently, the fact that a country actually has adequate water supplies does not deter the consumers from wanting to be informed about the water that they consume. Similarly, in South Africa, the service delivery protests (relating to water supply) of the past, and those more recent, are representative of a behaviour that is displayed to show the protesters' overall dissatisfaction with service provision. When the public is misinformed about issues related to *inter alia* water supply challenges, service delivery protests in the country could be intensified and their extent widened (Coetzee et al., 2016).

In a quest to gain the public's trust and to ensure that municipalities provide improved and efficient water supply services to households, Babel et al. (2010) recommends that the following measures be implemented:

1. Recruitment of new staff, trained to a high educational level in water management;
2. Empowering the existing staff through the provision of continuous training courses to improve their technical abilities;
3. The implementation of a performance management system for the appraisal of staff performance and the provision of competitive incentives;
4. Reducing the amount of time required to conduct maintenance services and reducing the time it should take technicians to repair pipelines;
5. Developing an efficient call centre that will ensure that queries and emergencies are attended to timeously;
6. Conducting regular surveys with water-users to gauge the level of customer satisfaction with the service provided;
7. Establishing a water transmission and distribution control centre, which uses the Supervisory Control and Data Acquisition (SCADA) aid, a continuous monitoring system that records water flow in pipelines and alerts the control room of leaks at specific locations and;
8. Implementing extensive projects to deal with areas of water loss and the establishment of District Metering Areas in numerous regions to narrow down the area of responsibility for the delegated officials.

The recommendations of Babel et al. (2010) are some of the measures that can be used by the City of Tshwane Metropolitan Municipality to address the challenges associated with the water supply services in the chosen research areas. Using these

recommendations, the City of Tshwane Metropolitan Municipality and other municipalities globally can alleviate the burden of providing an inadequate water supply service to the populations and various communities. This can alter people's water-use behaviours and ensure more sustainable use of water in the domestic sphere.

Further behaviours of communities on their water supply challenges relate to how water service providers actually manage water leakages. The failure of municipalities to solve the problem of water losses through pipeline leakages and system malfunctions at wastewater plants results in significant water losses, as well as water pollution incidents, that contribute to water scarcity and stress. For instance, in the rural areas of the Limpopo Province, municipal officials have highlighted the fact that at times when infrastructural failures occur, there is no one available to timeously repair the damage, and that these water losses, that occur then, over a relatively long period of time, significantly affect the water supply in such areas. A consequence of this is that residents could be apathetic in taking steps to report these leaks (Mothetha et al., 2013).

Furthermore, residents tend to disregard the importance of conserving water resources when public taps are left running and water is wasted, as well as in cases where people irrigate their gardens with potable water during droughts (Seshoka et al., 2004). Overall, as long as the water supply agencies are deemed untrustworthy by the public, the public will not be receptive to water conservation initiatives (Jorgensen et al., 2009).

Despite the negative perceptions that households might have of their water supply agencies, research has nevertheless attempted to devise water conservation awareness strategies to mitigate domestic water challenges and promote water conservation awareness actions in such households. A discussion on domestic water conservation awareness strategies and actions now follows.

2.12. Domestic Water Conservation Awareness Strategies and Actions

According to Adams et al. (2013), the ability of individuals to value the importance of water plays a significant role in their water conservation actions. These sentiments are in alignment with Edward Tolman's concept on purposive behavioursm which argues that the perceptions, beliefs and interactions of people and their environments inform their actions and behaviours, as opposed to constant stimulation through learning (Tolman, 1932). The demographic and socio-economic status of individuals does not affect their ability or capacity to apply water-saving and water-re-use methods (Clarke & Brown, 2006; Jorgensen et al., 2009). Furthermore, rural residential populations are more likely to

perceive water pollution as a community problem and to deal with the associated water issues as a collective in order to conserve the resource (Anderson et al., 2007).

What affects behaviours and water conservation awareness is the misconception that individuals have a right to a constant supply of water, without restrictions (Gilg & Barr, 2006). To alter these perceptions, initiatives have been introduced that aim to reduce household water consumption through the use of water-efficient devices and by encouraging residents to make changes to their gardening practices (Randolph & Troy, 2008).

In American households however, people would rather use basic water-saving strategies, such as taking shorter showers, as opposed to installing water-saving devices in the home (Attari, 2014). In this regard, the American population may be apathetic towards the installation of water-saving devices in their households as the USA generally experiences low water stress (Fischetti, 2012). In contrast, approximately 79% of the water consumers in South Africa's urban areas are aware of the fact that they should save water, but fail to do so (WRC, 2016).

An understanding of a consumer's perceptions and attitudes towards water supply could lead to an altered behaviour pertaining to his/her water usage through the promotion of water conservation initiatives (Ajzen, 2005; Adams et al., 2013). However, according to Syme et al. (2000), water-saving campaigns are intensively promoted only at the onset of droughts, when water scarcity is severe. These campaigns could, however, be regarded as a short-term solution to delay the implementation of water restrictions and inflationary increases in the price of water in a quest to curb the large demands made on the water supply. Therefore, in order to successfully diminish the large demands made by households on water, water-saving campaigns should be undertaken on a long-term basis, through various forms of media to encourage water-conserving actions and behaviours (Syme et al., 2000).

Although newspapers, pamphlets and various other forms of media reporting could be used as means to campaign for water-saving initiatives, these methods have not been effective in reducing the demand for water in the domestic sphere, especially when these campaigns are only undertaken during a water-related crisis. Nonetheless, conducting frequent exhibitions and open-day campaigns in local communities could enhance water conservation actions through the use of visual displays (e.g. posters) that depict some of the water-saving actions that could be applied in a household on a daily basis. The challenge with such exhibitions, however, is that maintaining the community's participation in these exhibitions cannot be confirmed and this form of campaigning is thus

also a short-term solution. In fact, television advertising could be the most effective platform for promoting water conservation awareness and altering the perceptions and beliefs of people in respect of water issues (Syme et al., 2000).

Other researchers have also attempted to provide solutions to alleviating domestic water supply challenges. For instance, Rosenberg et al. (2008) motivates households to install storage tanks to store rainwater, municipal water or collected grey water from showers and the laundry for the re-use of grey water to irrigate the garden. Moreover, Kahinda et al. (2007) elaborate on how the harvesting of rainwater domestically can improve the water sanitation challenges in many rural and peri-urban households across South Africa. It should be noted, however, that, in the variability of its climate, South Africa suffers severe conditions in the form of *inter alia,* a low rainfall, and as a result, the domestic harvesting of rainwater is not an adaptive long-term strategy that will alleviate the water supply issues that many communities across South Africa face.

In a quest to alleviate the impact of droughts, a proactive approach must be undertaken as a water management strategy in South Africa (Rossi & Cancelliere, 2012). The Intergovernmental Panel on Climate Change (IPCC) (2014) lists reactive and proactive approaches to droughts as measures to ensure resilience in the light of South Africa's climate variability and water scarcity. The IPCC highlights that using the reactive approach during a water crisis such as a drought seldom works effectively and often results in last-minute decision making, which yields expensive actions and unsustainable environmental and social impacts (Rossi & Cancelliere, 2012; IPCC, 2014).

In contrast, using a proactive approach ensures that the devised plans are adequate and are implemented efficiently and in advance of a drought crisis, through the more comprehensive drought-management plans and strategies that are put in place. It is also important to note that although proactive water management plans can be put in place prior to the occurrence of intense droughts, smooth communication and transparency between the water service providers and the public will ensure that water is used sustainably through the regular promotion of water conservation actions in households and human settlements, an initiative that should be driven by the water service providers (Rossi & Cancelliere, 2012).

Research and literature concerning the perceptions that households hold of their water challenges focus primarily on the quality and safety of the water and briefly discuss drought management strategies. However, the focus should be on the relationships between the perceptions, behaviours and water conservation awareness of the

consumers in rural townships facing water supply challenges as a result of inadequate service provision, as well as the household perceptions of water supply in the drought-stricken peri-urban areas. In essence, water usage and overall water stewardship by households under the aforementioned circumstances requires further investigation.

Synthesis of Literature Review

Water is an important resource, without which humanity, the aesthetic environment and animals cannot survive. Despite the huge demand for the resource globally, only 0.5% of the freshwater is suitable for potable use. This must be apportioned amongst the various economic sectors i.e. agricultural, municipal, industrial sectors and the domestic sphere. However, the uneven distribution of the human population and of freshwater sources exacerbates water scarcity. Furthermore, the overexploitation and pollution of freshwater supplies amplifies water stress.

The agricultural, municipal and industrial sectors are those economic sectors consuming the largest volumes of water globally. These sectors are constantly in competition with one another for this resource and as a consequence also pollute it in their respective ways. Furthermore, the increasing population growth rates globally have resulted in larger demands being made on food and water supplies and on ensuring their sustainability and security. This indeed highlights that the agricultural sector is the most water-consuming sector in the world. On the other hand, the large concentration of people in urban areas and the development of human settlements place pressure on the existing water infrastructure in its role to supply water in increasing amounts. This challenge often leads to NRW losses and wastewater spillages, the latter causing the pollution and contamination of freshwater bodies.

Quite evidently, literature has indicated that humans are at the forefront of depleting the Earth's freshwater resources. In addition to the human impacts on water resources, climate variability, associated with high temperatures and low precipitation patterns, has had a significant effect on the Earth's freshwater resources and has also contributed to the global water scarcity.

Global water quality challenges have placed additional stress on water supplies as a result of salinisation and the drainage of agro-chemicals in both surface and groundwater bodies. The challenge in this regard is that pressure is placed on the agricultural sector in its role to cater for the global food demands since the use of agro-chemicals enhances crop growth. It is, therefore, important that more innovative agricultural methods should be developed and that more effective irrigation be undertaken to reduce runoff and soil erosion. It is also imperative that more sustainable uses of water be implemented in the industrial and municipal sectors to reduce the overexploitation of water and the impacts from these sectors on water quality. Overall, the imbalances in the demand for water and

the limited water supplies intensify the issue of water scarcity and stress, especially in the domestic sphere.

South Africa is considered to have been and still to be plagued to a large extent by water scarcity. This has been as a result of the increased variations in the climatic conditions, the high population growth rates in the country and the increased demand for water made by the agricultural, industrial and municipal sectors. It has been mentioned that urban and rural domestic households consume approximately 84% of the water resources allocated to the municipal sector in this country. Despite being legally mandated to supply water to the South African population, municipalities in the country have been challenged in their role as suppliers of water on account of the failing water infrastructure, which has resulted in sewage effluent leakages and NRW losses. They have also been affected by the variability of the climate and the low rainfall which have affected dam levels.

Research on the perceptions of households highlights the fact that the perceptions of consumers could have an impact on the behaviours and awareness of households in terms of water conservation. The failure of municipalities to adequately communicate with the public on water scarcity issues, and the reasoning behind water restrictions having to be implemented, would in all likelihood make the public unresponsive to water conservation measures. Furthermore, if municipalities do not manage water leaks timeously and improve on their water treatment technologies, there will be a decline in the necessary trust of water-users which would result in rebellious behaviour in reporting water incidents such as leakages that occur in the water infrastructures serving human settlements. Overall, if there is no collaboration between municipalities and households in dealing with these demands and in enhancing sustainable water usage, households will continue to face intermittent water supplies. Furthermore, it is to be expected that there will be additional delays in the country's achievement of the targets of the 2030 SDGs that relate to ensuring that the global population has secure access to safe drinking water supplies.

Climate change is our new reality and populations will not realise the severity of water scarcity as long as the importance of water conservation is not proactively conveyed to them by the suppliers of water (municipalities). As it is of paramount importance that actions concerning water conservation awareness be carried out daily, drought management strategies should not be limited to crisis management but to daily practices in order to ensure the more sustainable use of water in the domestic sphere.

The significance of this current research is supported by the literature that has been reviewed in this chapter. In a quest to improve water conservation actions in Hammanskraal and Atteridgeville, cognisance should be taken of the comparison between the perceptions and behaviours of the residents of these human settlements. This is paramount in that it might improve actions concerning water conservation awareness in these areas and in other rural and peri-urban townships around South Africa that also experience intermittent water supplies and water restrictions.

Moreover, it is likely that improved water conservation awareness actions would be achieved once the household perceptions on the water services provided by the City of Tshwane Metropolitan Municipality are investigated and once the water stewardship in Hammanskraal and Atteridgeville has been established. This information could provide the municipality with information as to how to improve its water supply services to households, with particular focus being on the quality of the water and the quantities made available. Furthermore, research on the perceptions and behaviours of households could provide guidelines to the City of Tshwane Metropolitan Municipality as to how to promote future water conservation, drought management strategies and water conservation in the selected research areas to further enhance the culture of water stewardship in Hammanskraal and Atteridgeville. Essentially, it is necessary to prioritise improved water treatment technologies in South Africa to ensure the delivery of safe and secure water supplies to households. Moreover, more efficient water management strategies should be developed proactively in South Africa to ensure the more sustainable use of water in the country. This literature review achieved the first objective of this research and strengthened the researcher's understanding of current water supply issues, current water availability, perceptions related to water supply and water conservation awareness in the global and South African local contexts.

The following chapter discusses the methodology and data collection methods that were employed in this research to determine the perceptions, water-use behaviours, water conservation awareness and ultimately, the water stewardship of the domestic households in the research areas, namely Hammanskraal and Atteridgeville. The methodology will also determine whether Edward Tolman's purposive behaviourism concept is confirmed by this research.[1]

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[1] Tolman (1932) states that although individuals can respond positively to stimuli and learning methods, their actions are more informed by their perceptions, beliefs and interactions with their environments.

CHAPTER 3: RESEARCH METHODOLOGY

This chapter provides an overview of the research methods and techniques that were employed for the collection of the data that informed this research. The chapter firstly provides a background of the chosen research areas. The chapter further discusses the research design, data sources, sampling methods, data collection methods and the data collection instruments that were used. In addition, the chapter describes the methods used by the researcher to analyse and interpret the collected data. Lastly, the chapter presents a brief discussion of the relevant ethical considerations that were taken into account according to the obtained ethical clearance from the University of South Africa's College of Agriculture and Environmental Sciences (CAES) Health Research Ethics Committee (Appendix 1). The chapter concludes with a brief discussion of the limitations associated with the chosen research techniques and strategies. A brief discussion on the background to the research areas now follows.

3.1. Background to research areas

The chosen research areas for this comparative research are Hammanskraal and Atteridgeville. The former is a rural township located in the northern part of Pretoria, while the latter is a peri-urban township which lies on the western outskirts of Pretoria's Central Business District (CBD). A regional locality map which indicates the locations of Hammanskraal and Atteridgeville within the Gauteng Province is provided in Figure 3.1.

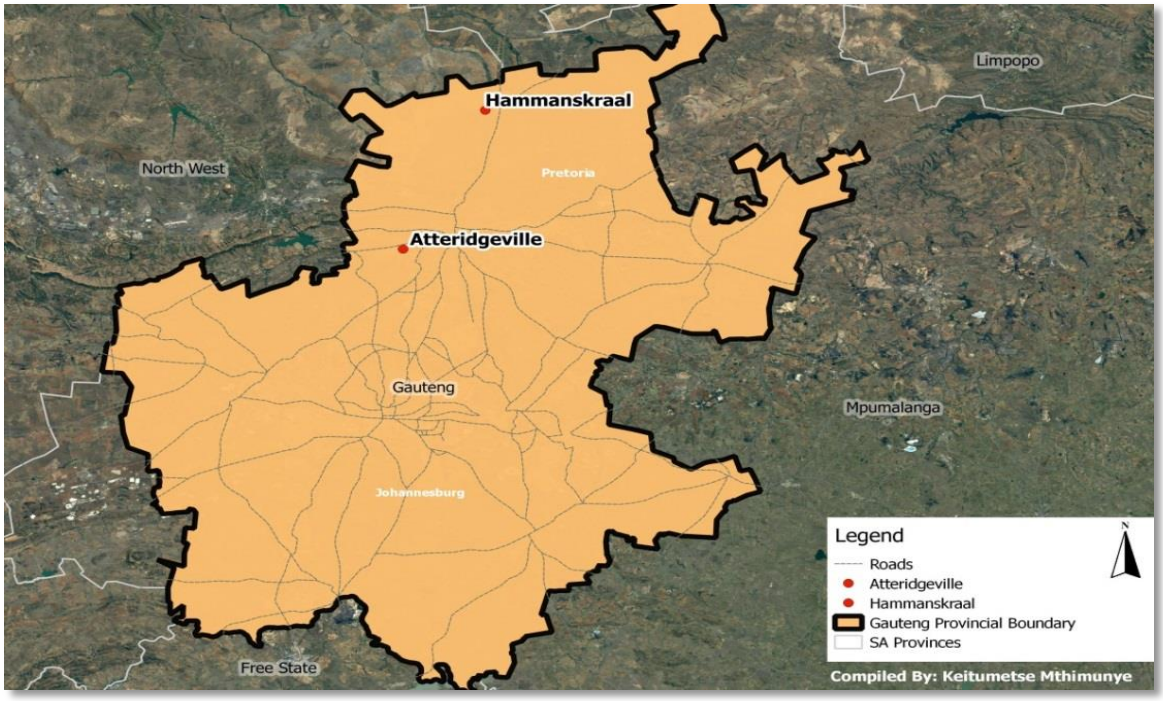

Figure 3.1: Regional locality map of research areas.

The demographic, socio-economic status and service provision data of both Hammanskraal and Atteridgeville were important components that were considered to be relevant for purposes of drawing local contexts of the research areas. The aforesaid data for the selected research areas was sourced from the 2011 census conducted by Statistics South Africa (StatsSA). An overview of the two mentioned and selected research areas now follows, starting firstly with Hammanskraal, followed by Atteridgeville.

3.1.1. Hammanskraal

Hammanskraal, is a rural township located north of Pretoria and has population of approximately 21 345 (StatsSA, 2011a). The locality map for this area is provided in Figure 3.2.

Figure 3.2: Locality map of Hammanskraal.

The population in this area constitutes of 98.3% black people, 0.4% coloured people, 0.29% Indian or Asian people and 0.4% white people. Setswana is the language most commonly spoken in this area (46.2%), followed by Sepedi (18.2%) and Xitsonga (14.71%). The greater majority of the population in Hammanskraal consists of men (50.1%), while 49.9% of the population are women (StatsSA, 2011a).

With regards to the socio-economic status of Hammanskraal, only 35% of the population has a Matric, while only 10.3% of the population has acquired a higher educational

qualification. In addition, 66% of the population falls within the working class age category of 15 to 64. Hammanskraal has approximately 6 665 households, with 61.2% of these households being formal dwellings.

In terms of service provision, 82.9% of the Hammanskraal population receives water from the regional water scheme (the local municipality) and 14.2% from water tankers. Approximately 0.7% of the Hammanskraal residents collect water in rainwater Jojo tanks, while the remaining 2.2% of the population collect their water either from boreholes, springs or they purchase water from local vendors. Furthermore, 58.1% of the population has flushing toilets which are connected to the local sewerage system, while 30.3% still make use of pit latrine toilets without ventilation (StatsSA, 2011a). The fact that pit latrines and water tankers are still used in Hammanskraal is indicative of the rural nature of the township and water-related challenges in the area as compared to Atteridgeville. The local context of Atteridgeville and a brief background of this area now follows.

3.1.2. Atteridgeville

Atteridgeville is a peri-urban township which lies on the outskirts of the Pretoria CBD and the locality map for this area is presented in Figure 3.3.

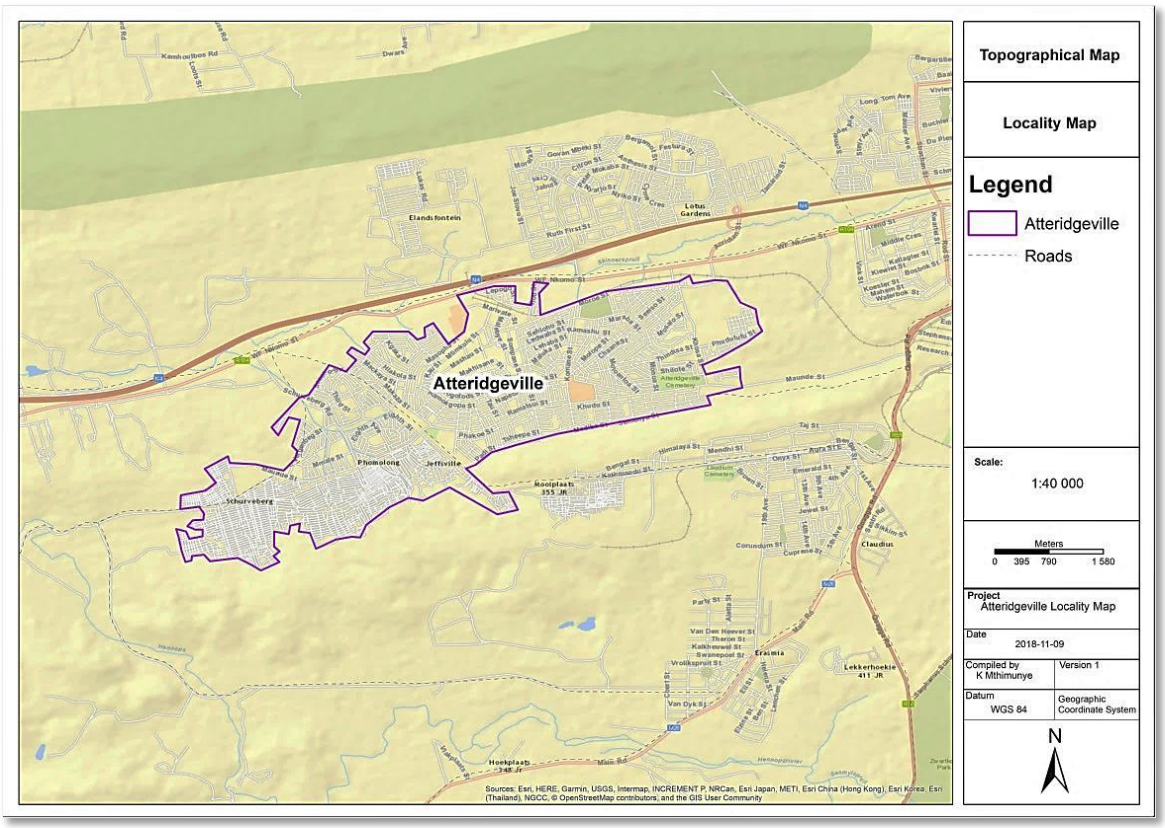

Figure 3.3: Locality map of Atteridgeville.

Atteridgeville hosts a total population of approximately 64 425 and has a population density of 6 550 persons/km^2. Approximately 72% of the working class in Atteridgeville is aged between 15 and 64, and the elderly (ages 65+) represent only 5.4% of the population. In addition, 15.8% of the population have a higher education qualification and are aged 20 years and above, while 38.6% of people in the same age group have a Matric. Only 4.5% of the population are aged 20 years and older have no schooling whatsoever. Moreover, 42.9% of the households in Atteridgeville are female-headed (StatsSA, 2011b).

With regard to housing, there are approximately 16 456 households in Atteridgeville and 92.6% of these households are formal dwellings. In terms of the overall service provision in the area, 98% of the Atteridgeville households have electricity connections and 96.1% enjoy weekly refuse removal. Additionally, 67.2% of the households have piped water and 99.3% of the households have flushing toilets connected to the local sewage system (StatsSA, 2011b). Water tankers are used by 0.1% of the population however, this rating can be assumed to be that of water tankers being used only during the times when the regional water supply is interrupted (StatsSA, 2011b). Overall, the census data indicates that the Atteridgeville residents have a higher socio-economic status and overall better service provision than Hammanskraal.

The maps above (Figure 3.2 and Figure 3.3) provide the local contexts of the two selected research areas, the second objective for this research. This comparative research focused on Hammanskraal and Atteridgeville in order to compare these two diverse settlements (one a rural settlement and the other a peri-urban township) in terms of a factor common to both of them, namely the municipal water restrictions that they are subject to and their overall behaviour towards using the resource. The research also focused on comparing these two areas in terms of the water conservation awareness and the overall water stewardship of the residents. This was undertaken using the chosen theoretical framework and also through the use of the data collection and analysis methods that will be discussed in the sections that follow. The following section briefly discusses the theoretical framework that was employed for this research.

3.2. Theoretical framework

A theoretical framework brings the research into focus and channels a researcher's choice of the research design, the data collection and analysis methods (Adom et al., 2018). The theoretical framework used in this research is interpretivism which entails gaining knowledge of the world, a phenomenon or an event through interpreting and/or

understanding the values that individuals attach to their behaviours and actions (O'Reilly, 2009). Interpretivism in this research was used to establish the water stewardship in Hammanskraal and Atteridgeville on account of the participants in these areas having lived in experiences of receiving water supply intermittently. Using the interpretivism research framework, a research design was therefore selected to establish the empirical data that had to be collected in order for this research to achieve its overall aim and objectives. A discussion of the research design employed in this research now follows.

3.3. Research Design

A research design is representative of the logical sequence by which empirical data is connected to the research questions and culminates in the conclusions reached (Yin, 2003). This research followed a case study research design approach investigating the circumstances surrounding the intermittent water supply events in Hammanskraal and Atteridgeville that the residents were experiencing at the time. According to Creswell (2003), in a case study research design, a researcher explores an event or an activity or the opinions and perceptions of one or more individuals in depth. Furthermore, a case study also involves a time frame and is an attempt to thoroughly explore a *"poorly understood situation"* (Leedy & Ormrod, 2001:149). In essence, a case study is a case-specific research design as it focuses on a specific event from which a researcher provides insight on the contexts and issues that have had an influence on that specific case (Leedy & Ormrod, 2010).

In terms of Hammanskraal, the systemic and infrastructural malfunctions at the Rooiwal Wastewater Treatment Plant resulted in sewage effluent spillages in the drinking water sources for the area and these water contamination incidents forced the City of Tshwane Metropolitan Municipality to implement water restrictions (Legodi, 2016). These water restrictions were implemented primarily to prevent the Hammanskraal residents from consuming the contaminated tap water while maintenance operations were still in progress at the aforesaid plant (Legodi, 2016; Etheridge, 2019). In Atteridgeville, the 2016-2017 drought forced Rand Water and the City of Tshwane Metropolitan Municipality to implement water restrictions on account of the large demand for water and its unsustainable consumption during the drought – this while the Vaal Dam levels were also running low (Tandwa, 2016; Ntshidi, 2019).

In essence, both the cases of Hammanskraal and Atteridgeville resulted in the implementation of water restrictions and intermittent water supplies to households in these areas. The case study research design in this regard followed a mixed method

approach, which entails the collection of both qualitative and quantitative data (Creswell, 2014). The mixed method approach enabled the researcher to use multiple data collection instruments (Lohr & Raghunathan, 2017). The quantitative data for this research were acquired through surveys, while the qualitative data were acquired by conducting focus group interviews, one-on-one interviews, as well as by making observations on transect walks. Overall, this research used a case study approach to investigate the perceptions, water-use behaviours, water conservation awareness and water stewardship of the Hammanskraal and Atteridgeville residents pertinent to the intermittent water supplies that these residents were facing following the implementation of water restrictions. As such, the researcher collected relevant data from various sources to achieve the set aim and objectives. A discussion of the sources of data used in the research now follows.

3.4. Sources of Data

Two types of data sources were used in this research, namely primary and secondary data sources. On one hand, primary data can be defined as the original data collected by the researcher for the purpose of attaining a specific research goal. Secondary data, on the other hand, is data that have been acquired from sources that already exist and with the purpose of being reused for other purposes (Hox & Boeije, 2005). In this regard, primary data for this research were obtained from observational transect walks, semi-structured focus group discussions, a semi-structured survey (questionnaires) and semi-structured interviews within the selected research areas.

In a quest to obtain the primary data for this research, the selection of participants that constituted the population sample was based on various sampling methods. A brief discussion on the methods used to calculate the sample size in this research now follows.

3.5. Sample Size

The sample size in a research project typically refers to the number of units or participants that are chosen by the researcher and from whom data are collected (Lavrakas, 2008). For the purpose of this research, the Slovin's Formula was used to determine the sample size (Table 3.1) (Stephanie, 2013). The Slovin's Formula is given as follows:

$$n = N/(1+Ne^2),$$

where*:*

n is the sample size,

N is the population size and

e is the margin of error to be decided by the researcher.

Table 3.1: Parameters and method used to calculate the sample size.

	Hammanskraal	Atteridgeville
Population size (N)	21 345	64 425
Confidence level (%)	95%	95%
Confidence interval (%) (e)	5%	5%
Sample Size (n):	**393**	**398**

As indicated in Table 3.1, both sample sizes for Hammanskraal and Atteridgeville respectively were measured at a confidence level of 95% and a confidence interval of 5% to narrow down the population size and create a suitable population sample size from which the researcher could collect data. A confidence level of 95% in essence would indicate that for 95% of the time, the calculated population sample size could be achieved and would represent the entire population in the research, while there would be a probability that 5% of the calculated population sample size would not participate in the research and would thus not be a true representation of the population (Kothari, 2004). It should, however, be noted that it was not feasible for the researcher to issue questionnaires and to conduct focus group discussions with 393 and 398 participants from Hammanskraal and Atteridgeville, respectively. These sample sizes were determined to be too large for a single researcher to achieve during the permitted time period for the ultimate completion of the research. Therefore, to reduce the sample size even further, the researcher aimed to collect data from a designated sample size which would represent the probable number of sample units or participants selected for the purpose of data collection (Lavrakas, 2008).

The designated sample size in this regard aimed to include 100 participants from Hammanskraal and 100 participants from Atteridgeville in the survey. A total population sample size of a 100 was selected to be of a representation of the selected study areas for this research, due to its achievability i.e. for a single researcher to undertake within the permitted time period. In addition, the researcher aimed to conduct 2 focus group discussions with 100 participants each from Hammanskraal and Atteridgeville respectively. The research aimed to complete 10 interviews with municipal officials from the Water Supply Division of the City of Tshwane Metropolitan Municipality to obtain the municipality's perspective on selected water related matters. A total of 10 were determined to be the most achievable due to the unavailability and/or unwillingness of the municipal officials.

This designated sample size appeared to be feasible to the researcher. However, this

research required that the participants would seriously commit to their involvement and that they would make time to participate in the survey, focus group discussions and interviews. What subsequently transpired, however, was an overall lack of interest of the Atteridgeville residents to participate in the focus group discussions and their lack of response in respect of the survey questionnaires. As a result, the designated sample size proved to be unattainable. Furthermore, there was also unresponsiveness to the attendance of the one-on-one interview meetings with the officials of the relevant municipality in the designated sample. Therefore, the researcher was obliged to collect data from a reduced number of participants, as designated in the final sample size. It should be noted that due to Hammanskraal being a rural township and Atteridgeville a peri-urban township, not all residents would have had access to online questionnaires. Most of the population in the selected study areas did not have the necessary online resources to complete online questionnaires. The researcher therefore undertook the survey using hard copy questionnaires to ensure a wider reach in both research areas. It should also be noted that in Atteridgeville there was some reluctance to participate in the research and convincing the population to participate in an online questionnaire would have yielded in even less response and participation.

In essence, the final sample size was determined by the actual number of participants from whom data were collected (Lavrakas, 2008). As such, this research included 170 participants in total. A breakdown of this final research sample is presented in Table 3.2.

Table 3.2: Breakdown of the final research population sample.

	Hammanskraal	**Atteridgeville**
Questionnaire participants	100	45
Focus group discussion participants	10	10
Interviews with municipal officials	5	
Final Sample Size	**170**	

In Hammanskraal, there were 100 survey participants and 10 participants who were actively involved in the focus group discussions. In Atteridgeville, 45 participants participated in the survey and 10 participated in the focus group. Furthermore, five municipal officials participated in the one-on-one interviews. Lastly, transect walk observations were undertaken in both research areas. Using these means as data collection instruments, data collection was completed within Hammanskraal and Atteridgeville.

On determining the size of the sample for this research, various sampling methods were used by the researcher to ensure that the participants in the sample would indeed provide the data required to achieve the aim and objectives of this research. A description of the sampling methods used in this research now follows.

3.6. Sampling Methods

Specific sampling methods are often employed when the total population in an area of interest is too large, ultimately resulting in time, cost and resource constraints (Brown, 2006). Sampling would then be the tool of choice in such a situation. It can be defined as the selection of a portion of the total population of an area that can be used to represent or to make generalisations about the attributes of the entire population. Sampling generally makes the data collection process more practicable and also improves the accuracy of the findings in that it makes the collected data manageable (Proctor, 2003; Brown, 2006).

The sampling methods applied in a research are highly dependent on the type of research methods employed. For instance, in qualitative and quantitative research (mixed method research), two different types of sampling techniques are used, namely probability and non-probability sampling techniques (Palinkas et al., 2015).

For this research, non-probability sampling techniques were used. In non-probability sampling, participants are selected subjectively and are not necessarily representative of the entire population (Ilker et al., 2016). Non-probability samples for qualitative research are generally selected purposefully in a quest to obtain in-depth information from the participants who are selected, primarily in terms of their availability, willingness to participate, as well as their overall experience in terms of the research problem and, therefore, their suitability in providing the sought-after insights (Palinkas et al., 2015).

The participants for this particular sample were selected on account of having experienced intermittent water supply challenges and their traits and insights that could satisfy the aim of this research (Koerber & McMichael, 2008). It is important to note that although this case study research in fact involves elements that could be investigated in terms of quantitative research, a qualitative research approach was followed to investigate the perceptions, water-use behaviours and water conservation awareness of the sampled residents of Hammanskraal and Atteridgeville according to the set questions.

Non-probability sampling was incorporated by this research and consists of four sampling strategies, namely snowball sampling, convenience sampling, quota sampling and

purposeful sampling (Tansey, 2007). This research used quota and purposeful sampling techniques. According to Tansey (2007:769), quota sampling strategies *"seek to ensure that the sample is selected so that certain characteristics are present in the sample in proportion to their distribution in the wider population".* The use of quota sampling for the survey allowed the researcher to obtain responses from participants in randomly selected households in both Hammanskraal and Atteridgeville who possessed the attributes of being informed about the topic of this research.

Furthermore, purposeful sampling techniques were used in this research. Purposeful sampling is a technique that is widely used on the basis that the selected participants in the research have an in-depth knowledge about and have experienced the phenomenon of interest (Patton, 2002; Creswell & Plano Clark, 2011). As such, the focus group participants and the municipal interviewees were purposefully selected to provide insights on the perceptions, water-use behaviours and water conservation awareness on account of the intermittent water supply challenges experienced in Hammanskraal and Atteridgeville.

Certain participants in Hammanskraal were notified of the focus group that they could potentially constitute when the researcher purposefully invited a group of local church members of the congregation to participate in the focus group discussions. At this stage, the researcher also enlisted the local church as the venue for conducting the focus group discussions. As such, 100 Hammanskraal residents were in attendance when the focus group met, although only 10 participants actually actively engaged and responded to the questions.

In Atteridgeville however, there were 10 participants that availed themselves of the opportunity to actively engage in the focus group. As in the case of Hammanskraal, the focus group in Atteridgeville consisted of 10 participants who were also members of a local church and youth club. The venue for the focus group meetings in Atteridgeville was a local park in the area. This purposeful invitation was implemented in both study areas due to the certainty that church members in the case of Hammanskraal, and members of the church and youth club in the case of Atteridgeville, were more likely to attend (Hofmeyer & Scott, 2007). Overall, the focus group participants in each research area were purposefully selected primarily due to their familiarity of the area. Lastly, the municipal officials from the Water Supply Division of the City of Tshwane Metropolitan Municipality were purposefully selected to provide insights into the service that the municipality renders to the people of Hammanskraal and Atteridgeville in terms of supplying water and the reasoning behind water restrictions in the selected research

areas.

Using the sampling techniques and strategies detailed in this section, survey and focus group data were collected in Hammanskraal and Atteridgeville, while further data were collected through interviews with officials from the City of Tshwane Metropolitan Municipality. A discussion on the data collection methods used in this research now follows.

3.7. Data Collection Methods

Quantitative research entails the testing of objective theories through analyses of the respective relationships between the relevant variables, while qualitative research explores and investigates that people attach to a specific social or human issue (Creswell, 2014). The quantitative data for this research was acquired firstly through a survey (questionnaires) conducted in both research areas. The questionnaire comprised of both semi-structured and structured qualitative questions which required responses to open-ended and close-ended questions respectively (Neuman, 2011; Bertram & Christiansen, 2014). Furthermore, qualitative data of this research was acquired through observations made by the researcher in Hammanskraal and Atteridgeville and through discussions in the semi-structured focus groups involving participants from both research areas. Qualitative data was also acquired through the use of semi-structured interviews that were conducted with the municipal officials from the Water Supply Division of the City of Tshwane Metropolitan Municipality.

The overall use of semi-structured questions in the survey, focus group discussions and interviews with the municipal officers allowed the participants to provide open-ended answers and enabled the participants to express themselves in the best possible way (Bertram & Christiansen, 2014). The quantitative and qualitative data for this research were collected using multiple data collection instruments. A detailed discussion on the data collection instruments used in this research now follows.

3.8. Data Collection Instruments

The researcher used four data collection instruments for this research. They included transect walk observations, surveys (semi-structured questionnaires), semi-structured focus group discussions in Hammanskraal and Atteridgeville, as well as semi-structured interviews with officials from the City of Tshwane Metropolitan Municipality which ensured that the third objective of this research was achieved. A brief discussion on the specific data collection instruments used in this research now follows.

3.8.1. Observations / Transect Walks in Hammanskraal and Atteridgeville

For the purposes of this research, observations were undertaken during transect walks in both Hammanskraal and Atteridgeville which enabled the researcher to analyse and observe the general behaviours of the residents in terms of water consumption and their practising of water conservation measures in the respective areas. These observations were documented by means of field notes and photographs taken by the researcher during the transect walks. In so doing, the researcher obtained a brief overview of the behaviours of the populations in Hammanskraal and Atteridgeville in respect of water consumption and conservation prior to actually conducting the survey and the focus group discussions. Following the transect walks, a survey was undertaken in each research area. A brief discussion of the data collection method employed during the survey (questionnaires) now follows.

3.8.2. Survey (Questionnaires) in Hammanskraal and Atteridgeville

In this research, semi-structured questionnaires were self-administered by the researcher and were completed by 100 participants from randomly selected households in Hammanskraal, while 45 questionnaires were completed by participants from randomly selected households in Atteridgeville. The randomness in selecting participants was ensured through the researcher randomly knocking on doors, seeing who opened the door and their willingness to participate in the survey. The consent form and semi-structured survey questionnaire is included in Appendix 2.

For the purposes of ensuring validity and for clarity on certain survey questions, the researcher further undertook focus group discussions with participants from Hammanskraal and Atteridgeville who did not participate in the survey. This was achieved by means of focus group discussions that were conducted in sections of Hammanskraal and Atteridgeville other than those areas where the surveys were undertaken. A brief discussion of the data collected through the focus groups now follows.

3.8.3. Focus Groups in Hammanskraal and Atteridgeville

For this research, 2 semi-structured focus group interviews which required open-ended responses were conducted with groups of 10 residents in each group from Hammanskraal and Atteridgeville respectively. The consent form and semi-structured questionnaire that the researcher used for the focus groups is included in Appendix 3.

The semi-structured questionnaire for the focus group discussions conducted in both

research areas included questions that were similar to those included in the survey questionnaires. In so doing, the researcher could validate the responses provided during the surveys to endorse the accuracy and for the clarification of the collected survey data (Creswell, 2003). The use of the semi-structured questions posed in the focus group discussions allowed the participants to provide insights into their perceptions and behaviours in terms of water consumption and their awareness of water conservation, all important aspects emanating from the intermittent water supplies that they were experiencing in their homes. The focus group interviews in Hammanskraal and Atteridgeville were recorded using a digital recording device and were subsequently transcribed. The researcher also made notes during the focus group discussions.

In addition to the focus group discussions, one-on-one interviews were conducted with 5 municipal officials from the Water Supply Division of the City of Tshwane Metropolitan Municipality. A brief discussion on the data collection through the undertaking of interviews with the municipal officials now follows.

3.8.4. Interviews with Municipal Officials

In a quest to determine the perceptions of the municipality towards its challenges in the provision of adequate water supplies to the research areas, one-on-one interviews were conducted with 5 municipal officials from the Water Supply Division of the City of Tshwane Metropolitan Municipality. The interviews with the municipal officials consisted of semi-structured questionnaires which required open-ended responses. This enabled the interviewees to express their in-depth perceptions of the municipality as service provider supplying water to the townships of Hammanskraal and Atteridgeville. The consent form and semi-structured questionnaire that was used by the researcher during the municipal interviews is included in Appendix 4. All of the interviews with the municipal officials were recorded by means of digital recording device and the recordings were subsequently transcribed. The researcher also wrote notes during the interviews.

All of the collected data for this research were subsequently analysed using specific data analysis methods. Using these methods allowed the researcher to evaluate and compare the current water conservation awareness, adaptations to water restrictions and the overall water stewardship in Hammanskraal and Atteridgeville and to recommend suitable actions which should be taken or measures which could be implemented to address the identified water supply challenges and promote future water stewardship in Hammanskraal and Atteridgeville (all of which are the objectives of the research). A discussion of the data analysis conducted for this research and the associated

interpretations made now follows.

3.9. Data Analysis and Interpretation

According to Coghlan and Brydon-Miller (2014), data analysis and interpretation refer to the processes that are undertaken to attach meaning and clarity to the data collected in a research project. During the quantitative phase of this research i.e. the survey, the collected data were recorded on an Excel spreadsheet and analysed through the Statistical Package for Social Sciences 21 (SPSS). SPSS is a computer programme that manages data and is designed to perform statistical analyses (Field, 2005). SPSS was used as the primary data analysis tool for data obtained from the questionnaires/survey as it was the available software that the researcher had full access to. Through the use of SPSS, the statistical data generated by this programme were graphically presented in the form of bar graphs and pie charts. Thereafter, the data were interpreted in detail by the researcher.

The researcher assigned separate codes to Hammanskraal and Atteridgeville respectively on the Excel spreadsheet to ensure that SPSS would distinguish between the questionnaire responses from the respective research areas. This enabled the researcher to compare the survey responses of the Hammanskraal participants to those of the Atteridgeville participants in terms of their perceptions, behaviours and conservation awareness and overall water stewardship in respect of their water-related issues. Furthermore, the responses of the questionnaires were synthesised and only the most important findings i.e. the responses which had the most insightful responses were analysed, interpreted and discussed. It should be noted that a case study research approach was used in this research and that statistical hypothesis testing was not used, the reason being that this research is qualitative and quantitative by nature.

The qualitative data for this research – i.e. the focus group and interview data - were analysed through thematic analysis, which entails the identification of themes, patterns and similarities in the data (Creswell, 2005). The recordings of the focus groups conducted in Hammanskraal and Atteridgeville, as well as the interviews conducted with the municipal officials from the Water Supply Division of the City of Tshwane Metropolitan Municipality were transcribed and each transcription was studied in detail by the researcher. The researcher encoded the transcribed data - a process in which the qualitative data are organised by placing specific responses from the collected data under relevant themes and categories in a margin or in tabular form (Rossman & Rallis, 2012). Notes were made on the transcriptions and the researcher individually highlighted similar

responses from the two research areas which were then placed in specific categories in a table.

The focus group and interview responses that related to specific categories from both research areas were recorded in Table 3.3, alongside the relevant themes namely perceptions on water supply, water conservation awareness and water-use behaviours (Coetzee et al., 2016). From the encoded data, the researcher also organised the responses that related to perceptions on water supply, water conservation awareness and behaviours around water-use from both research areas in the same table. The transcribed quotations from the Hammanskraal and Atteridgeville respondents, as well as the responses emerging from the interviews with the municipality were typed *verbatim* in black, red and blue respectively (Table 3.3).

Table 3.3: Qualitative data analysis of the focus group and interview responses (adapted from Coetzee et al., 2016).

Focus group quotations of the Hammanskraal and Atteridgeville respondents and interview quotations of municipality respondents (qualitative data)			
Themes	**Categories**	**Participants**	**Quotation**
Perceptions	Facilitation of water tankers	Hammanskraal	*"The tankers sell the water."*
		Atteridgeville	*"We have not received water from any water tankers on this side of the community, but there have been tankers in other areas."*
Behaviours	Collective community management of water issues	Hammanskraal	*"Yes, they meet here; there is, yes."*
		Atteridgeville	*"No, we don't do that."*
		Municipality	*"We have the Water Week, I know there is; yearly there is a water week during which there [are] awareness campaigns that are conducted."*

All the survey responses were presented graphically in the form of bar graphs and pie charts under the relevant themes and categories and were analysed and interpreted accordingly. In addition, the transcribed responses issuing from the focus group discussions and interviews that belonged to the same category as the survey responses were integrated. Furthermore, the observations noted during the transect walks in the research areas were also integrated into the correct/ relevant category. Using all the

aforesaid data collection methods, the survey responses could be validated by the researcher, which in turn highlights the true values of an interpretivism framework (Creswell, 2003; Chowdhury, 2014). This process was undertaken for all of the collected data, which were reviewed numerous times by the researcher to confirm that the data had been analysed correctly. It should be noted that data cleaning was undertaken and only the most relevant categories were analysed. Lastly, the organised analysed data in respect of Hammanskraal and Atteridgeville were interpreted by the researcher in order to determine the findings of the research and to ascertain whether the aim and objectives of the research had been attained and whether water stewardship is prevalent in the research areas.

It was necessary during the data collection and analysis phases of this research to consider certain ethical considerations to ensure that the researcher had collected the data with integrity and that the dignity and anonymity of the research participants had been prioritised. Overall, the ethical considerations also ensured that the data collected in this research project were not manipulated in any way (Bryman & Bell, 2007). A brief discussion on the ethical considerations and limitations for this research now follows.

3.10. Ethical Considerations and Limitations

Ethical considerations are taken into account during a research project to ensure that the participants are respected and for the researcher to collect data with the utmost integrity (Bryman & Bell, 2007).

The researcher made a point of reading to the participants from both research areas, the ethical consideration letter attached to every questionnaire of each data collection instrument. The purpose of reading the ethical consideration letter to participants was to obtain their consent prior to their involvement and participation in the survey, focus group discussions and/or interviews. The consent forms for each of the aforesaid data collection instruments have been attached to the respective questionnaires that are presented in Appendices 2 to 4.

The survey participants in both research areas remained anonymous and were not obliged to indicate their contact details on the questionnaire. The researcher made a point of reading the ethical clearance letter to the participants prior to their completion of the questionnaire (Appendix 2). In instances where a participant was unable to fill in the questionnaire, the researcher filled in the questionnaire on his/her behalf by *verbatim*

writing down what the participant articulated to the researcher and without manipulating the responses in any way.

Furthermore, the researcher also read the ethics consent form to the focus group participants in Hammanskraal and Atteridgeville and they were also not obliged to indicate their names or any other form of identification during the focus group discussions (Appendix 3). Lastly, the researcher read out the ethics consent form prior to conducting interviews with the municipal officials (Appendix 4). The researcher also obtained permission to conduct this research in the City of Tshwane Metropolitan Municipality and to interview five municipal officials in the water supply division of the municipality (Appendix 5). Finally, it should be noted that for record-keeping purposes in the municipality, each municipal official that participated in the interviews signed a consent letter to do so.

There were numerous limitations that the researcher faced during the data collection phase and included the following.

The Atteridgeville residents were not keen to participate in the research owing to the fact that water restrictions were no longer being applied in the area. There were only 45 survey participants in Atteridgeville owing to the reluctance of the residents in this area to complete the questionnaire. Furthermore, despite the researcher scheduling focus groups on numerous occasions during the period October 2018 to March 2019, no one attended the focus group meetings in Atteridgeville. Eventually, only 10 participants availed themselves of the opportunity to do so and participated in the focus group discussions in Atteridgeville in April 2019.

Whereas the researcher had initially requested 10 interviews with the relevant municipal officials, only five availed themselves for the interviews. Additional interviews could have provided the researcher with greater insights into the provision of water by the City of Tshwane Metropolitan Municipality in the respective research areas. These limitations prolonged the data collection process of this research.

It is important to note that all references made in this research to the poor quality of the water in Hammanskraal were based primarily on the current literature about this issue and the responses provided by the participants. The researcher did not undertake any sampling or quality analysis of the water for this research since the focus of this research was by no means on water quality issues. Another limitation of this research is that its findings are case-specific to Hammanskraal and Atteridgeville. As such, since water-

related issues vary in the townships nationwide, not all findings of this research can be generalised to apply to the wider population of South Africa (McLeod, 2019).

Overall, the researcher ensured that the dignity of all of the participants was honoured and that they were treated with respect. All participants were reassured of their anonymity for participating in this research. In addition, all of the completed questionnaires have been stored in a locked cabinet and the recordings of the focus group discussions and interviews, as well as their transcriptions have been stored in a password-protected computer. The data collected in this regard will be kept safe by the researcher for a period of five years.

This chapter provided a detailed overview of the research methodology and data analysis techniques that were used in this case study research. Through the use of a mixed method approach, the researcher was able to obtain in-depth qualitative data to inform the findings and conclusions of this research. The collected data were analysed and interpreted to determine whether the research findings would correlate with those published in the existing literature, as well as to ultimately achieve the set aim and objectives of this research. A detailed discussion of these results now follows.

CHAPTER 4: RESULTS AND DISCUSSION

This chapter presents the results for this research, which focuses on the perceptions, water-use behaviours, water conservation awareness and overall water stewardship of a sample of residents from both Hammanskraal and Atteridgeville who were selected as research participants, with the first-mentioned aspects having arisen from the intermittent water supplies experienced in these two townships over the years 2015 to 2017. This chapter includes an analysis and interpretation of the data collected through surveys (questionnaires), observations made on transect walks and outputs of focus group discussions conducted with the participants from each research area. In addition, data emanating from the interviews conducted with the municipal officials in the Water Supply Division of the City of Tshwane Metropolitan Municipality are also analysed. Finally, a comparative analysis of the data collected in Hammanskraal, Atteridgeville and the municipality was conducted to determine the similarities and contrasts in terms of perceptions, water-use behaviours, water conservation awareness and water stewardship in the research areas.

Following the case study approach employed in this research, the collected data were differentiated into three themes. The first theme includes the observed water-use behaviours in the respective research areas; the second, an assessment as to whether the respective water-use behaviours of the participants in these two research areas were informed by their perceptions of the intermittent nature of their water supplies at the time of the research; and the third, the awareness of the participants from both research areas in terms of their water stewardship and conservation initiatives.

A brief discussion on the water-use behaviours in Hammanskraal and Atteridgeville now follows.

4.1. Water-use Behaviours in Hammanskraal and Atteridgeville

The current water-use behaviours of the survey and focus group participants in Hammanskraal and Atteridgeville were investigated in this research. These water-use behaviours were investigated subsequent to the imposition of water restrictions as a result of infrastructural failures at the Rooiwal Wastewater Treatment Plant which resulted in the contamination of Hammanskraal's drinking water sources, and of the 2016-2017 drought which also affected Atteridgeville. Firstly, it was imperative to determine whether or not the participants in these areas had adapted to the intermittent nature of their water supplies and secondly, whether they had prepared ahead of the water restrictions by implementing water-saving initiatives.

Brief discussions in respect of the adaptation of the respective communities to their intermittent water supplies and the preparations that they might have made for it now follows.

4.1.1. Adaptation to and Preparation for Intermittent Water Supplies in Hammanskraal

When the survey participants from Hammanskraal were asked whether or not they had made preparations in advance for the interruptions to their water supply, 76% stated that they were making a practice of storing water in buckets and plastic containers as they expected their water supplies to be cut off for up to a week at a time. In addition, 7% of the surveyed participants were storing water in bathtubs and 11% were collecting rainwater in Jojo tanks. On account of the perception that the water in Hammanskraal was contaminated, 6% of the surveyed participants indicated that they were purchasing 20 to 40 litres of bottled water per week for cooking and drinking purposes (Figure 4.1). The focus group participants were also storing water by means of the aforesaid methods.

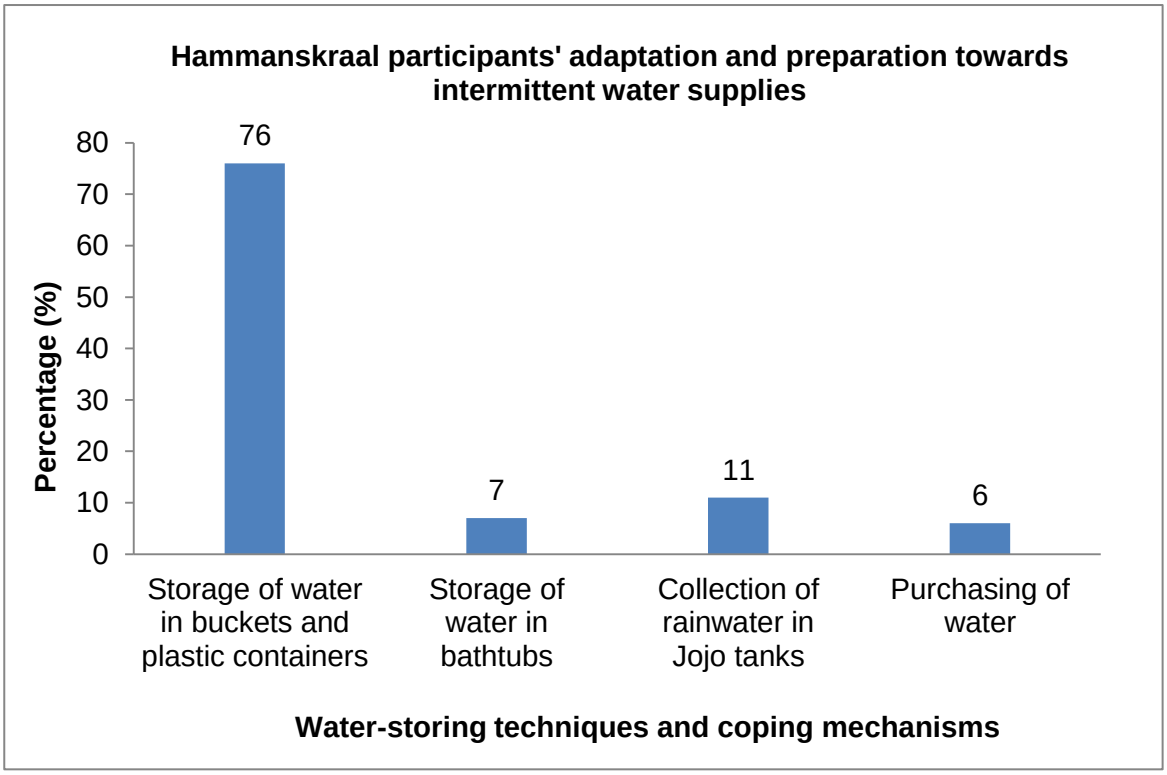

Figure 4.1: Hammanskraal participants' adaptation and preparation towards intermittent water supplies.

These adaptations/ preparations were further confirmed during the transect walk in the area. Initially, the researcher observed that water storage drums and plastic containers were being sold at the entrance to Hammanskraal. Furthermore, it was observed that

households in the area were using buckets in which to store water. Lastly, Jojo tanks for storing water and for the harvesting of rainwater from the roofs were also observed in many of the yards across the township (Figure 4.2).

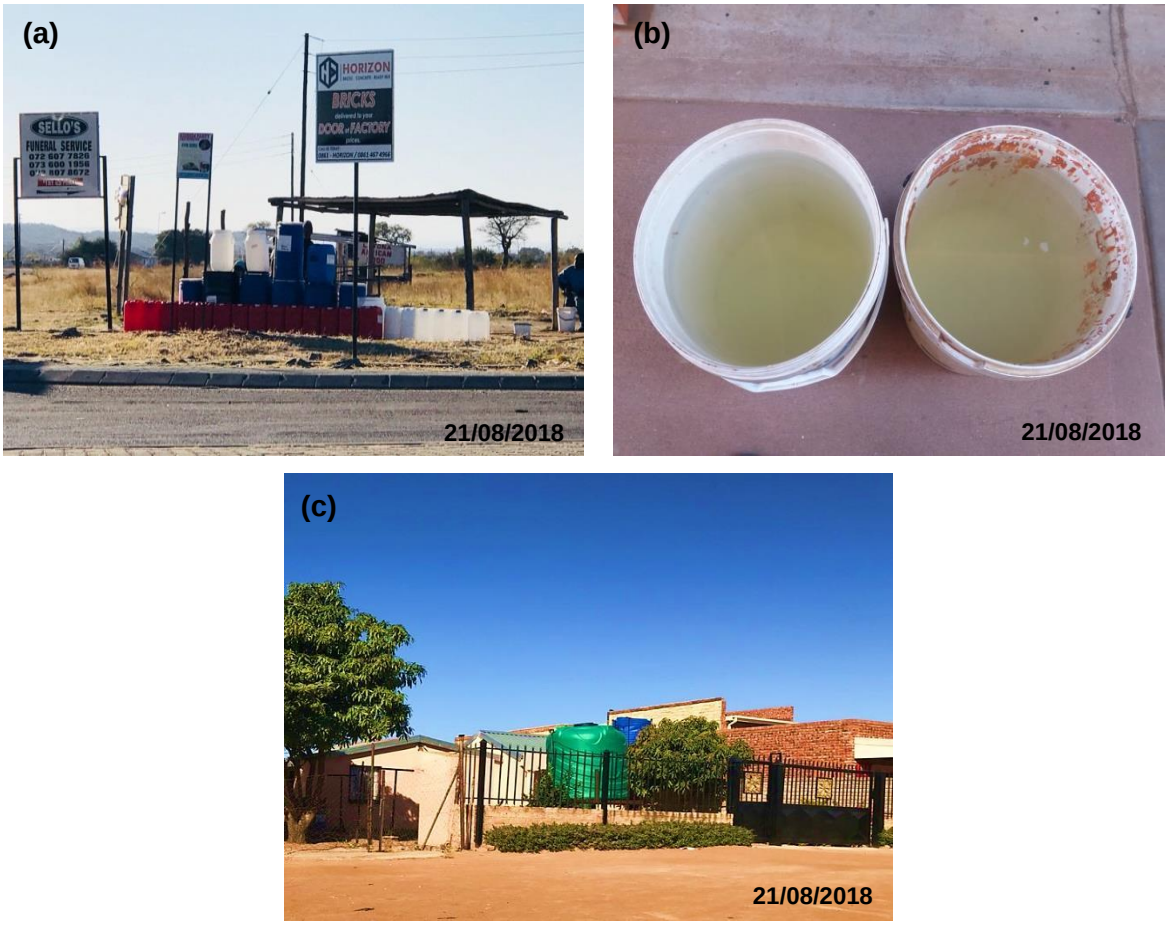

Figure 4.2: (a) Water drums and containers being sold at the entrance to Hammanskraal; (b) Storage of water in buckets in Hammanskraal; and (c) The use of Jojo tanks for the harvesting of rainwater by a Hammanskraal household (Researcher's Photos, 21/08/2018).

It was evident that numerous water-saving initiatives were being practised in Hammanskraal at the time of the research. On the other hand, however, further investigation was necessary to determine whether or not the survey and focus group participants in Atteridgeville had also adapted to and had prepared for water restrictions in advance. This was done in order to establish whether the drought had heightened the participants' sensitivity towards storing water and using this resource sparingly on a daily basis in their households post-drought and is discussed in the following section.

4.1.2. Adaptation to and Preparation for Intermittent Water Supplies in Atteridgeville

In Atteridgeville, 60% of the surveyed participants were found neither to have stored water nor to have prepared for an intermittent supply of water in advance. Instead, they had resorted to purchasing water or collecting it from the fire hydrants in the area. An additional 20% of the participants were storing water in buckets and plastic containers, while the other 20% were storing water in bathtubs, however this was only undertaken during the water restrictions when water supplies were intermittent (Figure 4.3).

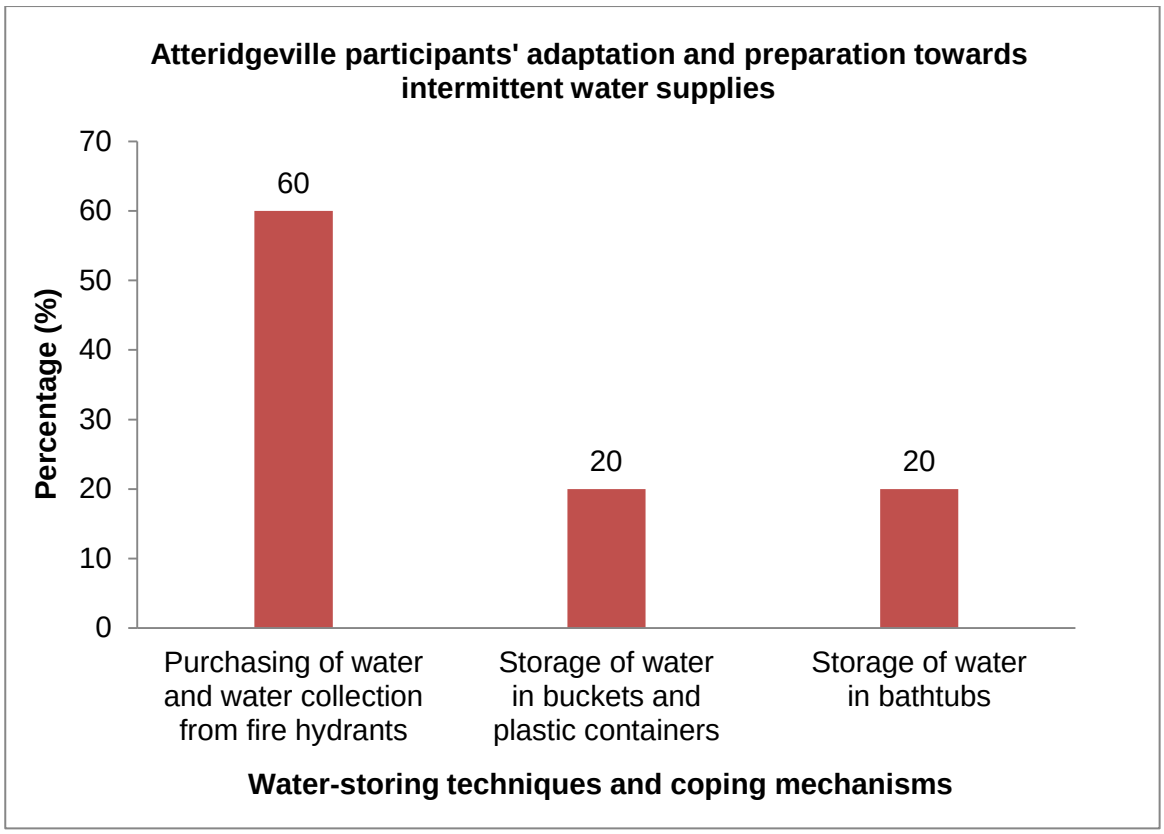

Figure 4.3: Atteridgeville participants' adaptations and preparation towards intermittent water supplies.

The focus group participants in this area highlighted the fact that preparations for water restrictions had been undertaken only when strict water restrictions were in place or during routine maintenance operations by the municipality, when water supplies were cut off for a while. They also explained that they had not stored any water on a daily basis and that they had only done so when there was a need, provided that they had been notified of the water cuts in advance. Furthermore, these participants explained that they had resorted to purchasing water only once there were interruptions in the water supply. Alternatively, they obtained water from the fire hydrants in the area.

Some non-compliance to the water restriction regulations in Atteridgeville was highlighted by the municipal officials, with one particular official emphasising this fact and stating that a resident in Atteridgeville had become violent when reprimanded about irrigating his garden with tap water during water restrictions. Such behaviours indicate that the Atteridgeville participants had not prepared for water cuts and did not store water for future use and that they were generally apathetic towards the implementation of water-saving initiatives in their households, despite strict water restrictions being in place.

A comparative analysis of the Hammanskraal and Atteridgeville participants' adaptation and preparation towards intermittent water supplies now follows.

4.1.3. Comparative Analysis of the Hammanskraal and Atteridgeville Participants' Adaptation to and Preparation towards Intermittent Water Supplies

Their practices of storing water in containers and of harvesting rainwater in Jojo tanks indicates that the Hammanskraal participants were proactive in conserving water for future use and had indeed adapted to the intermittent supply of their water. Regardless of their harvesting of rainwater in Jojo tanks, this method of water conservation is not, however, an adaptive long-term strategy for overcoming water supply challenges in this area, nor on a larger scale, in South Africa. This is because the Gauteng Province, as well as South Africa as a whole, has variable rainfall and high temperatures which together limit rainwater harvesting. These sentiments were also echoed by a municipal official in an interview who stated that *"we are living in a country that doesn't have sufficient rainfall",* despite being in contrast with Kahinda et al. (2007) who recommend that the harvesting of rainwater domestically could improve the water sanitation challenges in many rural and peri-urban households across South Africa.

Overall, on account of the expected intermittence of their water supplies on a regular basis, the majority of the Hammanskraal participants were actively involving themselves in storing water for future use. In fact, as a result of the water challenges in Hammanskraal being dubbed as a humanitarian crisis, the respondents here were, as described by Sono (2016), storing water as a coping mechanism to overcome the regular water restrictions and cuts imposed upon them. This indicates that the storage of water is undertaken when there are no alternative sources of water and as such, using water sparingly becomes habitual an act which can be undertaken globally too.

As opposed to the situation in Hammanskraal, water-saving initiatives in Atteridgeville were not being practised on a regular basis at the time of the research. In both the survey and the focus group discussion, the Atteridgeville participants stated that they had neither

stored water nor actively prepared for water restrictions subsequent to the suspension of water restrictions following on the 2016-2017 drought. The participants in Atteridgeville were also purchasing bottled water once the water supply showed signs of being interrupted. Furthermore, as reported by the municipal officials, there was little to no adherence to water restrictions in Atteridgeville. As such, it was clear at that stage in the research that the majority of the participants in this area had not yet adapted to using water sparingly and had only started preparing for water restrictions during the actual crisis. The large demand for water, coupled with its unsustainable use, as in the case of Atteridgeville, is a microcosmic reflection of the case in South Africa generally, with additional pressure being placed on the already limited but fully allocated water resources (Muller et al., 2009).

On a regional level, the City of Tshwane Metropolitan Municipality has made attempts to promote water conservation in Tshwane as a whole as expressed in the words of a municipal official: *"Preserving water is not something you do sometimes; it must be a way of life. That's what we need to instil in the citizens of this country"*. However, water conservation, the subject of many campaigns, is considered to be a reactive measure when it is highly promoted during a water crisis, such as a drought, and when household water supplies are restricted. Quite evidently and as confirmed by Syme et al. (2000) and Rossi and Cancelliere (2012), following a reactive approach during a water-related crisis, neither mitigates the huge demand for water; nor does it encourage water-saving behaviours and adaptations on a long-term basis globally, and not primarily in the research areas only. Therefore, more proactive water-saving campaigns should be promoted on a continuous and long-term basis in the research areas in an attempt to reduce the huge demands placed on the water supply and to promote water conservation routinely, and not only during a water crisis.

In addition to determining the extent to which adaptive and preparatory measures were being employed to cope with intermittent water supplies in Hammanskraal and Atteridgeville, a further investigation into the water-saving techniques that participants were applying to cope with the water restrictions was conducted and is discussed in the following section.

4.2. Household Water-saving Techniques Observed in Hammanskraal and Atteridgeville

The initial discussion in this respect deals with the specific water-saving techniques applied by the Hammanskraal and Atteridgeville survey and focus group participants

respectively. These sections are then followed by a comparison of the water-saving techniques practised in the two townships. A brief discussion on the water-saving techniques utilised in the Hammanskraal households now follows.

4.2.1. Household Water-saving Techniques observed in Hammanskraal

In the survey, 67% of the Hammanskraal participants were saving water by reusing grey water for garden irrigation, 17% were actively making efforts to close running taps at all times to minimise water wastage, while 16% were showering or using plastic basins for bathing (Figure 4.4).

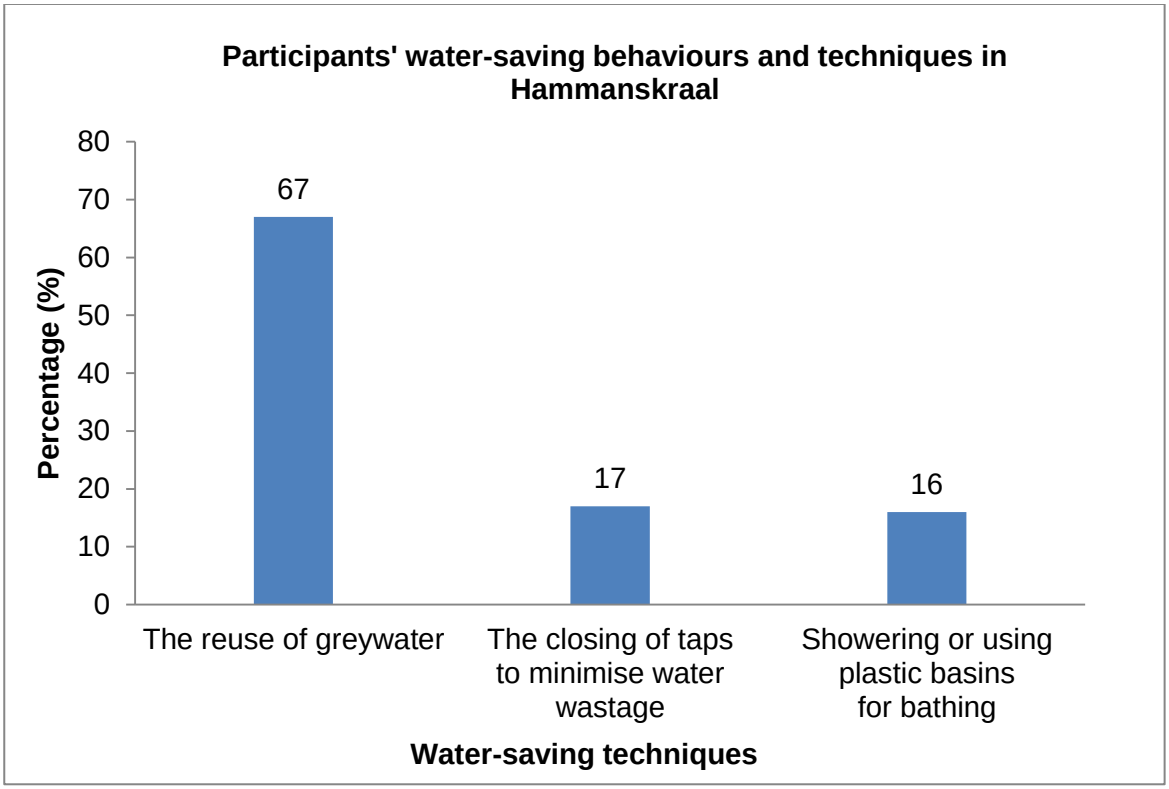

Figure 4.4: Participants' water-saving behaviours and techniques in Hammanskraal.

Like the survey participants, the focus group participants also indicated that they had become accustomed to reusing grey water as they *"use bath water to flush toilets"* and *"use laundry water for the garden"*. Furthermore, they explained that the water that they stored in buckets was used for cooking and drinking, while the rainwater stored in the Jojo tanks was used sparingly for household purposes such as cleaning, bathing and garden irrigation. Activities such as car washing and garden irrigation were also undertaken once a week using either grey water or harvested rainwater. The reuse of grey water was confirmed during the transect walk in Hammanskraal, where a resident was observed reusing grey water to irrigate her garden (Figure 4.5).

Figure 4.5: A resident in Hammanskraal reusing grey water for garden irrigation (Researcher's Photo, 21/08/2018).

The water-use behaviours and the water-saving techniques observed in Hammanskraal were not considered in isolation, it was also important to determine whether or not similar water-saving techniques were also being used in Atteridgeville. A discussion on the observed water-saving techniques in Atteridgeville now follows.

4.2.2. Household Water-saving Techniques observed in Atteridgeville

In the survey, 96% of the participants in Atteridgeville stated that they were not saving or storing water for future use, while 4% admitted to obtaining water from the fire hydrants in the area (Figure 4.6).

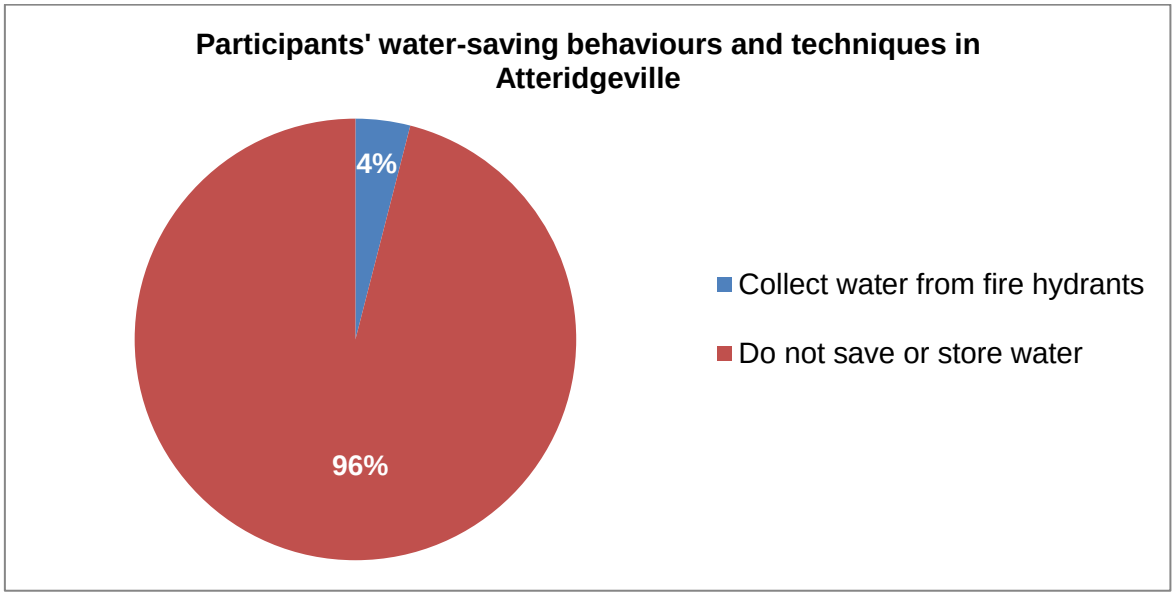

Figure 4.6: Participants' water-saving behaviours and techniques in Atteridgeville.

In terms of water-use behaviour, the surveyed participants in Atteridgeville stated that during the water restrictions they washed their laundry twice a week, irrigated their gardens with tap water four times a week, and washed their cars three times a week using clean tap/municipal water. Furthermore, the focus group participants explained that when their domestic water supplies were interrupted, they often drew water from the fire hydrants located in various areas across Atteridgeville. The use of fire hydrants was confirmed during the transect walk where community members and numerous car-wash businesses in the area were observed to be collecting water in buckets from the fire hydrants (Figure 4.7) which, as highlighted by Grobler (2014), is an illegal activity.

Figure 4.7: Water collection from a fire hydrant in Atteridgeville (Researcher's Photo, 23/03/2019).

Many of the fire hydrants in Atteridgeville were left running, resulting in severe water wastage. Overall, there were no water-saving or reuse behaviours observed in Atteridgeville. It is evident that the participants in this area generally lack a sense of urgency to save and use water sparingly.

The comparative analysis of the household water-saving techniques in both research areas now follows.

4.2.3. Comparative Analysis of Household Water-saving Techniques observed in Hammanskraal and Atteridgeville

Owing to the intermittent water supply in Hammanskraal, water resources were used sparingly by the survey and focus group participants during the time of the research. They

stored water in buckets and containers on a daily basis, and were also proactive in reusing grey water. Furthermore, there was also clear evidence of rainfall harvesting in the Jojo tanks installed in many of the yards/properties. According to Rosenberg et al. (2008), the reuse of grey water and the harvesting of rainwater are some of the water-saving methods currently being promoted globally to alleviate domestic water supply challenges. As such, it can be stated that the Hammanskraal participants are also actively practising these global water-saving initiatives.

In contrast, the survey and focus group participants in Atteridgeville regarded the saving of water as unimportant. Routinely, the Atteridgeville participants did not practise water-saving initiatives and would only do so during a water crisis (e.g. the 2016-2017 drought when strict water restrictions were in place). Furthermore, instead of saving water and using the resource sparingly during water restrictions, the participants in this area relied on the fire hydrants located in the streets as an alternative source for water supply.

In accordance with Part 7 of the Water Supply By-Laws for the City of Tshwane (2003), only authorised municipal personnel and engineers are permitted to make use of the fire hydrants, and only during emergency situations. Under such circumstances, the authorised municipal personnel are also required to monitor the water consumption at the fire hydrants with suitable devices such as portable meters in order to prevent wastage at all times (City of Tshwane, 2003). As indicated by Grobler (2014), individuals using the fire hydrant water for personal use are acting illegally. In fact, according to Gilg and Barr (2006), water conservation and water-saving behaviours are seriously affected by the misconception that people have a right to constant water supplies, without any restrictions. Furthermore, Strydom (2009) highlights that an increased access to water leads to increased water wastage, which has indeed been observed in Atteridgeville. Therefore, since the Atteridgeville participants use the fire hydrants as an alternative source of water supply during water restriction periods, the misuse of the fire hydrants in the area indicates that the participants here are apathetic towards using water sparingly and implementing water-saving initiatives. The challenge in this regard is that as long as the municipality fails to control and limit access to the fire hydrants, the unsustainable use of this water will continue.

The overall water wastage behaviours in Atteridgeville correlates with what has been highlighted in literature on people having excessive access to water. This is echoed by the sentiments of Syme et al. (2000) who maintain that as long as water-saving campaigns are promoted only during a crisis such as a drought, the overall careless attitude and behaviour of the participants will continue unabated and water will be used

unsustainably. The water-use behaviours in Hammanskraal and Atteridgeville were further investigated to determine the communality of water-saving methods as discussed in the following section.

4.3. Communal Water-usage and Water-saving Behaviours observed in the Hammanskraal and Atteridgeville Communities

According to Anderson et al. (2007), rural communities are more likely to manage water-related issues communally - as a collective. Therefore, to determine whether or not the water issues were perceived as a community issue in Hammanskraal and Atteridgeville respectively, the communal water-use behaviours of the participants were investigated. The collective water-use behaviours of the Hammanskraal participants as a community are discussed, followed by those of the Atteridgeville participants. Thereafter, the aforesaid behaviours observed in both research areas are compared.

A discussion on the collective community water-use and saving behaviours observed in Hammanskraal now follows.

4.3.1. Communal Water Usage and Water-saving Behaviours observed in Hammanskraal

In the survey, 76% of the Hammanskraal participants mentioned that regular community meetings were generally held to discuss the intermittence of the water supply and water-saving methods in the area. In addition, 12% of the participants collectively lodged complaints with the ward councillor and the municipality, 3% stated that they promoted the drilling of boreholes in the community, while 9% initiated protests related to their water issues (Figure 4.8).

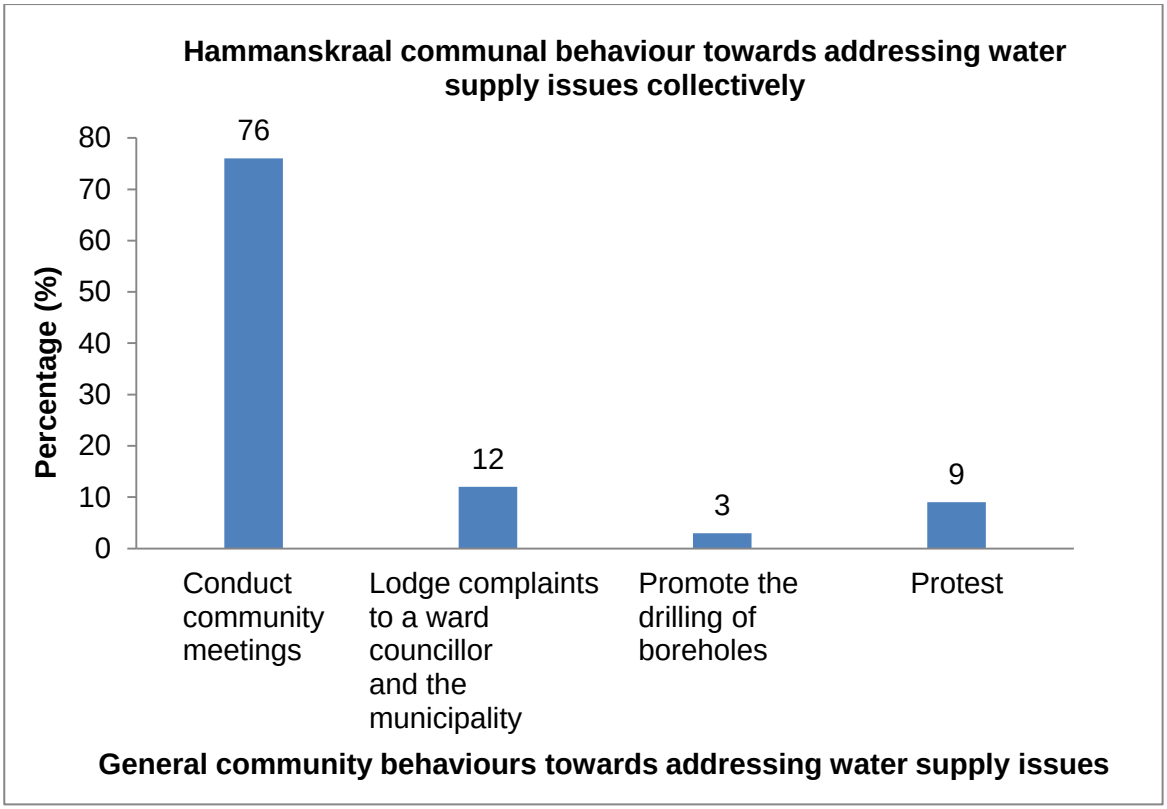

Figure 4.8: Hammanskraal communal behaviours towards addressing water supply issues collectively.

During the focus group discussion in Hammanskraal, a focus group participant stated that the wastage of water is not tolerated in Hammanskraal and that the children are taught to avoid playing with water or wasting it. Both the survey and focus group participants reiterated that they would be more likely to report water wastage by their neighbours to the municipality as water conservation is considered to be a high priority in Hammanskraal.

However, despite the community's efforts in practising water-saving initiatives, the failure of the municipality to timeously manage complaints about water-related issues has in turn negatively influenced the behaviours of residents around water. One municipal official explained in an interview that there had been a great deal of vandalism of the municipal infrastructure which not only exacerbated the challenge of providing water, but also prolonged the inadequacies pertaining to the service provision of water by the municipality. This was observed during the transect walk in Hammanskraal where, following protest action in the area, the damages that were made to the bulk water supply infrastructure were observed (Figure 4.9).

Figure 4.9: Burnt pipeline infrastructure observed subsequent to a water-related protest in Hammanskraal (Researcher's Photo, 21/08/2018).

Following the observations made in Hammanskraal, attention was directed to the situation in Atteridgeville as to how the participants there collectively addressed water issues within their community. This is discussed in the following section.

4.3.2. Communal Water Usage and Water-saving Behaviours observed in Atteridgeville

In the survey, 89% of the Atteridgeville participants stated that they did not collectively participate in community engagements to address the intermittence of water supplies during water restrictions. They also stated that they would not ordinarily report water wastage incidents in the area. Only 11% of the Atteridgeville participants were inclined to convene and conduct meetings with other neighbours, but this happened only when the water supply had been interrupted for longer than a day. The empirical findings are presented in Figure 4.10.

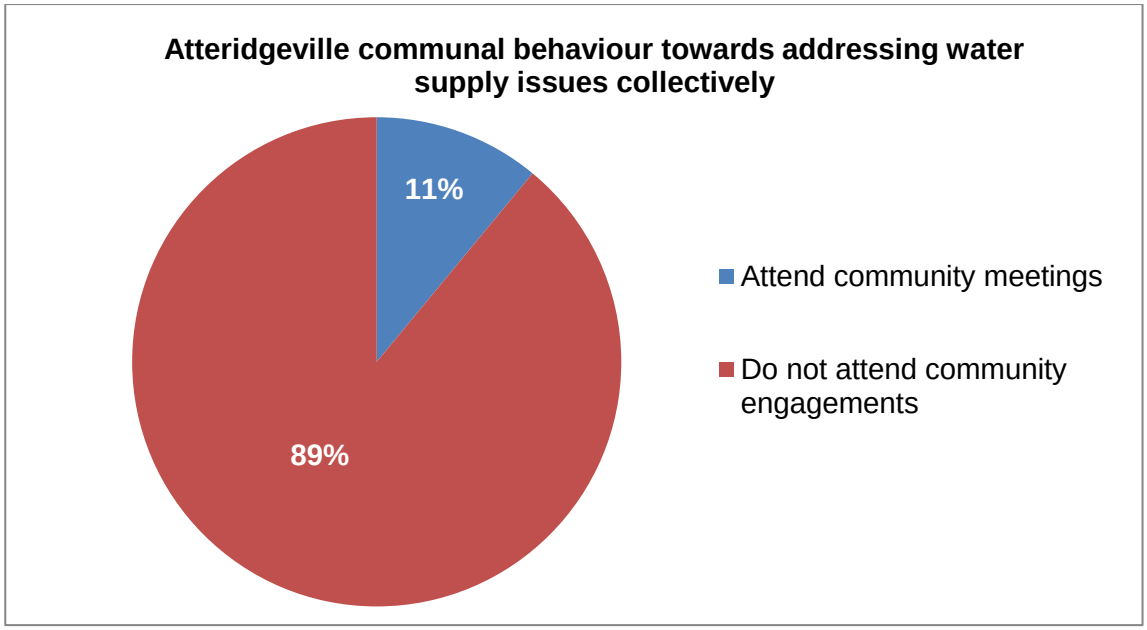

Figure 4.10: Atteridgeville communal behaviours towards addressing water supply issues collectively.

The focus group participants stated that the water supply in Atteridgeville was usually interrupted for a day or two during routine maintenance operations by the municipality. They emphasised that there were no community initiatives to address any water-related issues in the area. Instead, water was being misappropriated in the community in that everyone could freely collect water from the fire hydrants.

Since the adults in the community did not discourage the misappropriation of water from the fire hydrants, the children in Atteridgeville are unlikely to be accustomed to saving water either. This was confirmed by one focus group participant who highlighted the fact that: *"[p]eople in this community misuse the water from the fire hydrants, so the kids will not learn how to use water sparingly either."* It should be noted that in the interviews, the municipal officials expressed concern over the Atteridgeville community's use of water from fire hydrants during water restrictions as the fire hydrants are specifically meant for use during emergencies.

A comparative analysis of the overall disparity in the respective views of the Hammanskraal and Atteridgeville communities as to the manner in which water supplies are used and managed communally now follows.

4.3.3. Comparative Analysis of the Communal Water-usage and Water-saving Behaviours observed in the Hammanskraal and Atteridgeville Communities

The Hammanskraal participants highlighted the fact that their community is actively involved in addressing their water-related issues as a collective by conducting regular community meetings. The households in this area have been plagued by intermittent water supplies and as such, they use water sparingly. However, the frustrations about the water-related challenges in Hammanskraal have resulted in a prevalence of protests. In fact, one of the challenges faced by the municipality has been the damage made to the bulk water supply infrastructure during such community protests. The infrastructural damage during such protests prolongs the process of mitigating the water supply challenges faced by the community and has further heightened the intermittence of the water supply to the area. In addition, Coetzee et al. (2016) maintain that service delivery protests are always intensified when water-related challenges in an area worsen. This has been evident in Hammanskraal. The frequency of such protests could however be reduced provided that there are open communication lines between the community and the municipality, and that the delivery of tap water to households is timeously implemented, a view supported by Babel et al. (2010) who highlighted similar successes in reducing such protests in Bangkok and may other cities in Asia.

In contrast, the Atteridgeville participants were found to be remiss in collectively addressing water supply issues with other community members. Instead, the participants highlighted the fact that the fire hydrants in the area are constantly being misappropriated. Jorgensen et al. (2009) maintain that if people within a community believe that other community members are wasting water, it is unlikely that they will save water themselves. These behaviours are in line with the theory of the 'Tragedy of the Commons', as highlighted by Higgins (2015). This is because every participant in Atteridgeville aims to use and consume as much water as possible for the purposes of their own household, not realising the far-reaching impacts that the unsustainable use of water has on water scarcity holistically. In essence, the overall lack of a communal practice to conserve water and the acts of non-compliance to water restrictions by the Atteridgeville participants deter other community members and children in the area from saving water too. These behaviours and actions in Atteridgeville actively support the views of Atwood et al. (2007) and Jorgensen et al. (2009), who propound that communities are more likely to comply with water restrictions provided the community holds a common interest in doing so.

Stark contrasts in the water-use behaviours and water-saving techniques applied by the participants in the two research areas were evident from the research. The sentiments of

Seshoka et al. (2004), to the effect that water-users in any community tend to disregard water-saving initiatives when public taps are left running and when the culture of saving water is not practised as a norm in the community, were indeed confirmed by this research. Therefore, as suggested by Rossi and Cancelliere (2012), in order to reduce the large demand for water and the misappropriation of water in the research areas, more water-saving campaigns should be undertaken in the research areas, especially Atteridgeville, as a proactive measure to lessen the huge demand for water and to encourage adherence to the water restriction regulations. Through the observed successes achieved in Bangkok and many other Asian cities in reducing service delivery protests (Babel et al., 2010), the municipality should also ensure transparency during the enforcement of water restrictions in order to eliminate service delivery protests and the ultimate damage to the water-provisioning infrastructure, especially in the case of Hammanskraal.

Having investigated and observed the water-use behaviours of the participants in Hammanskraal and Atteridgeville, it was considered necessary to determine whether behaviours are in fact informed by their respective water supply challenges. This issue caused the researcher to delve deeper into the research problem by conducting a survey, focus group discussions and interviews with officials of the City of Tshwane Metropolitan Municipality. A discussion on the perceptions and observations on the water supply issues in Hammanskraal and Atteridgeville now follows.

4.4. Perceptions and Observations on the Water Supply Issues in Hammanskraal and Atteridgeville

The question as to whether or not the water-use behaviours of the Hammanskraal and Atteridgeville participants were in fact informed by their perceptions towards their intermittent water supplies at the time of the research was investigated primarily to determine the overall water conservation awareness and water stewardship in these areas. In order to do so, specific questions were posed to the survey and focus group participants in both research areas and during the interviews with the municipal officials.

The perceptions of the Hammanskraal participants on the water supply issues in their area are the first to be discussed, and are followed by those of the Atteridgeville participants. Finally, a comparative analysis of the perceptions of the participants in both research areas follows. It should also be noted that the observations made during the transect walks have been integrated into the body of information and discussed in the

relevant sections. A discussion on the perceptions on water supply issues and observations in Hammanskraal now follows.

4.4.1. Perceptions of Water Supply Issues and Main Observations made in Hammanskraal

In Hammanskraal, 97% of the survey participants had negative perceptions of their water supply on account of its intermittence and the poor quality of the tap water in the area. These negative perceptions were primarily based on the appearance of the water and its taste and smell, since the participants emphasised that the tap water was *"dirty", "brown", "smells very bad", "is of poor quality"* and *"it comes and goes all the time"*. Although this research focuses mainly on water supply, majority of the Hammanskraal participants were mainly concerned about the quality of their water (Figure 4.11).

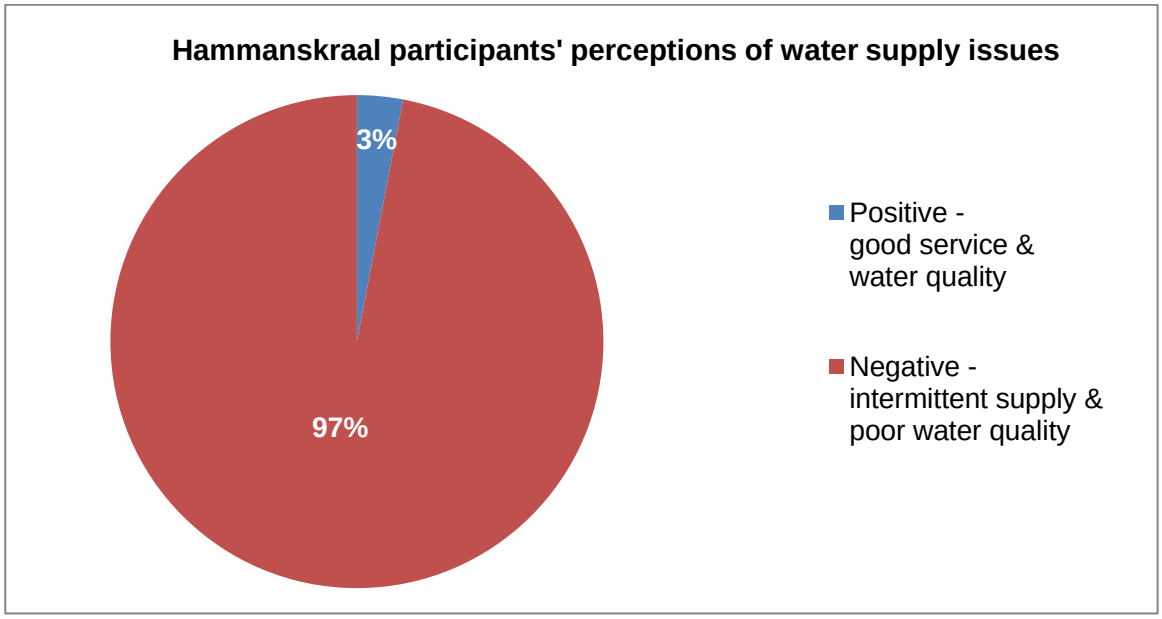

Figure 4.11: Participants' perceptions of the water supply in Hammanskraal.

During the focus group discussion, one participant stated that the water was *"dirty, stinky and unclean",* while another participant stated that *"sometimes there is a smell of faeces"* in the water. Furthermore, another focus group participant stated that on occasion, subsequent to orally consuming the tap water, most community members complained of experiencing diarrhoea and stomach pain. Both the survey and focus group responses indicated that the participants in Hammanskraal were more concerned about the poor quality of their tap water supplies than the actual intermittence of the supply.

Furthermore, during the completion of the survey questionnaire by a participant in Hammanskraal, the researcher was shown two containers of stored water: one from a

household tap (left container) and the other containing water collected from a roaming tanker (right container) (Figure 4.12).

Figure 4.12: Stored tap water (left container) and stored water collected from a water tanker (right container) in Hammanskraal (Researcher's Photo, 25/08/2018).

The tap water in the given container appeared to have a yellowish tinge as opposed to the water from the tanker which appeared to be clear. Although the municipal officials stated that tap water becomes discoloured following pipeline maintenance, the Hammanskraal survey and focus group participants stated that their tap water supplies constantly smelt and tasted bad and had a yellowish tinge, thus leading them to purchase bottled water for cooking and drinking purposes. Observations made during the transect walk showed some Hammanskraal residents purchasing water from local water purification vendors in the area (Figure 4.13).

Figure 4.13: (a) A person observed to have purchased water; (b) A water purification shop in Hammanskraal that sells purified bottled water (Researcher's Photos, 21/08/2018).

Quite evidently, the quality of the tap water in Hammanskraal requires further investigation in order to soften the negative perceptions that people in the area are holding of it. On the other hand, in Atteridgeville, main observations and the perceptions on the water supply issues in the area were also investigated. A discussion thereof now follows.

4.4.2. Perceptions of Water Supply Issues and Main Observations made in Atteridgeville

In contrast to the perceptions of the Hammanskraal participants, 86% of the surveyed participants in Atteridgeville had positive perceptions with regard to their water supply service, even after the 2016-2017 drought. The survey responses in this regard indicated that there were "*no water supply issues*" in Atteridgeville. Furthermore, only 14% of the participants in Atteridgeville had negative perceptions with regard to their water supply (Figure 4.14). They indicated that when the water supply is restricted for maintenance purposes, the water appears to be *"dirty when the water comes back"*.

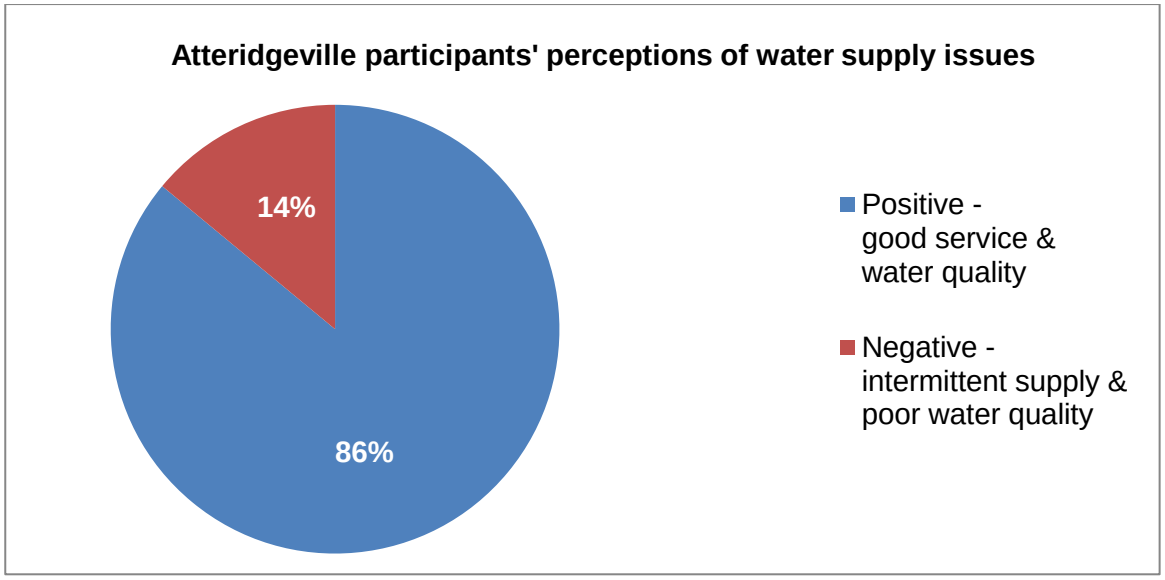

Figure 4.14: Participants' perception of the water supply in Atteridgeville.

On the other hand, the focus group participants in Atteridgeville stated the following: "*We were once informed that there is a drought; we saw it trending on social media, but it didn't really affect us much".* They indicated that they were not negatively impacted by the water restrictions implemented by the municipality. Furthermore, it was during the transect walks in Atteridgeville when the residents were observed to be using tap water and the water from fire hydrants for car-washing in the area. This overall indicated that the Atteridgeville participants were not experiencing the harsh impacts of the drought at the time of the research as they were not complying with the water restrictions that were being implemented during the drought, and furthermore, they also had access to other sources of water (i.e. fire hydrants). This is despite the statements by the municipal officials that the public was encouraged to use water sparingly, especially during droughts.

A comparative analysis of the perceptions of the participants on water supply issues and the main observations made in Hammanskraal and Atteridgeville now follows.

4.4.3. Comparative Analysis of the Perceptions of Water Supply Issues and Observations made in Hammanskraal and Atteridgeville

According to one municipal official, the main reason for the intermittent water supply in Hammanskraal is *"because of the lack of infrastructure",* while another official stated that the sources of water for Hammanskraal *"have been contaminated a lot"*. As such, the Hammanskraal participants tend to gauge their perceptions of their water by its taste, smell and appearance, collectively termed *"organoleptics"* by Doria et al. (2009:5455).

Globally, people gauge their water quality using organoleptics too. For instance, in Sri Lankan households, research confirms that people who perceive their water as contaminated either boil or filter their drinking water (Nauges & van den Berg, 2006; Wright et al., 2012). This highlights that access to clean drinking water indeed is a global issue. Nonetheless, people across the world tend to find alternative ways to use their water despite having negative perceptions on its quality. This was further observed om Hammanskraal where the discolouration of the tap water supplies in the area and the negative perceptions towards it do not deter the participants from practising water-saving initiatives. Instead, the Hammanskraal participants continue to store their tap water supplies in buckets and containers for household chores and often purchase water for drinking and cooking purposes.

An important aspect pertaining to the perceived lack of clean water in the Hammanskraal area that should be addressed by effectively determining the quality of the water, and the reasons behind it, is the deficient infrastructure at the Rooiwal Wastewater Treatment Plant which has caused the spillage of sewage effluent into the surrounding freshwater resources that serve as a source of water for the Hammanskraal communities[2]. This facility should be investigated so that applicable remedial actions can be undertaken to effectively maintain it. These measures could limit the sewage spillage and hopefully improve the availability and supply of water to Hammanskraal, and ultimately possibly address certain negative perceptions regarding its quality.

With regard to Atteridgeville, the dominant perception the participants had at the time of the research was that the water supplied to this research area was not necessarily contaminated or of poor quality *per se*, but that immediately following maintenance-related water cuts, it was temporarily of a poor quality upon being switched on again to its original source of supply. This is supported by Liu et al. (2017) who confirms that the discolouration of tap water following water cuts over extended periods can be attributed to the release of old pipe material and other contaminants during pipeline maintenance.

On account of the fact that water restrictions in Atteridgeville are generally of short duration, this has neither formed any negative perceptions on the quality of the water in the area, nor warranted the storage of water by participants in containers for future use. Overall, it was found that most of the survey and focus group participants in Atteridgeville had positive perceptions towards their water supply as there were, according to them, minimal issues in this regard.

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[2] A detailed discussion on this topic is presented in Chapter 1.

A discussion on the perceptions of the possible causes of the respective water supply issues in the two research areas now follows.

4.5. Perceptions on the Possible Causes of Water Supply Issues in Hammanskraal and Atteridgeville

In both research areas, the participants' perceptions on the possible causes of their water supply issues were investigated through surveys and focus group discussions. These techniques therefore established whether or not these perceptions affected the water-use behaviours of the participants in the research areas. The Hammanskraal participants' perceptions of the possible causes of water supply issues are discussed first, and then followed by those of the participants in Atteridgeville. Thereafter, the aforesaid perceptions of the Hammanskraal and Atteridgeville participants are compared. The following section discusses the Hammanskraal participants' perceptions on the possible causes of water supply issues in the area.

4.5.1. Perceptions of the Possible Causes of Water Supply Issues in Hammanskraal

In Hammanskraal, 56% of the participants attributed the water supply issues in the area to *"mismanagement at the municipality"* and 25% to *"damaged infrastructure"*. Additionally, 14% of the participants stated that the *"ways of cleaning (purifying) the water"* were *"inadequate",* while 5% blamed the poor quality of the water on *"issues at the Temba and Rooiwal Wastewater Treatment Plants"* (Figure 4.15).

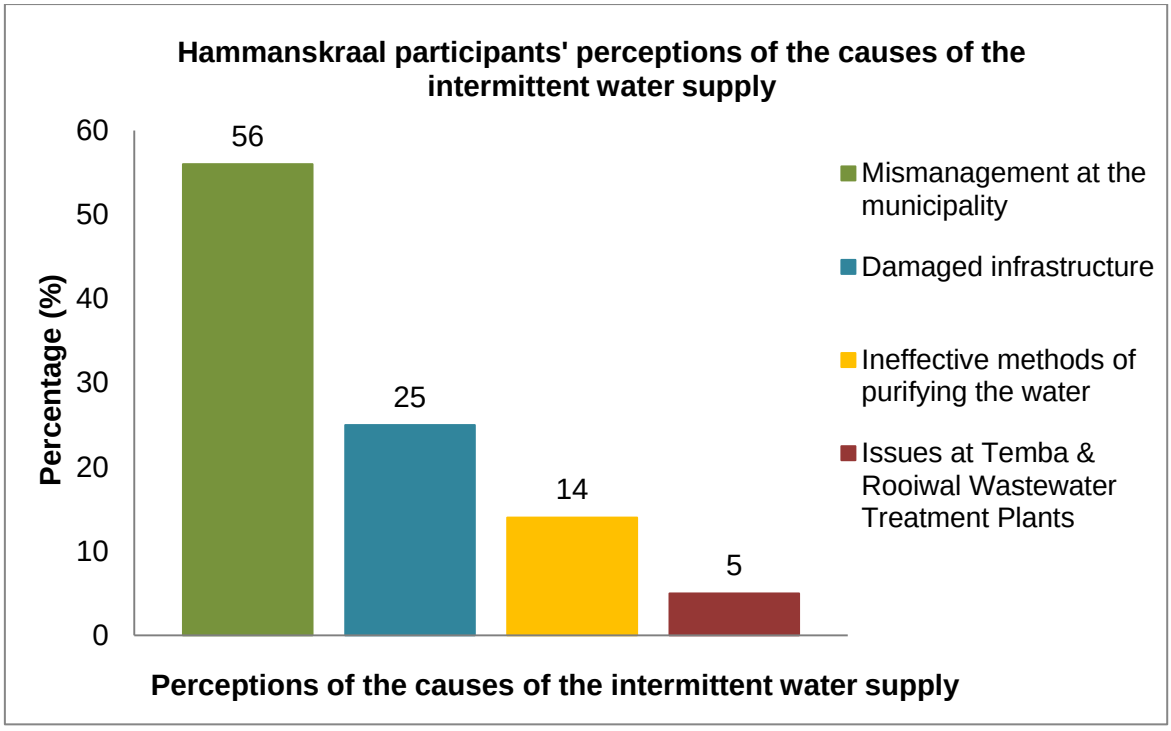

Figure 4.15: Hammanskraal participants' perceptions of the causes of the intermittent water supply.

Like the survey participants, the focus group participants in Hammanskraal indicated that the municipality was supplying them with unclean tap water and that they were experiencing intermittent water supplies on a regular basis. They were also of the opinion that the service delivery of water by the municipality was generally flawed. During the transect walks, a leaking underground pipeline, as well as incomplete pipeline developments, were observed in Hammanskraal (Figure 4.16).

Figure 4.16: (a) Seepage observed from damaged underground pipelines; (b) Incomplete pipeline developments in Hammanskraal (Researcher's Photos, 21/08/2018).

In essence, the Hammanskraal participants were dissatisfied with the municipality's water supply services and generally blamed the municipality for all of their water-related challenges. Furthermore, the failure of the municipality to timeously maintain and manage pipeline leakages and the continued abandonment of pipeline developments in Hammanskraal fuelled the negative perceptions that the participants held against the municipality. Basically, they lacked trust in the ability of the municipality to plan for the provision of clean and secure water services.

On the other hand, it was also considered necessary to determine whether the Atteridgeville participants were holding similar negative perceptions towards the municipality and the water services it rendered. A brief discussion in this regard now follows.

4.5.2. Perceptions of the Possible Causes of Water Supply Issues in Atteridgeville

In the case of Atteridgeville, 47% of the survey participants attributed their intermittent water supplies to "*the old infrastructure and damaged pipelines*", while 20% attributed them to "*municipal maintenance issues*". Thus, in essence, a total of 67% of the Atteridgeville participants blamed their interrupted water supply issues on the lack of maintenance and planning by the municipality. Furthermore, 13% stated that the drought and the large demand for water were responsible for the intermittent water supplies, while 20% of the participants did not believe that there were any water-related issues in the area and were generally positive in their perceptions of their water supply (Figure 4.17).

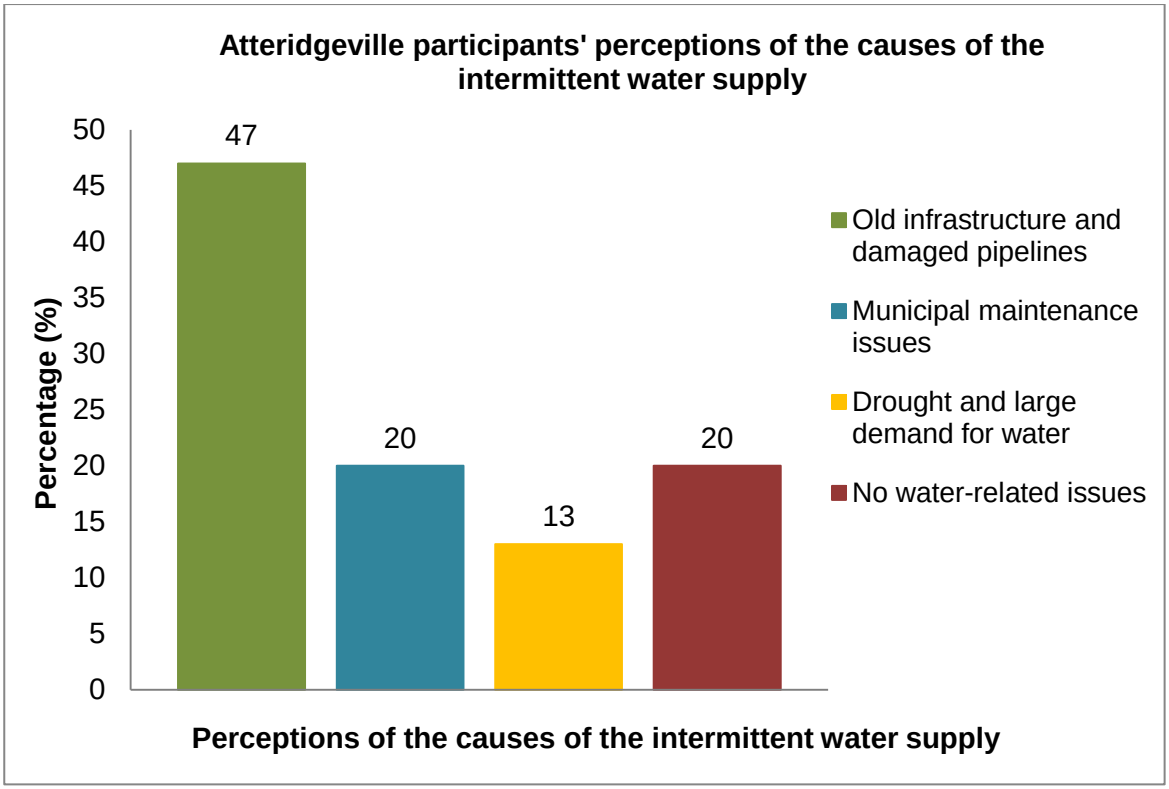

Figure 4.17: Atteridgeville participants' perceptions of the causes of the intermittent supply of water.

During the data collection phase of this research, it was found that many of the Atteridgeville residents were apathetic about participating in the survey and focus group discussion. In fact, they were of the opinion that there were no water supply issues in Atteridgeville, apart from the interventions and routine maintenance operations that the municipality was required to make as a result of the old infrastructure and damaged pipelines. On the other hand, those who participated in the focus group believed that the municipality implemented water restrictions only during droughts and that these were subsequently lifted post-drought.

Both the Hammanskraal and Atteridgeville participants blamed the municipality as the reason behind their various water-related challenges. In essence, those who participated in the survey and the focus group discussions held in both research areas had similar perceptions as to the causes of the intermittent water supply. A comparative analysis of their respective perceptions now follows.

4.5.3. Comparative Analysis of the Perceptions of the Possible Causes of Water Supply Issues in Hammanskraal and Atteridgeville

Both the Hammanskraal and Atteridgeville participants were of the opinion that their water supply issues were primarily caused by a rundown water infrastructure and challenges facing the municipality in its provision of adequate water supply services at all times. It should be noted that these research areas have been subjected to constant expansion, with an obvious increase in the demand for water as a result of sustained population growth. These circumstances confirm the views of Seetharam and Bridges (2005), Le Blanc (2008) and Simukonda et al. (2018) that population growth, particularly in rural settlements, contributes to an increase in the demand for water, ultimately amplifying the issues of water scarcity and stress. These increased water demands, as confirmed by Babel et al. (2010), place additional pressure on the current dilapidated water infrastructure, leading to burst pipes and water leaks, the end result being the loss of clean drinking water, and sewage spillages. Nonetheless, McKenzie et al. (2012) maintains that a mitigation measure to reduce NRW losses would be for water leakages to be timeously managed. As such, it is imperative for the municipality to be inspecting and maintaining the pipeline infrastructure and repairing pipeline leakages on a regular basis to improve water supply to households in the research areas, another view supported by McKenzie et al. (2012).

In the light of the similarity of the perceptions of the Hammanskraal and Atteridgeville participants as to the causes of their respective intermittent water supplies, it was considered important to determine their perceptions on the use of water tankers for supplying them with water when household tap water supplies were restricted and intermittent. A discussion on the participants' perceptions on the role of tankers in providing them with water now follows.

4.6. Perceptions of the Provision of Water by Means of Water Tankers in Hammanskraal and Atteridgeville

As highlighted by Tandwa (2016), when water restrictions were imposed on Hammanskraal and Atteridgeville, numerous contractors were appointed by the City of Tshwane Metropolitan Municipality to provide these communities with clean drinking water through the strategic positioning of water tankers in these areas. The tankers delivered water to these communities when the municipal water supplies were running low. This is a measure which as confirmed by Srinivasan et al. (2010) is undertaken by governments in many of the developing countries. As such, the participants' perceptions

on the provision of water by the tankers in Hammanskraal and Atteridgeville were investigated. Whether or not the water made available by these tankers alleviated the water challenges faced in the respective households was the primary focus of investigation. The following section entails a discussion on the Hammanskraal participants' perceptions on the water supplied by the water tankers.

4.6.1. Perceptions of the Provision of Water by Means of Water Tankers in Hammanskraal

During the survey that was conducted in Hammanskraal, 34% of the participants stated that "*there are not enough water tankers to supply water to the entire community",* 8% stated that "*the tankers sell water to residents*" and 4% stated that "*the water tankers are at times located too far*" from their households. Nonetheless, only 10% of the Hammanskraal participants were satisfied with the water provided by the tankers in the area. Lastly, 44% of the Hammanskraal participants stated that there were irregularities and overall uncertainty in the provision of tankers which supplied water to the community. These survey responses are graphically presented in Figure 4.18 below.

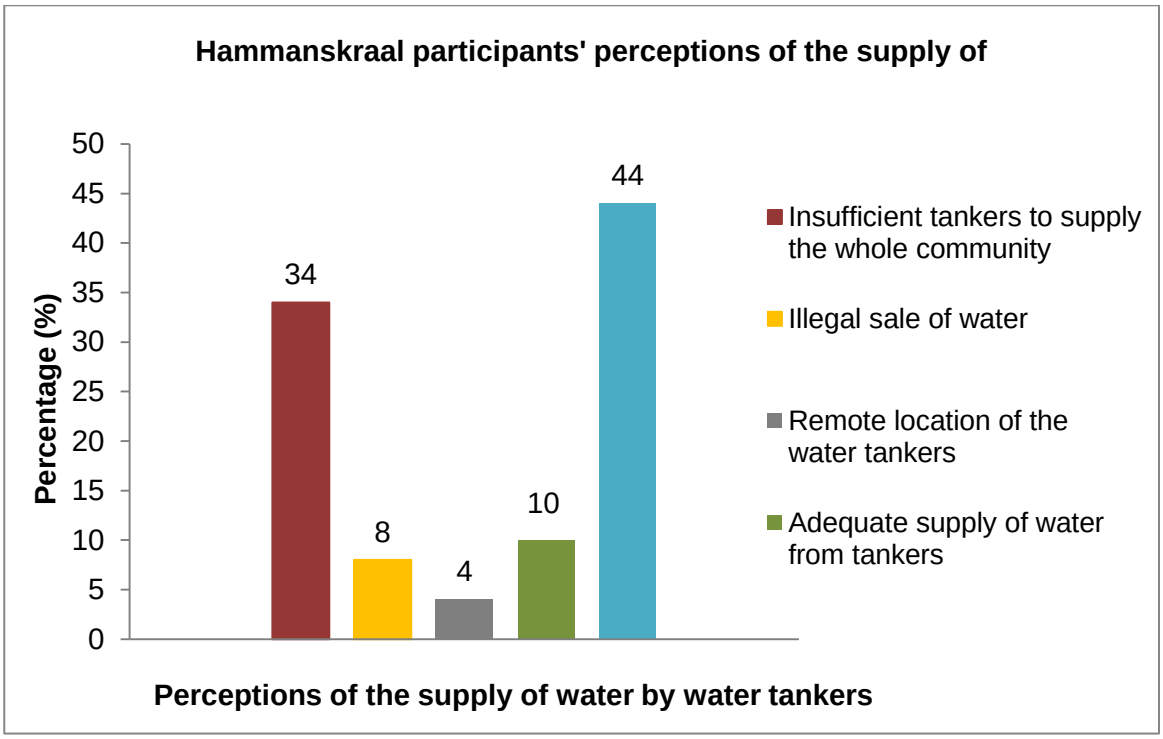

Figure 4.18: Hammanskraal participants' perceptions of the water supplied by the tankers.

The focus group participants shared sentiments similar to those of the survey participants as to the service and water supplied by the tankers. They indicated that the tanker water

was insufficient and unable to cater to the large water demands of the entire community. They further stated that on occasion, the water from the tankers was sold to them. These participants lastly highlighted the fact that not all of the water tanker service providers in the community were contracted to the municipality for their service. In fact, some of these water tanker service providers proceeded to sell water as a means of earning an income when intermittent water supply challenges were facing the Hammanskraal community and there was a large demand for water in the area.

On the other hand, in the interviews however, the municipal officials expressed the opinion that the water supplied by the tankers during water restrictions should not be offered for sale to the communities but that the tanker water was meant to alleviate the challenges associated with the water restrictions on the households. They also highlighted the fact that it is generally impossible to monitor the efficiency of the water dispensed by the tankers once they have been dispatched into the community as the municipal officials did not have the capacity to do so. It was also noted that the community members in an area were not restricted in terms of the amount of water that they could collect from the tankers. During the transect walks through Hammanskraal, numerous observations were made on the water tankers and their role in providing water to the community. Firstly, community members were observed queuing with buckets and containers to collect water from the tankers (Figure 4.19).

Figure 4.19: (a) Hammanskraal residents queuing with plastic bottles at a water tanker to collect water; (b) Hammanskraal residents collecting water in containers and buckets from a water tanker (Researcher's Photos, 24/03/2019).

Numerous other observations were made of the water tankers collecting water from a communal tap located at the Temba Wastewater Treatment Plant in Hammanskraal.

Significant water spillages were observed at the communal tap when the tankers overfilled during water collection, which resulted in clean water losses (Figure 4.20).

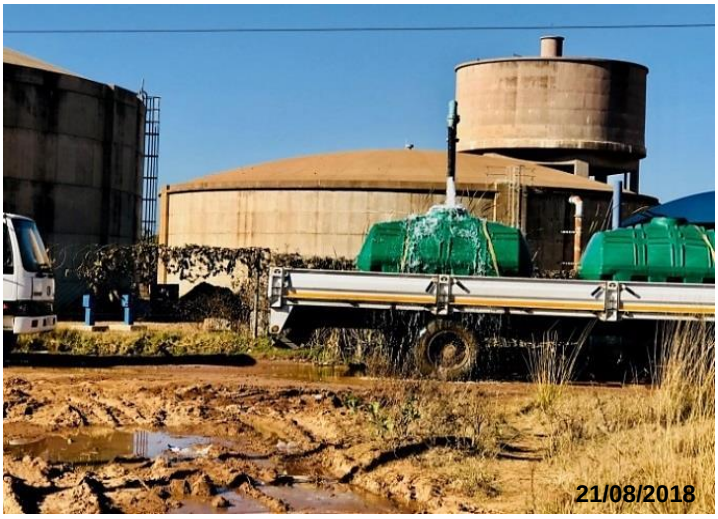

Figure 4.20: Overfilling a water tanker causing water wastage at a community tap in Hammanskraal (Researcher's Photo, 21/08/2018).

Furthermore, it was observed that the communal tap was left running as one water tanker drove off and another pulled up under the tap to subsequently collect water. During this process, significant water losses of clean water also occurred (Figure 4.21).

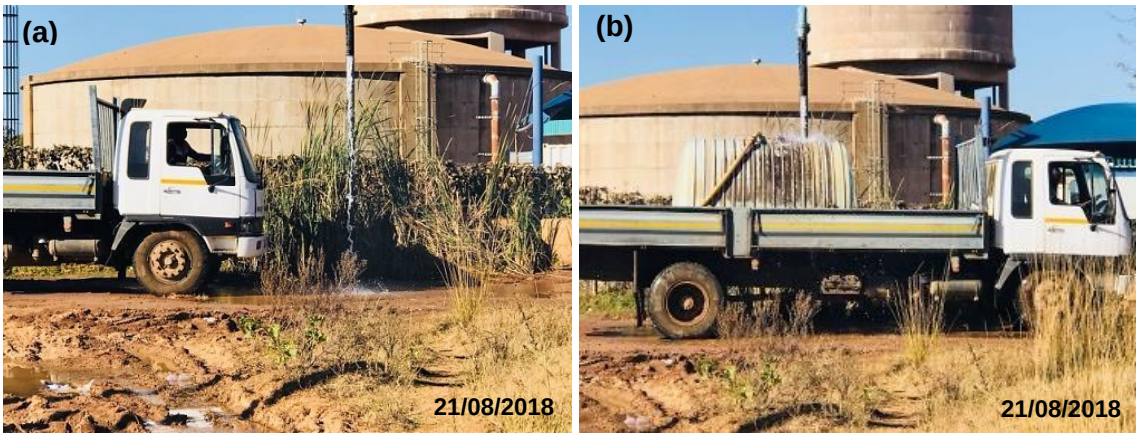

Figure 4.21: (a) Communal tap left running; (b) Communal tap left running as water tankers drive off after having collected water at Hammanskraal (Researcher's Photos, 21/08/2018).

Overall, significant water losses were observed at the communal tap located at the Temba Wastewater Treatment Plant in Hammanskraal during the refilling of the water tankers. Nonetheless, the water tankers appeared to be an important source of clean

water in Hammanskraal as numerous roaming and stationary water tankers were observed in many places across the township.

Attention was then directed to Atteridgeville - to the possible provision of water by water tankers and investigations to this purpose were set afoot and are discussed in the section that follows.

4.6.2. Perceptions of the Provision of Water by Means of Water Tankers in Atteridgeville

According to the survey, 60% of the Atteridgeville participants stated that they had not observed water tankers roaming the community during the 2016-2017 drought, when water restrictions were implemented. Furthermore, 40% of the participants stated that the tankers were at times stationed in remote locations of this peri-urban township (Figure 4.22).

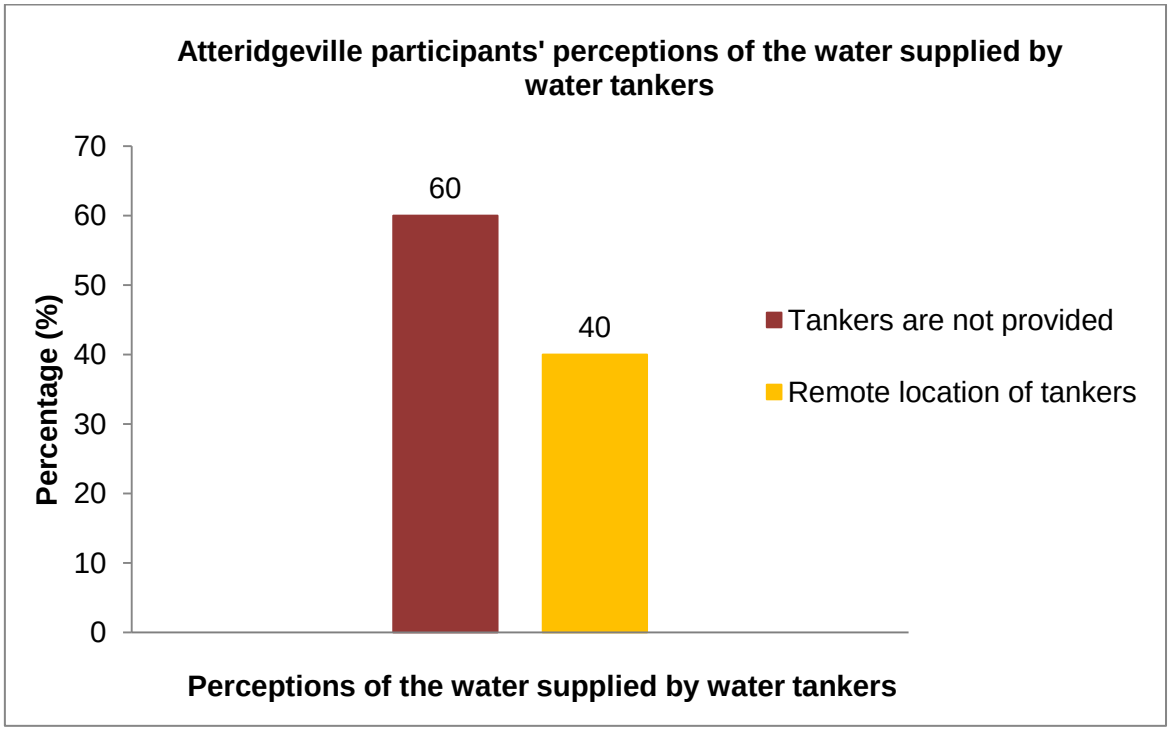

Figure 4.22: Atteridgeville participants' perceptions of the water supplied by the tankers.

The focus group participants in Atteridgeville stated that they had not at any time been the recipients of water from any water tankers. Instead, they stated that they had resorted to collecting water from fire hydrants in the streets of Atteridgeville when no water tankers were provided during the water restrictions. Furthermore, no water tankers were observed during the transect walks in Atteridgeville, and residents in the area were observed collecting water in buckets from the fire hydrants.

During an interview with the municipality, an official stated that at the time of the research, the provision of water tankers in Atteridgeville was undertaken only temporarily in order to alleviate the pressure that was being placed on the Vaal Dam with its low dam levels during the drought. Other municipal officials explained how there were roaming and stationary water tankers that were contracted by the municipality to provide water to the Atteridgeville communities on a daily basis during the drought. They were supposed to provide water to residents until late in the evening. The municipal officials also admitted that the residents in this township often collected water from the fire hydrants in spite of not being permitted to do so. This furthermore indicated that the Atteridgeville participants often had alternative sources of water when they could not obtain water from the water tankers.

A comparative analysis of the perceptions around tanker water in the two research areas now follows.

4.6.3. Comparative Analysis of the Perceptions of the Water Supplied by Means of Water Tankers in Hammanskraal and Atteridgeville

The majority of the Hammanskraal and Atteridgeville participants were dissatisfied with the water supplied by the tankers. Overall, the distribution of water by the water tankers in both research areas was uneven. Nonetheless, there was a higher reliance on the water tankers to deliver water in Hammanskraal than in Atteridgeville. This was because the Hammanskraal participants experienced interruptions to their water supplies more frequently and also because the communal tap in Hammanskraal was located a large distance from many of the households in the area. Sadly, the sale of the water by the water tanker contractors was a challenge to those community members who could not afford to incur additional expenses in purchasing this water. This ultimately resulted in negative perceptions about the water tankers in Hammanskraal, as confirmed by Baisa et al. (2008) and Srinivasan et al. (2010), who reveal that the members of the public are often dissatisfied when the water provision services by the tankers are ineffective and when the residents are forced to purchase their water from the tankers.

Nonetheless, although numerous tankers were observed supplying water in Hammanskraal, there was evidence of mismanagement in the manner in which they collected water from a communal tap in the area. On the other hand, the lack of tankers in Atteridgeville further contributed to the inappropriate use of the water from the fire hydrants in the area. Because the tankers provide water when tap water is not available, it

is therefore imperative, as highlighted by Srinivasan et al. (2010), that the municipality should facilitate a more adequate provision of water tankers for this purpose.

Lastly, the collection of water from the fire hydrants in Atteridgeville and the significant water losses observed at the communal tap in Hammanskraal both exacerbate NRW losses, which, according to Babel et al. (2010), on a larger scale and in the South African context, are caused by leakages and water losses in the distribution system. To compound the issue, the communal tap and fire hydrants are inevitably left running after use. Currently, the NRW losses in South Africa amount to 41% of the total water losses in the country (DWA, 2013; Ncube & Taigbenu, 2019). The concern, however, is that the NRW in South Africa could eventually supersede the global average of 126 billion cubic metres per year if the NRW losses in the country are not timeously managed (Al-Washali et al., 2019; Liemberger & Wyatt, 2019). It is therefore imperative for the municipality to put stricter measures in place to ensure the more efficient facilitation of water tankers and a more equitable distribution of water by the tankers during water restrictions. As proposed by Broas (2003), it is also imperative for water-saving devices, such as an aerator control tap, to be installed at communal taps (e.g. in Hammanskraal), to minimise the wastage of water during the refilling of the water tankers. Most importantly, the access to the fire hydrants in Atteridgeville should be monitored, with fines/penalties being implemented to discourage the community from using the fire hydrants illegally.

On account of the dissatisfaction of the Hammanskraal and Atteridgeville participants regarding the provision of water by tankers, further investigations were conducted to determine whether or not the participants in these areas were of the opinion that they were receiving accurate information about their water-related issues. A discussion on these aspects, also including their perceptions on the municipal communiques that they receive and other methods to notify them about water-related issues, now follows.

4.7. Hammanskraal and Atteridgeville Participants' Perceptions of the Municipal Communiques and the Perceived Methods of Notification about Water-related Issues

In order to ensure that the promotion of water-saving initiatives is successful, Coetzee et al. (2016) emphasises that the public should be adequately informed about any water-related issues that might lead up to an intermittent supply of water to their households.

The following sections (4.7.1 to 4.7.3) discuss the participants' perceptions of the communiques from the municipality, as well as the methods that the municipality uses to inform them of water-related issues such as an interrupted water supply. Also discussed,

are the perceptions of the respective municipal officials regarding the methods used by the municipality to notify the public of water-related issues. Lastly, a comparative analysis is presented to highlight the similarities and contrasts between the established perceptions in each case.

A discussion on the participants' perceptions on the municipal communiques and the perceived means of notification about water-related issues in Hammanskraal and Atteridgeville now follows.

4.7.1. *Participants'* Perceptions of the Municipal Communiques and Perceived Means of Notification about Water-related Issues in Hammanskraal and Atteridgeville

In Hammanskraal, 17% of the survey participants stated that they were notified of water restrictions through the radio, 5% via social media and 7% through the newspaper. In addition, 36% of the participants heard about water restrictions through the community (by word of mouth), while 35% indicated that they had never been informed about any water supply interruptions whatsoever by the municipality (Figure 4.23).

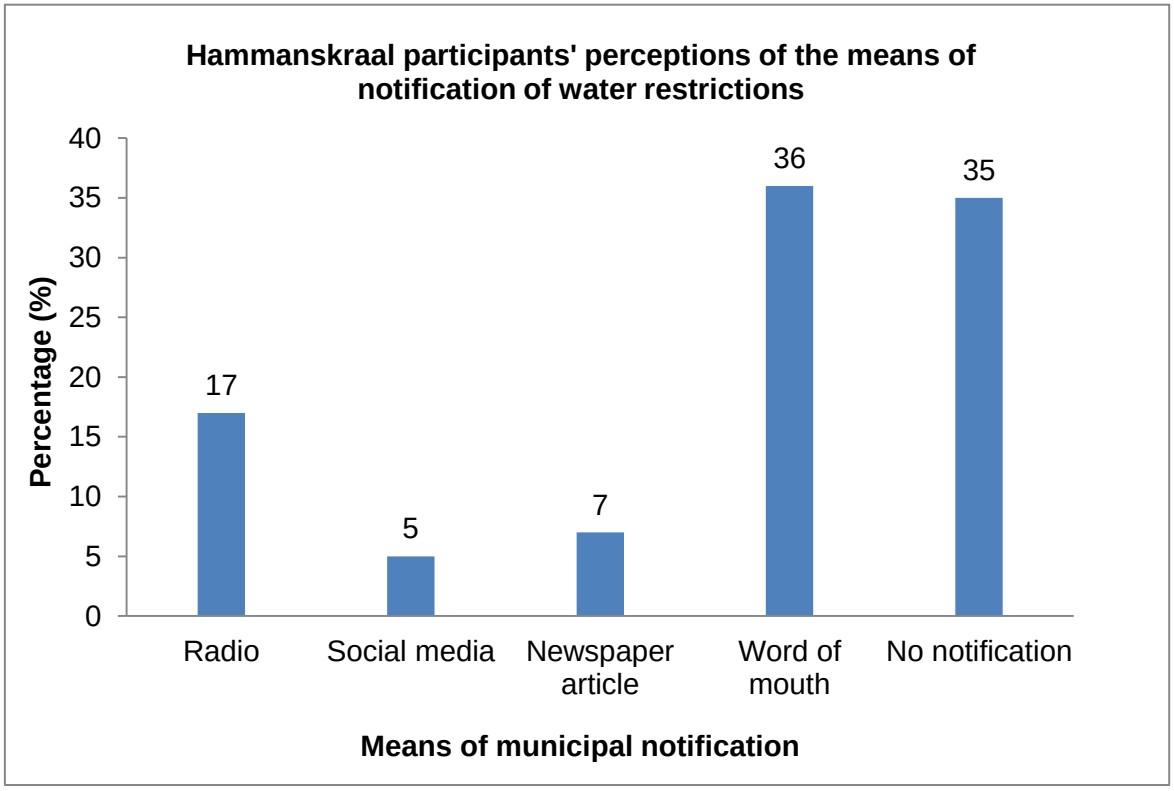

Figure 4.23: Means of notification of water restrictions in Hammanskraal.

In Atteridgeville on the other hand, 24% of the survey participants heard of the drought and subsequent water restrictions through the radio, 11% were notified through the

newspaper, while 7% heard through the community - by word of mouth. Furthermore, 7% of the participants were not notified prior to the implementation of the water restrictions. Most of the participants in this area (51%) were notified about water interruptions and water-related issues through advertisements on the municipality's social media pages. The empirical data in this regard is presented in Figure 4.24.

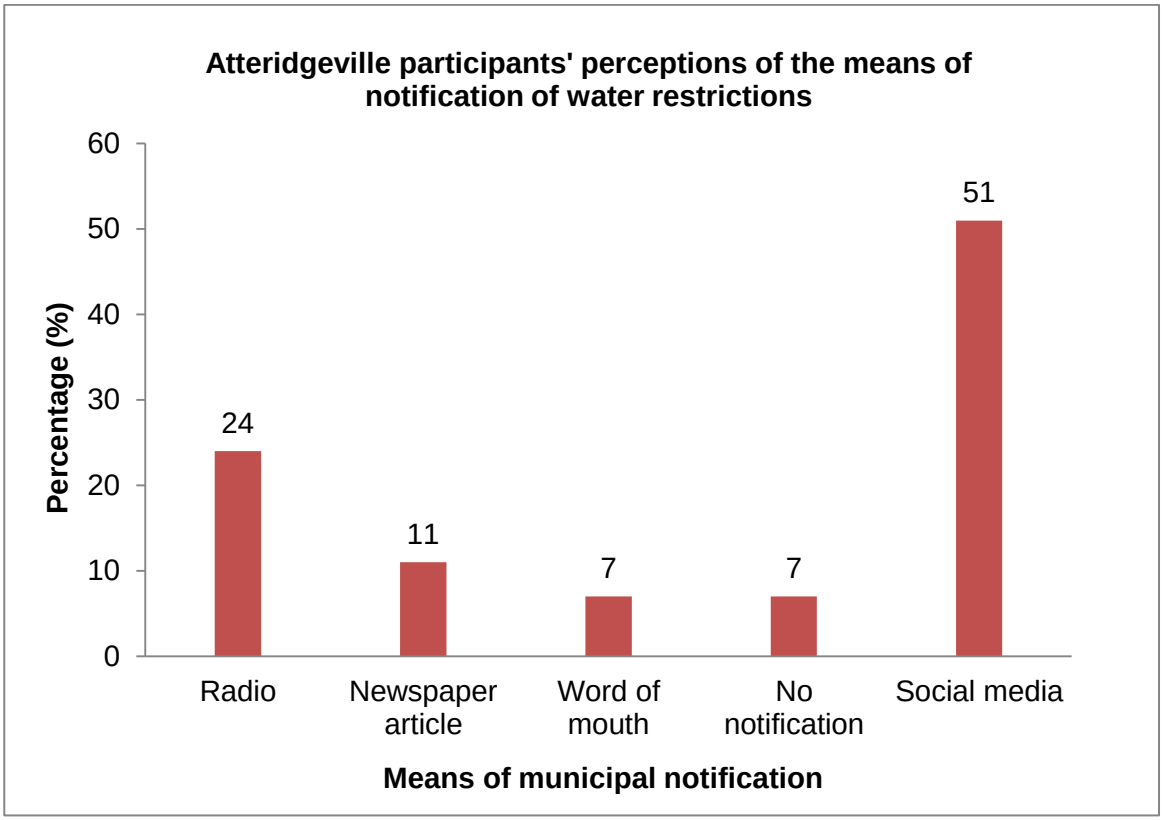

Figure 4.24: Means of notification of water interruptions in Atteridgeville.

Furthermore, during the respective focus group discussions in the research areas, the participants reported that they were not adequately notified by the municipality about any water-related issues. The same collective response was received from all of the focus group participants in Hammanskraal, namely *"no"*. On the other hand, only a single focus group participant in Atteridgeville stated that *"sometimes we see it on Facebook, but we have not received any letters or anything like that"*. In essence, the focus group participants in both research areas generally shared similar sentiments on the lack of adequate notification by the municipality.

Apart from the Hammanskraal and Atteridgeville participants' perceptions in respect of notifying the public about water interruptions, the perceptions of the municipal officials were also investigated to determine the method of notification used to announce water restrictions to the public. A brief discussion in this respect now follows.

4.7.2. Municipal Officials' Perceptions and Methods of Informing Residents of Interruptions to the Water Supply in Hammanskraal and Atteridgeville

Interviews conducted with the municipal officials brought to light the methods that the municipality uses to inform the public about water-related issues.

One municipal official indicated that the municipality notifies the public about *"planned water interruptions"* through the following measures:

"By radio, press releases, by posters on all the stop streets and the robots. We also distribute flyers, especially to the hospitals and the clinics and old age homes. We use Facebook and Twitter also. And it's on the website, our website, all our planned interruptions are always on the municipality's website."

Quite obviously, the municipality cannot inform the public of water supply issues when unplanned water interruptions occur. However, it does adopt some measure of communication to inform the public about planned water interruptions. Another municipal official explained the process that is followed prior to informing the public of any water-related issues as follows:

"…we communicate it in advance and then the group head gives the go-ahead for the communication. Once that is done, it goes out to the media via our Public Relations section. Then it's in the form of - I think - what is it?... posters? Ja, posters, they also use Facebook and Twitter a lot."

Evidently, the municipal officials believe that they are adequately informing the public of water-related issues through the use of posters and social media. They are also of the opinion that the communication from the municipality to the public is content-specific to the water-related issues. As one official stated:

"We say we might experience a water shortage, because Rand Water supplies four of these big reservoirs, so if they are maintaining these valves, the job is very big. Because you want people to be conscious of how they use water, we communicate just in case and we tell them: this area ***might*** *experience water shortages after so many hours, knowing that we [allocate a time estimate] for the work [that is to be done]. So we do say: 'It's either a broken valve or a leak in the pipe.' We mention exactly what it is we are doing: it's very transparent".*

The responses of the municipal participants indicated that they believe that the municipality communicates adequately with the public when there are water-related issues.

A comparative analysis pertaining to the two research areas of the perceptions in respect of municipal communiques and the methods of notification about water-related issues now follows.

4.7.3. Comparative Analysis of the Hammanskraal, Atteridgeville and Municipal Participants' Perceptions on the Municipal Means of Notification about Water-related Issues

From the empirical findings, it is evident that the majority of the Atteridgeville participants made use of social media to access information about water supply issues as opposed to the Hammanskraal participants who relied mostly on word of mouth communication from other residents in the area. Radio was also found to be an important channel for promoting media publicity in both research areas. Although numerous participants from both research areas were informed about their water-related issues through the newspaper, many are still not adequately informed about water restrictions and they ultimately relied on other community members for the word of mouth dissemination of information.

The municipal officials on the other hand indicated that they use numerous communication methods to notify the public of water supply challenges in both of the research areas. Nonetheless, not all of the Hammanskraal and Atteridgeville participants were satisfied with the municipality's means of notification.

Jorgensen et al. (2009) confirm that when water supply agencies are perceived by the public to be unreliable, the public will tend to be unreceptive to implementing water conservation initiatives, as observed particularly in Atteridgeville. It can thus be deduced that when the public is not adequately informed about water restrictions and when the reasoning for the implementation of water restrictions is not clearly articulated to the public, water supply agencies such as municipalities can be deemed untrustworthy. This in turn could cause the public to rebel against practising water-saving initiatives, as was found to be the case in Atteridgeville.

Moreover, a lack of information about water-related issues could lead to or intensify protests, which, as confirmed by Coetzee et al. (2016), are an aggressive act of displaying the community's overall distrust in terms of the municipal sector and the

efficacy of its service provision. Such protests have occurred in Hammanskraal, which bears testimony of damage through arson of the water infrastructure by community members.

Therefore, more effective and informative methods of notification should be implemented by the municipality to ensure that the public is well informed about the overall availability of water, water scarcity and any other water-related issues that might affect the water supply to households. Also, as highlighted by Syme et al. (2000), the use of platforms such as television advertising could be the most effective platform for promoting water conservation awareness and altering the perceptions and beliefs of people in respect of water issues. This is an additional measure that the City of Tshwane Metropolitan Municipality could employ to inform the public about water-related issues and for the overall promotion of water conservation over a wider reach.

To further investigate the communication lines between the participants in the research areas and the municipality, the participants were asked about their perceptions and behaviours in respect of reporting water problems, specifically water leaks, in the research areas, and the municipality's subsequent response and management of these challenges, which will be discussed in the following sections.

4.8. Participants' Perceptions and Behaviours on Reporting Water Leaks and the Perceived Responses by the Municipality to such Complaints

The research also focused on whether or not the survey and focus group participants in Hammanskraal and Atteridgeville were inclined to and did in fact report water leaks. A further issue that was investigated was whether or not the municipality responded timeously and managed the leaks efficiently. In the first place, the aforesaid perceptions and behaviours of the township participants and the municipal officials were investigated in Hammanskraal and then in Atteridgeville. As such, the discussion below is sequenced accordingly. The following section also includes a discussion of the perceptions of the municipal officials as to whether the public actually took active steps to report water leaks to them. Lastly, a comparison is presented of the Hammanskraal, Atteridgeville and municipal participants' perceptions on the reporting of water leaks and the management of such leaks.

A discussion on the perceptions and behaviours in both research areas towards reporting water leaks and the perceived management thereof by the municipality now follows.

4.8.1. Hammanskraal and Atteridgeville Participants' Perceptions and Behaviours on Reporting Water Leaks and their Perceived Management by the Municipality

In Hammanskraal, 74% of the survey participants stated that they reported water leaks to the municipality, while the other 26% of the participants stated that they did not. In contrast, 29% of the Atteridgeville survey participants stated that they reported water leaks to the municipality while 71% did not (Figure 4.25).

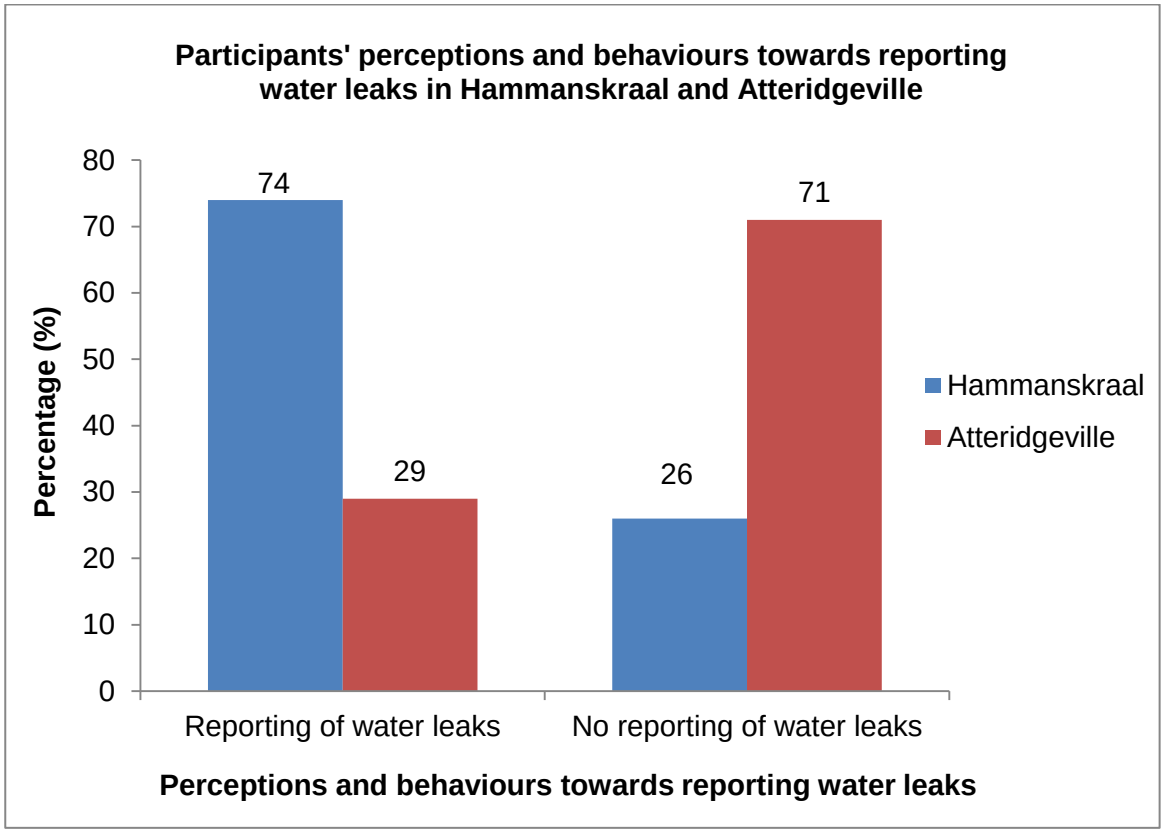

Figure 4.25: Participants' perceptions and behaviours regarding the reporting of water leaks in Hammanskraal and Atteridgeville.

The focus group participants in both Hammanskraal and Atteridgeville stated that the municipality did not manage the reported water leaks in a timely manner and as such, the majority of these participants were unmotivated to report further in this respect. In fact, one focus group participant in Atteridgeville stated the following:

"But we report the water and electricity problems and the municipal officials don't come to help us, so, ah, what's the point? They give you a reference number, then don't follow up with you... so we also lose hope."

Lastly, it was evident that water leaks were not managed effectively in both research areas - significant water spillages were observed at a communal tap left running in Hammanskraal, while a malfunctioning fire hydrant was left running thus resulting in substantial runoff, as observed in Atteridgeville during the transect walks (Figure 4.26).

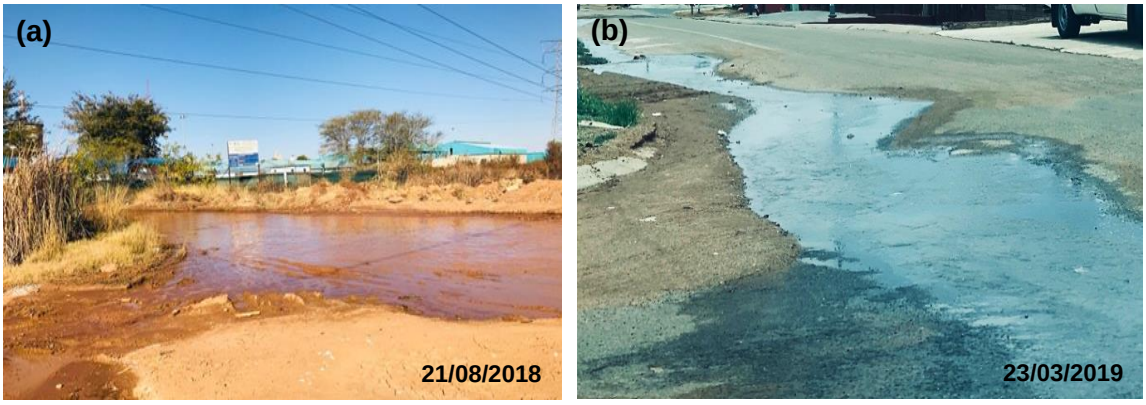

Figure 4.26: (a) Water spillage at the communal tap outside the Temba Wastewater Treatment Plant in Hammanskraal; (b) Sustained runoff from a malfunctioning fire hydrant in Atteridgeville (Researcher's Photos, 23/03/2019).

Moreover, runoff from a burst pipe was observed inside the boundary of the municipal offices at the Temba Wastewater Treatment Plant in Hammanskraal (Figure 4.27).

Figure 4.27: Runoff from the burst pipe observed at the municipal offices at the Temba Wastewater Treatment Plant in Hammanskraal (Researcher's Photos, 21/08/2018).

In the light of the perceptions noted and the observations made at Hammanskraal and Atteridgeville regarding the reporting of leaks and the perceived lack of management in

this respect by the municipality, the municipal officials' perceptions on the methods used by the municipality to address complaints and manage water leakages in the research areas were investigated and are discussed in the following section.

4.8.2. Municipal Officials' Perceptions towards Addressing Water-related Complaints and the Perceived Municipal Management of Leakages in Hammanskraal and Atteridgeville

An investigation was undertaken to provide clarity on whether or not there was any miscommunication between the municipality and the public and also to ascertain whether or not the municipality timeously managed water leakages in the research areas.

The municipal officials explained that the public often failed to report water leaks to the municipality as one official had the following to report:

"The people aren't concerned [about water leaks]… they aren't concerned about it, they just go on; there's just no urgency. We actually have an email address for the reporting of water leaks, namely waterleaks@tshwane.gov.za. People are also supposed to or can report leaks at (012) 358 9999."

It should, however, be noted that the majority of the participants in Hammanskraal and Atteridgeville expressed very little trust in the municipality on account of the perception that their complaints about water leaks were not managed timeously in any case. To this effect, one municipal official responded as follows:

"…the communities are becoming intolerant [of] the municipalities and the government because promises were made which cannot be met. One of my favourite sayings is: 'Never make a promise you cannot keep'. That's why I say to the Call Centre operators: Don't make a promise on my behalf or on my section's behalf. Don't tell the people by tomorrow afternoon 18:00 your complaint will be dealt with. Don't say that, because you cannot make a promise. You are making a promise to the person which you, you in your person, cannot meet. So, don't make promises on my behalf and be careful when making a promise that you are unable to meet."

It should be noted, however, that for those survey and focus group participants that did report water leaks, the generic response from the Call Centre agents at the municipality did not satisfy them and further deterred them from reporting water leaks again.

Despite the flaws of not timeously addressing water leaks, the municipality officials conceded that it is their responsibility to manage water leaks timeously. However, the

challenges with the lack of capacity and fewer personnel designated to manage such issues are a serious constraint for the municipality. This was confirmed by one municipal official who stated the following:

"I think that [it] is again the responsibility of the regions to repair burst pipes and leaks and they have to do it as soon as they can, but most of them are also under-resourced."

According to Mothetha et al. (2013), municipalities in South Africa are indeed short-staffed and unable, therefore, to manage water leaks timeously. Thus, it is important that the municipality should address the issues of short-staffing and ensure more efficient management of water leaks in the research areas in order to not only reduce NRW losses, but to regain the confidence of the community.

A comparative analysis on the Hammanskraal, Atteridgeville and municipal participants' perceptions on reporting of leaking pipes and the perceived management thereof by the municipality now follows.

4.8.3. Comparative Analysis of the Hammanskraal, Atteridgeville and Municipal Participants' Perceptions on the Reporting of Leaking Pipes and their Perceived Management by the Municipality

Numerous participants in Hammanskraal and Atteridgeville explained that they would not report a leaking tap as the municipality does not respond to water leaks timeously. Mothetha et al. (2013) confirms that when water leaks are not timeously managed by the municipality, residents in an area could lack the motivation and interest in taking steps to report these leaks as well. This has indeed been the case in both research areas as the participants were not confident that their reporting of leaks would meet with any success owing to their perceptions that the municipality would not in any case address these complaints. Furthermore, the observed water leak in the grounds of the municipal offices, as well as the interruptions to the complete installation and development of the pipeline infrastructure in Hammanskraal have contributed to and even exacerbated the apathy of the participants towards reporting water leaks.

Overall, the lack of trust in the municipality has also fuelled the negative perceptions towards the municipality in both research areas. Wright et al. (2012) and Kings (2015) further reiterate that if the public is not adequately informed about water-related issues, they will not take the initiative to report on the water-related issues that they might be facing, or even save water, which has been the case in both research areas. Therefore, it is important for the municipality to prioritise the timeous management of leakages and

response to the complaints lodged by members of the public to counter the apathy of the public and ultimately instil trust in them.

Despite the negative perceptions towards the addressing of water leaks by the municipality in both areas, the Hammanskraal participants appeared to be more active in reporting water leaks than the participants in Atteridgeville. This generally indicates that the Hammanskraal participants are more proactive about water conservation and stewardship.

This chapter presented an investigation into the water-use behaviours of a sample of research participants in Hammanskraal and Atteridgeville in an attempt to establish whether or not these behaviours are actually informed by the participants' perceptions of the interruptions in the water supply that they are experiencing in these research areas in times of drought and municipally-imposed water restrictions.

The methodological approach used in this research and the collection of data through surveys, focus group discussions, observations and one-on-one interviews enabled the validation of the responses provided by the participants from Hammanskraal, Atteridgeville and the City of Tshwane Metropolitan Municipality. The researcher was therefore able to align the findings of this research with what is highlighted in existing literature regarding current water-use and availability and the recommendations to improve the promotion of water conservation awareness actions globally and in the research areas. The observed water-use behaviours and perceptions regarding the water supply issues in Hammanskraal and Atteridgeville have highlighted the current water conservation awareness and water stewardship issues in these areas which are discussed in the following section.

4.9. Water Conservation and Stewardship in Hammanskraal and Atteridgeville

The ability of individuals to value the importance of water plays a significant role in their water conservation abilities (Adams et al., 2013). In addition, their ability to practise water conservation is closely interlinked with the concept of water stewardship. Water stewardship is the choice taken by individuals or stakeholders to ensure that they use water in sustainable ways for the benefit of the economy, the environment and humankind (AWS, 2018; Hamilton, 2019). Individuals and stakeholders practising water stewardship have a deep-rooted understanding of how they can ensure more sustainable ways of using water; how they can reduce their own impacts on the water resources; and how they can collaborate with other water-users to reduce their impacts (WWF, 2020).

Based on the participants' water-use behaviours and their perceptions in respect of their intermittent domestic water supplies, the water conservation and water stewardship aspects of the Hammanskraal and Atteridgeville communities were identified. A discussion of these aspects now follows, starting with Hammanskraal.

4.9.1. Water Conservation and Water Stewardship in Hammanskraal

Even though Hammanskraal is described as a rural township, the participants in this area were observed to be proactive about implementing and practising water-saving techniques and initiatives. The majority of the participants in this area could not define 'sustainability', 'water conservation' and 'climate change'. Nonetheless, they practise water conservation through the storage of water in containers, the reuse of grey water and the harvesting of rainwater in Jojo tanks. They have developed ways to adapt to intermittent water supplies in their households despite having negative perceptions of the supply and quality of the water in the area. These aspects reflect the sentiments of Clarke and Brown (2006) and Jorgensen et al. (2009) that the demographic and socio-economic status of individuals does not necessarily always affect their ability to implement and practise water-saving techniques or initiatives. Furthermore, it also indicates how people who have experienced water-related problems, tend to conserve water on account of being personally involved with the problem in the past (Holland et al., 2019). The Hammanskraal participants therefore emphasise the fact that water-saving actions can be adapted to and be practised on a routine basis when people have no choice but to do so. This in essence highlights the theory of Tolman (1932) that at times, learning may not always inform people's behavioural changes and decisions; instead their perceptions play a pivotal role in their decision-making abilities i.e. to conserve water as in the case of the Hammanskraal, even without the participants in the area being provided with prior education on water-saving initiatives.

Most of the water-use behaviours that were observed in Hammanskraal were not always informed by the participant's perceptions on the water-related issues in the area. These participants were found to be highly proactive about saving water even though they had negative perceptions of the municipality's ability to manage water-related issues and complaints associated with that.

A culture of water stewardship was therefore ultimately found to prevail in Hammanskraal. Even though the Hammanskraal participants had the predominant perception that they did not receive adequate water-related information from the municipality, they relied on working collectively with other community members to address and report their water-

related issues to the municipality. These behaviours have been confirmed by Anderson et al. (2007), who maintain that populations in rural areas are more likely to address water-related issues as a collective. The Hammanskraal participants, along with other community members, continually discuss water-saving methods and during their community meetings, they teach one another how to use water sparingly. This creates a common culture of saving water in the community, even without municipal intervention and assistance.

Sadly, out of desperation, and owing to the participants' predominant negative perceptions of the municipality in not timeously addressing water-related issues in Hammanskraal, some of the residents in this area have resorted to protests, which often results in damage to the infrastructure, a behaviour similarly observed and highlighted by Coetzee et al. (2016). As Moatshe (2019) confirmed that the tap water in Hammanskraal is not safe for human consumption, it can be deduced that the poor quality of the water could heighten frustrations in people, ultimately resulting in such protest actions. Such a situation has arisen as not all participants have the luxury of purchasing bottled water despite perceiving that their tap water is contaminated - sentiments echoed by Mothetha et al. (2013).

Overall, although water stewardship has been a culture identified in Hammanskraal, increased water-saving education campaigns should be promoted in the area to expand on the existing water conservation methods being practised by the participants in this area. This could ensure water conservation on a long-term and routine basis and could also encourage intensified water stewardship in the area, even after the water supply issues in Hammanskraal have been addressed by the municipality. Syme et al. (2000) shares equal sentiments and states that in order to successfully minimise the high water demands by households, water-saving education campaigns ought to be undertaken on a long-term basis, through the application of various forms of media publicity, such as television. By so doing, the water stewardship in areas such as Hammanskraal could be intensified, and the same could also be achieved in Atteridgeville.

A discussion on the water conservation and water stewardship in Atteridgeville now follows.

4.9.2. Water Conservation and Water Stewardship in Atteridgeville

In Atteridgeville, the majority of the participants were found to be easily able to define 'sustainability', 'water conservation' and 'climate change'. They could also describe general water conservation methods such as saving water and refraining from irrigating

gardens during water restrictions. Nonetheless at the time of this research, they were not practising any form of water conservation actions themselves.

Seshoka et al. (2004) maintains that residents in an area often disregard the importance of saving water when other residents irrigate their gardens with potable water, which was found to be the case in Atteridgeville. Overall, the Atteridgeville participants had a heightened awareness of water conservation and were more cognisant of their responsibility in conserving water and teaching others to do so, but were not doing so themselves. Quite evidently, compliance to water restrictions can be achieved only when there is a common interest for the community to conserve water and when community members understand the need to do so, as echoed by Atwood et al. (2007) and Jorgensen et al. (2009). Generally, the level of water stewardship practised in Atteridgeville is low.

The participants' negative perceptions towards the municipality have exacerbated their complete disregard for water-saving initiatives in the area, as well as their increased non-compliance to the regulations around water restrictions. This attitude is primarily based on their predominant perception that the water restrictions had been suspended post-drought and that water conservation would therefore no longer be necessary. Furthermore, the participants' negative perceptions towards the tardiness of the municipality in timeously addressing water leaks has also undermined the practice of water conservation in Atteridgeville - similar sentiments shared by Jorgensen et al. (2009).

Seshoka et al. (2004) also indicates that water resources are often misused when community taps are left running. This was evident in Atteridgeville as the participants had open access to fire hydrant water during water restrictions which in turn exacerbated their non-compliance to the water restrictions and resulted in their misappropriation of the water resources in this area.

Lastly, at the time of the research, some of the Atteridgeville participants were cognisant of the fact that the water restrictions were implemented on account of the drought and the low dam levels - a definition of water restrictions by Muller et al. (2009). This shows that they were aware of the negative impacts of the drought in reducing the water supply in the area, yet they were not prepared to practise water-saving initiatives in this regard. Such attitudes echo the sentiments of Syme et al. (2000) and the IPCC (2014), that activism for implementing water-saving initiatives during a water crisis is indeed a short-term solution, which does not result in altered water-use behaviours.

In conclusion, the Hammanskraal participants were found to have a predominantly negative attitude towards their intermittent water supply and the overall water provisioning service by the municipality on account of the inadequate provision of water by tankers, the lack of being adequately informed about water-related issues, the municipality's lack of response to their complaints, as well as delays in the timeous management of the water leaks that they reported. Additionally, the Hammanskraal participants also highlighted poor water quality as a major issue in the area. At times, the inferior quality of the water within the community has forced them to purchase bottled water from local water purification vendors, especially because the water provision by water tankers was also deemed to be irregular. In order to improve the water quality and amplify water stewardship in the Hammanskraal area, it is imperative for the infrastructure at the Rooiwal Wastewater Treatment Plant to be investigated and maintained to ensure reduced sewage effluent spillages into the surrounding freshwater resources, to prohibit further contamination of Hammanskraal's drinking water.

The negative water-related perceptions in Hammanskraal have been accompanied by protests and considerable damage to the bulk water pipeline infrastructure of the area. However, despite these negative perceptions and intermittent water supply challenges experienced in Hammanskraal, the participants in this area have become accustomed to a culture of water stewardship and of practising water conservation on a regular basis. They have adapted to and adequately prepare themselves for frequent interruptions to their water supplies by storing water in buckets and containers, reusing greywater and harvesting rainwater in Jojo tanks. These are in fact some of the coping mechanisms and adaptations that they are using when water cuts and restrictions are imposed by the municipality. Ultimately, the community has collectively addressed its water-related issues and promoted water conservation over many years (from 2015 till the present), thereby creating a culture of water stewardship in Hammanskraal.

Owing to the perception that there is no longer a drought and that the water restrictions have been suspended and are no longer being enforced in Atteridgeville, the majority of the research participants in this township were found to show little interest in participating in the research. In fact, the survey and focus group participants in Atteridgeville stated that the water interruptions experienced at the time of the research occurred only when routine maintenance operations were being carried out by the municipality. Furthermore, although the Atteridgeville participants explained that the municipality did not provide enough water tankers during water restrictions, they would then resort to purchasing water or to collecting water from the fire hydrants in the area. Quite evidently, these

participants were not adequately equipped to adapt to the water restrictions and were consequently not prepared for the water cuts.

Although most of the Atteridgeville participants were notified of the water-related issues in their community via social media, the participants did not feel the need to practise water-saving initiatives. Moreover, they perceived that the municipality was neither able to respond to water-related complaints nor to timeously manage water leaks. These negative perceptions therefore discouraged the participants from reporting water leaks and collectively solving water-related issues with other community members. It was thus deduced that owing to the predominant perception that water conservation is not a necessity, there were no (or very limited) water stewardship and water conservation initiatives that were being practised in Atteridgeville at the time of the research.

The limited need for water conservation can be attributed to the great reliance that the Atteridgeville participants place on fire hydrant water during water supply interruptions or water restriction periods. This illegal and unsustainable means of acquiring water during water restrictions often resulted in significant wastage of the resource as these fire hydrants would invariably be left open and running. It is therefore imperative for the municipality to limit access to and improve the monitoring of the fire hydrants to reduce the continued unsustainable use of water in the area. Furthermore, the overall demand for water should be reduced through intensified awareness campaigns supporting water conservation that should be undertaken on a regular basis in an attempt to reduce or alleviate water scarcity and water stress on the region's freshwater resources, a suggestion similarly echoed by Rossi and Cancelliere (2012) who recommends that a similar approach should be implemented in the rest of South Africa.

Overall, there is evidently poor communication between the participants in the research areas and the City of Tshwane Metropolitan Municipality. The research findings indicate that the municipality promotes water-saving initiatives and implements water restrictions only as a reactive measure during a crisis such as a drought or when infrastructural malfunctions result in water contamination incidents. Such a reactive method seldom mitigates the heavy demand for water. Moreover, as expressed by the IPCC (2014), it does not heighten water conservation awareness; nor does it result in altered water-use behaviours.

Finally, the research findings have indicated that the negative perceptions towards the municipality have deterred some of the Hammanskraal and Atteridgeville participants from reporting water-wastage incidents to the relevant authorities. Moreover, incomplete pipeline developments, a persistent water leak in the grounds of the municipal offices at

Hammanskraal, and water-wastage incidents associated with the fire hydrants and the communal tap in Atteridgeville and Hammanskraal respectively, have further fuelled the participants' negative perceptions of the municipality and its reneging on its responsibilities. Quite evidently, if the municipality is perceived as being unreliable in addressing complaints and in managing water leaks timeously, the public will see no reason to save water either. Despite the explanation by the municipal officials that the municipality is short-staffed, it is imperative for additional qualified people to be employed in order to address water-related issues and to manage water leaks in order to reduce NRW losses, as Mothetha et al. (2013) highlighted that South African municipalities experience excessive short staffing. Jorgensen et al. (2009) and Babel et al. (2010) however recommend that employing the relevant qualified people to address water-related issues could in turn improve the trust that the general public puts in the municipality and ensure adherence to the water restriction regulations. Through the employment of qualified people, similar successes were achieved in Bangkok and many other Asian countries as confirmed by Babel et al. (2010).

Through the use of an interpretive research approach and the chosen research design this research has established that, the City of Tshwane Metropolitan Municipality should be at the forefront of promoting water conservation awareness and encouraging water stewardship in, amongst others, these two research areas. As confirmed by Rossi and Cancelliere (2012), it is important for water-saving initiatives to be promoted by the municipality on a proactive basis in order to encourage the public to save water on a daily basis. In addition, there is an overall need for more education on water conservation in both research areas. Also, according to Syme et al. (2000), through the regular running of water-saving education campaigns, such as exhibitions in the local areas and the placement of advertisements promoting water conservation on media such as the television, even more attention can be drawn to water stewardship.

The following chapter concludes this research and provides applicable recommendations.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

This chapter provides a synthesis of this research and highlights its main findings, thus indicating whether or not the aim and objectives of the research have been achieved. Furthermore, this chapter provides recommendations and conclusions based on the primary findings. A summary of the research findings now follows.

Water is a valuable and essential resource that sustains the lives of humans, animals and the environment. This resource should be utilised in a sustainable manner to ensure that both the current and future generations benefit from it. Literature, however, indicates that the amount of water available on a global scale is limited; and that the current supply of freshwater resources is becoming scarcer owing to the burgeoning growth in population numbers and the persistent overexploitation of this vital resource by the agricultural, industrial and municipal sectors including domestic households and recreational establishments.

The overall quality of freshwater resources is also declining globally on account of major contaminants in the water such as nutrients, trace metals, human-produced organic chemicals and toxins, contaminants that are discharged into the water body on a regular basis, sedimentation and eutrophication - arising from soil erosion, thermal water pollution, acid rain, salinisation and pathogenic organisms. The continued decline in the quality of the water also eventually contributes to the reduced availability of water and the increased water stress experienced across the globe as water becomes unacceptable for use by the various sectors of the economy.

Moreover, the high population growth rates across the world have resulted in the increased demand for water and food security. They have also accelerated the expansion of human settlements as the demand for shelter has also increased. Such growth not only results in a greater demand for water for domestic use, but also places pressure on the existing rundown water infrastructure, ultimately exacerbating water leakages (NRW losses), sewage effluent spillages and the pollution of freshwater resources in the vicinity. Lastly, climate variability, resulting in low rainfall and droughts in particular regions, contributes to the scarcity of water, global water scarcity and subsequently water stress.

The global challenges associated with water scarcity are also being felt in South Africa. These challenges need to be managed to ensure that the country achieves the targets set by the SDGs initiative by 2030 and also the overall integrated water resource management through informed decision-making processes.

Although South African municipalities are mandated by law to supply the population with clean drinking water services, many municipalities across the country and specifically the City of Tshwane Metropolitan Municipality, have experienced numerous challenges in doing so.

The development and spatial expansion of human settlements has exacerbated the increased losses of municipal NRW, while infrastructural failures and malfunctions of wastewater treatment plants have resulted in the increased contamination of the region's freshwater resources. Furthermore, climate variability and droughts have further exacerbated the water supply challenges faced by municipalities and the country as a whole. In recent times, many human settlements have experienced intermittent water supplies on account of the water restrictions imposed on consumers by municipalities.

The focus areas for this research were Hammanskraal and Atteridgeville. The implemented water restrictions and ultimately the intermittence in the supply of water to domestic households in these areas were the focal point of this research which investigated the water supply perceptions of the participants of these areas, their behaviour in terms of their usage of water and their awareness of water conservation measures following varying water crisis events that have occurred.

This enabled the researcher to determine the overall extent of water stewardship in both research areas and to ultimately recommend suitable actions which should be taken and measures which could be implemented to address the identified water supply challenges. By so doing, an intensified culture of water stewardship could thus be promoted in both Hammanskraal and Atteridgeville.

In terms of Hammanskraal, the research established the following.

The intermittent water supply and water contamination incidents at the Rooiwal Wastewater Treatment Plant did not deter the participants in this area from using water sustainably. The Hammanskraal participants are generally accustomed to purchasing water, collecting water from the roaming water tankers, storing water daily in buckets and containers, as well as practising rainwater harvesting - as long as they have Jojo tanks. Despite the variable climatic conditions that prevail over the area, they generally practice all of the recommended water-use and water conservation behaviours that are often highlighted in awareness campaigns. In essence, the Hammanskraal participants have been adapting to and preparing themselves prior to interruptions to their household water supplies.

Despite being accustomed to practising water conservation actions, the concern for the quality of the tap water in Hammanskraal was raised in this research by numerous participants. In the light of this, it is recommended that the water quality issues in Hammanskraal should be investigated in greater detail to determine whether or not the quality of the water in the area is of an acceptable standard for domestic use. It is also recommended that the sewage effluent spillages which contaminate the drinking water sources for Hammanskraal as a result of the failing infrastructure at the wastewater treatment plants in the region must be seriously investigated and prioritised by the municipality. Furthermore, it is recommended that the municipality should ensure that water tankers provide a more efficient service when delivering water to communities during times when tap water supplies are intermittent.

Furthermore, the Hammanskraal participants use community meetings as their platform for discussion to collectively discuss and address their water-related challenges with other community members. Apart from their collective efforts to address these issues, they also indicated that they were generally dissatisfied with the method that the municipality has employed to notify them about these issues. In fact, when some of them realised that the municipality was unresponsive to their water-related complaints, they were not only discouraged and subsequently refrained from reporting water leaks and other water-related issues - but also engaged in protest actions, which resulted in the greater part of the water pipeline infrastructure being vandalised.

Therefore, it is recommended that the municipality should prioritise the development of improved means of notifying the public about water-related issues. This will improve transparency, which is currently perceived by the Hammanskraal participants to be lacking. Increased transparency will encourage the Hammanskraal public to report issues such as water leaks and reduce the occurrence of service delivery protests.

This research ultimately found that in spite of the significant and unrelenting water-related challenges in terms of both water supply and quality in Hammanskraal, there is in fact a culture of water stewardship in this community. In fact, the residents generally support a culture of using water sparingly and reusing greywater wherever possible, on a daily basis and not only during a water-related crisis, i.e. the water contamination events of Hammanskraal's drinking water sources. This clearly confirms the fact that people can adapt to water challenges by practising water conservation on an ongoing basis if they have no other option but to do so.

In order to support the water stewardship initiative and to encourage more water conservation measures in Hammanskraal, it is recommended that more intensified water-

saving campaigns be organised in the area. In so doing, the Hammanskraal participants would be likely to continue to use water sustainably even once the maintenance and infrastructural malfunctions at the Temba and Rooiwal Wastewater Treatment Plants have been addressed.

In contrast to Hammanskraal, this research found no to very little evidence of water stewardship in Atteridgeville. Although the participants in this area are fully aware of the water-saving initiatives that they could implement in their households, they nevertheless choose not to do so. Essentially, the Atteridgeville participants are of the opinion that there are no droughts or water supply issues in the area and that water cuts are only likely to occur during the occasional maintenance operations carried out by the municipality on the pipeline infrastructure. This perception has resulted in the illegal and unsustainable use of the fire hydrant water in the area on the occasions when water restrictions have been in force. Quite evidently, the goal of imposing water restrictions in an attempt to reduce the huge demand for water has not been realised in Atteridgeville as water is still being used unsustainably regardless of the fact that the participants in the area fully understand the nature of droughts and their consequences and the necessity for water restrictions. Instead, the participants in the area continue to misuse the fire hydrants as an alternative water source.

It is thus recommended that the municipality should address the irresponsible, unsustainable and illegal behaviour of the residents concerning the misuse of the fire hydrants in this area through improved monitoring and the enforcement of by-laws.

This research also concluded that the implementation of water restrictions and the promotion of water-saving initiatives as reactive measures at the onset of a drought or a water crisis are only short-term solutions to reduce the substantial demand for water. It is therefore recommended that the staging of water conservation campaigns be intensified and that exhibitions be promoted and implemented by the municipality to ensure that water conservation is practised proactively and on a long-term routine basis. The municipality should exploit the various forms of the media, including television, to good effect to ensure that a wider audience can be reached and also organise interactive meetings with the affected communities.

Lastly, the empirical findings of this research indicate that both the Hammanskraal and Atteridgeville residents are generally demotivated and not eager to report incidents of water wastage (e.g. pipeline leaks) owing to their perception that the municipality does not respond timeously - or not at all -, to complaints. The overall lack of response to complaints of water-related issues or, the lack of timeous management of pipeline

leakages, as well as the imperfect and unfinished pipeline developments in the research areas, have exacerbated the negative perceptions of the participants (residents) and distrust in respect of the municipality's attention to detail and diligence in carrying out its duties.

It is therefore recommended that the short-staffing issue at the municipality should be addressed to ensure that there are sufficient numbers of qualified personnel employed to replace rundown pipeline infrastructure and timeously manage water leaks, which contribute to the high municipal NRW losses. Furthermore, the recruitment of qualified personnel to complete the pipeline developments, monitor water wastage at communal taps and fire hydrants during a water crisis and having a team that addresses the public's complaints will substantially instil public trust in the municipality. This research essentially recommends that there should be improved and open communication and public participation between the municipality and the general public to increase the overall transparency of the former and indicate its proactiveness in providing an efficient water supply service to the public.

The primary conclusion issuing from this research indicates that people can adapt to water-saving initiatives and adopt a culture of water stewardship when they have no option but to do so. The actions of the participants of Hammanskraal are a prime example of good water stewardship, even though major water-related issues and challenges still remain in the area. This research also found that people are unlikely to adhere to water restrictions if they have access to alternative water supplies, as in the case of the Atteridgeville community and their use of the fire hydrants in the township.

By implementing relevant water conservation measures and addressing the water-related issues that have been highlighted in this research, the City of Tshwane Metropolitan Municipality would then be empowered to contribute towards the achievement of the 2030 SDGs for the region and ultimately for South Africa. The collaboration and interaction between the municipality and the public could build trust, which is currently lacking and encourage the public to timeously report issues such as water leaks. This in turn would ultimately result in the mitigation of NRW losses and increased water conservation efforts.

Open communication lines between the municipality and the public are of prime importance as effective communication would also defuse the anger and frustration of the residents and discourage them from participating in protest actions - as long as the major water-related issues that are reported are given the attention that they deserve and are addressed.

In conclusion, the promotion of water conservation initiatives and measures could ultimately contribute to the development of a water stewardship culture across many South African communities. By seriously considering and implementing the recommendations endorsed by this research, municipalities could ultimately be assisted in creating a water stewardship culture within the various communities across the country. Creating a culture of water stewardship could serve as a catalyst in contributing to the achievement of the 2030 SDGs, specifically related to supporting and providing improved water and sanitation management. The promotion of water stewardship within the country should be considered to be of prime importance if the country is to avoid further water stress and a possible water supply crisis.

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APPENDIX 1 – ETHICAL CLEARANCE DOCUMENTATION

UNISA university of south africa

CAES HEALTH RESEARCH ETHICS COMMITTEE

Date: 13/02/2019

NHREC Registration # : REC-170616-051
REC Reference # : 2018/CAES/026
Name : Ms KI Mthimunye
Student #: 51268272

Dear Ms Mthimunye

Decision: Ethics Approval Renewal after First Review from 01/02/2019 to 31/01/2020

Researcher(s): Ms KI Mthimunye
51268272@mylife.unisa.ac.za

Supervisor (s): Dr A Du Plessis
duplea@unisa.ac.za; 011-471-2877

Working title of research:

A comparative analysis of perceptions on water supply, water conservation awareness and behaviours in Hammanskraal and Atteridgeville

Qualification: MSc Geography

Thank you for the submission of your progress report to the CAES Health Research Ethics Committee for the above mentioned research. Ethics approval is renewed for a one-year period. After one year the researcher is required to submit a progress report, upon which the ethics clearance may be renewed for another year.

Due date for progress report: 31 January 2020

*The **low risk application** was **reviewed** by the CAES Health Research Ethics Committee on 16 February 2018 in compliance with the Unisa Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.*

The proposed research may now commence with the provisions that:

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Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

1. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.
2. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the Committee.
3. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
4. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing, accompanied by a progress report.
5. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
6. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data require additional ethics clearance.
7. No field work activities may continue after the expiry date. Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.

Note:

*The reference number **2018/CAES/026** should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.*

Yours sincerely,

Prof EL Kempen
Chair of CAES Health REC
E-mail: kempeel@unisa.ac.za
Tel: (011) 471-2241

Prof MJ Linington
Executive Dean : CAES
E-mail: lininmj@unisa.ac.za
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UNISA GENERAL RESEARCH ETHICS REVIEW COMMITTEE

Date: 19/02/2018

NHREC Registration # : REC-170616-051
ERC Reference # : 2018/CAES/026
Name : Ms KI Mthimunye
Student #: 51268272

Dear Ms Mthimunye

Decision: Ethics Approval from 16/02/2018 to 31/01/2019

Researcher(s): Ms KI Mthimunye
51268272@mylife.unisa.ac.za

Supervisor (s): Dr A Du Plessis
duplea@unisa.ac.za; 011-471-2877

Working title of research:

A comparative analysis of perceptions on water supply, water conservation awareness and behaviours in Hammanskraal and Atteridgeville

Qualification: MSc Geography

Thank you for the application for research ethics clearance by the Unisa CAES General Research Ethics Review Committee for the above mentioned research. Ethics approval is granted for a one-year period. After one year the researcher is required to submit a progress report, upon which the ethics clearance may be renewed for another year.

Due date for progress report: 31 January 2019

Please note the points below for further action:

1. The Committee requests that the inclusion/exclusion criteria for the selection of the participants be provided.
2. Some of the respondents may be illiterate - how will the researcher deal with them?
3. It could be problematic to get enough people to complete the questionnaire as well as attend the focus group discussion. Is it essential that the focus group participants also complete the questionnaire?

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*The **low risk application** was **reviewed** by the CAES General Research Ethics Review Committee on 16 February 2018 in compliance with the Unisa Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.*

The proposed research may now commence with the provisions that:

1. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.
2. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the Committee.
3. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
4. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing, accompanied by a progress report.
5. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
6. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data require additional ethics clearance.
7. No field work activities may continue after the expiry date. Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.

Note:

*The reference number **2018/CAES/026** should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.*

Yours sincerely,

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APPENDIX 2 – INFORMED SURVEY CONSENT FORM & SURVEY QUESTIONNAIRE

Ethical clearance: 2018/CAES/026
Research permission: 2018/CAES/026

COVER LETTER TO ANONYMOUS QUESTIONNAIRE

Title of Research:

A COMPARATIVE EVALUATION OF WATER SUPPLY PERCEPTIONS AND OVERALL WATER STEWARDSHIP IN HAMMANSKRAAL AND ATTERIDGEVILLE

Dear Prospective participant,

You are invited to participate in a survey conducted by Ms Keitumetse Mthimunye under the supervision of Dr Anja du Plessis, a Senior Lecturer in the Department of Geography towards an MSc in Geography at the University of South Africa.

The survey you have received has been designed to study your perceptions on the water supply in your household and overall community, your water conservation awareness as well as your behaviours in using water when its supply is limited in your home. You were selected to participate in this survey because the lack of an adequate water supply is an issue that is faced by many residents in your community and it is important for the researcher to gain an in depth understanding of your personal perceptions towards the water supply in your home and overall community and to investigate just how the people living in this area cope in using water when the household's water supply is limited. You will not be eligible to complete the survey if you are younger than 18 years. By completing this survey, you agree that the information you provide may be used for research purposes, including dissemination through peer-reviewed publications and conference proceedings.

It is anticipated that the information we gain from this survey will help the researcher in understanding your perceptions towards your water supply challenges and this will in-turn enable the researcher to supply recommendations that may be used as coping

mechanisms when there is no water supply in your home. The information gained from this survey also aims to increase water conservation awareness within your community. You are, however, under no obligation to complete the survey and you can withdraw from the study prior to submitting the survey. The survey is developed to be anonymous, meaning that we will have no way of connecting the information that you provide to you personally. Consequently, you will not be able to withdraw from the study once you have completed the questionnaire and given it to the researcher. Based on the anonymous nature of the survey all information you provide will remain confidential and will be disclosed only as required by law. If you choose to participate in this survey it will take up no more than 15 minutes of your time. You will not benefit from your participation as an individual, however, it is envisioned that the findings of this study will ultimately supply suitable recommendations to address the water supply challenges faced in your area of residence and furthermore promote future water conservation awareness during the times where there is a lack of water in your home. The information gained from this survey will also supply suitable recommendations to the municipality on how it could improve its water supply service to you. We do not foresee that you will experience any negative consequences by completing the survey. The researcher undertakes to keep any information provided herein confidential, not to let it out of its possession and to report on the findings from the perspective of the participating group and not from the perspective of an individual. The records will be kept for five years for audit purposes where after it will be permanently destroyed and all hard copies of the questionnaires will be shredded. You will not be reimbursed or receive any incentives for your participation in the survey.

The research was reviewed and approved by the research ethics chairperson of the CAES General Ethics Review Committee, Prof EL Kempen. The primary researcher, Keitumetse Mthimunye, can be contacted during office hours at 0781260291 or keitumetsemthimunye@gmail.com. The study leader, Dr Anja du Plessis, can be contacted during office hours at 011 471 2877 or duplea@unisa.ac.za. Should you have any questions regarding the ethical aspects of the study, you can contact the chairperson of the CAES General Ethics Review Committee, Prof EL Kempen at 011 471 2241 or kempeel@unisa.ac.za. Alternatively, you can report any serious unethical behaviour at the University's Toll Free Hotline 0800 86 96 93.You are making a decision whether or not to participate by continuing to the next page. You are free to withdraw from the study at any time prior to handing the questionnaire over to the researcher.

RESEARCH QUESTIONNAIRE

1. What is your perception on your water supply issues in this community?

_____

2. What do you perceive could be the cause of the water supply issues?

_____

3. Does the municipality communicate adequately and in advance when there will be no water supply?

Yes ☐ No ☐

4. Does the municipality provide water tankers in times of no water supply?

Yes ☐ No ☐

5. If yes to 4, is the facilitation of water supply at the water tanks adequate? Please motivate your answer.

_____

6. How would you normally be informed of intermittent water supply?

Radio ☐ Facebook/Twitter ☐ Newspaper Article ☐

Word of Mouth ☐ Never heard anything ☐

7. Does the municipality explain why there would be no water supply?

Yes ☐ No ☐

8. For up to how long would you go without water supply in the household?

1– 2 Days ☐ 2 – 3 Days ☐ 3 – 4 Days ☐ 5–7 Days ☐

9. Are there ever any leaking water pipes in your community?

Yes ☐ No ☐

10. Would you report a leaking pipe or tap?

Yes ☐ No ☐

11. If yes to 9 and 10 above, does the municipality respond to this water leak immediately?

Yes ☐ No ☐

12. Is the municipality actively involved in teaching the community about water saving and conservation?

Yes ☐ No ☐

13. How do you prepare for the lack of water supply in advance?

_____

14. As a community how would you deal with the lack of water supply as a collective?

_____

15. For what is water used for in your household?

Bathing / Showering	☐	Brushing Teeth	☐	Flushing of Toilets	☐
Cooking	☐	Drinking	☐	Gardening	☐
Laundry	☐	Washing the Car(s)	☐	Cleaning the Home	☐

16. **How many times is water used for the following weekly?**

Laundry ☐

Washing the Car(s) ☐

Gardening ☐

17. **How do you cope without water in the home?**

_____

18. **Do you and your family save water in your home?**

Yes ☐ No ☐

19. **If yes to 18, how do you save water in your home?**

_____

20. **Does showering save more water than bathing?**

Yes ☐ No ☐

21. **Do you wash your car using a hosepipe or a bucket?**

Hosepipe ☐ Bucket ☐

22. **Do you use only tap water to water your garden?**

Yes ☐ No ☐

23. **What is grey water?**

_____

24. **Have you ever heard of reusing water in the household?**

Yes ☐ No ☐

25. **How can you reuse water in the home?**

_____

26. **Have you ever heard of the term *"water conservation"*?**

Yes ☐ No ☐

27. **If yes to 26, what is it?**

_____

28. **What is your perception on water scarcity?**

_____

29. **Are you aware of climate change?**

Yes ☐ No ☐

30. **What causes water scarcity?**

_____

31. **What is a drought?**

_____

32. **What is your perception on your rights and responsibilities towards water?**

_____

33. **Do you know what sustainability is?**

Yes ☐ No ☐

34. If yes to 33, what is it?

_____

35. Do you know if your neighbour saves and conserves water?

Yes ☐ No ☐

36. If your neighbour was wasting water would you report this?

☐ ☐

Yes No

37. Have you ever heard of the term *"water restrictions"*?

Yes ☐ No ☐

38. If yes to 37, what is it and why would water restrictions be implemented?

_____

39. Do you think water supply issues are only the fault of the municipality?

Yes ☐ No ☐

40. Are you responsible to saving water and teaching others in your home and community on how to save it?

Yes ☐ No ☐

41. How do you use water upon the return of its supply?

_____

42. At which points in the day is the water likely to return?

Morning ☐ Midday ☐ Afternoon ☐ Night-time ☐ Midnight ☐

43. Does the water returning at this time alleviate the water crisis in the home?

_____

44. Has the intermittent supply of water caused you to be more conscious of how you and your family use water in the household?

Yes ☐ No ☐

45. Has the intermittent supply of water caused you to incur any additional costs in purchasing bottled water?

Yes ☐ No ☐

46. If yes to 45, how many litres of water do you purchase and how often?

_____

APPENDIX 3 – INFORMED CONSENT FORM & FOCUS GROUP QUESTIONNAIRE

PARTICIPANT INFORMATION SHEET

Ethics clearance reference number: 2018/CAES/026

Research permission reference number: 2018/CAES/026

Title: **A COMPARATIVE EVALUATION OF WATER SUPPLY PERCEPTIONS AND OVERALL WATER STEWARDSHIP IN HAMMANSKRAAL AND ATTERIDGEVILLE**

Dear Prospective Participant

My name is Keitumetse Mthimunye and I am doing research under the supervision of Dr A. du Plessis in the Department of Geography towards an MSc degree in Geography at the University of South Africa. I am inviting you to participate in a study entitled:

A COMPARATIVE ANALYSIS OF PERCEPTIONS ON WATER SUPPLY, WATER CONSERVATION AWARENESS AND BEHAVIOURS IN HAMMANSKRAAL AND ATTERIDGEVILLE.

WHAT IS THE PURPOSE OF THE STUDY?

I am conducting this research to establish and compare the perceptions of water supply, water conservation awareness and behaviours of the Hammanskraal and Atteridgeville residents towards the water supply challenges faced in both these areas. The research also aims to suggest suitable recommendations to address the identified water supply challenges in both these study areas and to also contribute to promoting future water conservation awareness and actions within both Hammanskraal and Atteridgeville.

WHY AM I BEING INVITED TO PARTICIPATE?

You are being invited to participate herein to assist the researcher in conducting research on the water supply issues/challenges faced in Hammanskraal and Atteridgeville. Participants who reside in these identified areas will be asked to participate by answering questionnaires and also participating in focus group interviews. Residents have been randomly selected through random selection process of households within the identified

areas. In light of the *Protection of Personal Information Act*, Nr 4 of 2013, which necessitates the disclosure of how access was gained to the personal information of prospective participants, you have been chosen to participate in this research as you reside in an area which has been identified as an area facing water supply challenges. This research will have 100 participants from Hammanskraal and 100 participants from Atteridgeville. The researcher will then compare all responses from the participants residing in both study areas and develop findings to the research project accordingly.

WHAT IS THE NATURE OF MY PARTICIPATION IN THIS STUDY?

The research involves a questionnaire being issued to you of which you will be requested to complete. The research also involves you attending and participating in a semi-structured focus group interview. You will be requested to answer questions related to the use of water in your specific household as well as to give your opinion freely regarding water conservation and water supply issues you have faced both in your household and community. The questionnaire has been attached to this document for your completion. The expected duration of your participation in the focus group will take no longer than 45 minutes to 1 hour.

CAN I WITHDRAW FROM THIS STUDY EVEN AFTER HAVING AGREED TO PARTICIPATE?

Your participation in this research is voluntary and that there is no penalty or loss of benefit for your non-participation. Participating in this study is voluntary and you are under no obligation to consent to participation if you do not want to take part. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a written consent form. Your identity need not be revealed for purposes of this research and you may withdraw from answering the questionnaire at any time. It will however not be possible to withdraw once you have submitted the questionnaire to the researcher, however, your responses will be kept anonymous. Furthermore, you are free to withdraw from the focus groups at any time and without giving a reason.

WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THIS RESEARCH?

The benefits of your participation in the research will contribute to the research achieving its findings and ultimately contributing to the body of knowledge. Your participation will also ensure that the researcher can suggest suitable recommendations to address the water supply challenges you have faced in your community and will ultimately add to the

promotion of future water conservation awareness as a coping mechanism during the times where there is a lack of water in your household and in your community.

ARE THEIR ANY NEGATIVE CONSEQUENCES FOR ME IF I PARTICIPATE IN THE RESEARCH PROJECT?

The only inconvenience and/or discomfort you may experience is that your participation requires a bit of your time. There are no foreseeable risks of harm or side-effects to your health or security should you take part in this research.

WILL THE INFORMATION THAT I CONVEY TO THE RESEARCHER AND MY IDENTITY BE KEPT CONFIDENTIAL?

You have the right to insist that your name not be recorded anywhere and that no one, apart from the researcher and identified members of the research team, will know about your involvement in this research. Your answers will be given a code number or a pseudonym and you will be referred to in this way in the data, any publications, or other research reporting methods such as conference proceedings.

The researcher will be the transcriber of all recordings in the focus groups interviews and thus your identity need not be revealed to the researcher. Your answers may be reviewed by people responsible for making sure that research is done properly, including the transcriber, external coder, and members of the Research Ethics Review Committee. Otherwise, records that identify you will be available only to people working on the study, unless you give permission for other people to see the records.

Also note that the responses you provide during your participation of the research will remain data and may be used for other purposes, such as research reports, journal articles and/or conference proceedings. A report of the study may be submitted for publication, but individual participants, such as yourself will not be identifiable in such a report. Please keep in mind that it is sometimes impossible to make an absolute guarantee of confidentiality or anonymity during focus groups although the researcher will ensure that a code number or a pseudonym be assigned to each participant to ensure that there is both anonymity and confidentiality.

A focus group is a form of data collection in qualitative research wherein the researcher may sit with a group of participants and a discussion about the relevant topic is conducted and participants can voice out their opinions within the group. While every effort will be made by the researcher to ensure that you will not be connected to the information that

you share during the focus group, I cannot guarantee that other participants in the focus group will treat information confidentially. I shall, however, encourage all participants to do so. For this reason I advise you not to disclose personally sensitive information in the focus group.

HOW WILL THE RESEARCHER(S) PROTECT THE SECURITY OF DATA?

Hard copies of your answers will be stored by the researcher for a period of five years in a locked cupboard/filing cabinet in the researcher's study room at her home and for future research or academic purposes; electronic information will be stored on a password protected computer. Future use of the stored data will be subject to further Research Ethics Review and approval if applicable. After the five year period, the hard copies of the questionnaire will be shredded and electronic copies will be permanently deleted from the hard drive of the computer through the use of a relevant software programme.

WILL I RECEIVE PAYMENT OR ANY INCENTIVES FOR PARTICIPATING IN THIS STUDY?

You will not receive any payment or incentives for your participation in the study.

HAS THE STUDY RECEIVED ETHICS APPROVAL

This study has received written approval from the Research Ethics Review Committee of the College of Agriculture and Environmental Sciences, Unisa. A copy of the approval letter can be obtained from the researcher if you so wish.

HOW WILL I BE INFORMED OF THE FINDINGS/RESULTS OF THE RESEARCH?

If you would like to be informed of the final research findings, please contact Keitumetse Mthimunye on 0781260291 or keitumetsemthimunye@gmail.com. The findings are accessible for a period of five years only. Should you require any further information or want to contact the researcher about any aspect of this research, please contact Keitumetse Mthimunye, on 0781260291 or keitumetsemthimunye@gmail.com. Should you have concerns about the way in which the research has been conducted, you may contact Dr A. du Plessis at duplea@unisa.ac.za. You are welcome to contact the research ethics chairperson of the CAES General Ethics Review Committee, Prof EL Kempen at 011-471-2241 or kempeel@unisa.ac.za if you have any ethical concerns. Thank you for taking time to read this information sheet and for participating in this study.

UNISA university of south africa

FOCUS GROUP QUESTIONNAIRE

1. Please motivate your perceptions on the supply of water in the community?
2. How efficient are the water tankers that the municipality supplies when there is no water supply in the community?
3. Does the municipality engage adequately in informing the community that there will not be any water supply?
   3.1. How does the municipality do this?
4. Has there been any collective community engagement on how to manage the water supply issues faced in the community collectively?
5. What is the general conservation awareness in the community and in your households?
6. Are the community members actively engaged with the municipality to ensure sustainable use of water to reduce the amounts of water restrictions?
7. Is there any water reusing initiatives going on?
8. Are the community members aware of how their neighbours use water?
9. Since the water restrictions, have your behaviours towards water use changed in any way?
10. Have you incurred any additional charges by purchasing bottled water because the community taps are dry?
11. Are you more aware of water conservation?
12. Are you aware of water reusing and recycling methods?
13. How can there be a mutual balanced relationship between the municipality supplying water better and the use of water by community as a whole?
14. Are you teaching your kids how to use water sparingly in the community?
15. Are you teaching your kids how to never pass a leaking tap?
16. Are you teaching the kids not to play with water in the streets?
17. Has the water supply taught you all how to sustainably use water in your households?

APPENDIX 4 – INFORMED CONSENT FORM & MUNICIPAL INTERVIEW QUESTIONNAIRE

UNISA university of south africa

PARTICIPANT INFORMATION SHEET

Dear Prospective Participant

My name is Keitumetse Mthimunye and I am doing research under the supervision of Dr A. du Plessis in the Department of Geography towards an MSc degree in Geography at the University of South Africa. I am inviting you to participate in a study entitled:

A COMPARATIVE EVALUATION OF WATER SUPPLY PERCEPTIONS AND OVERALL WATER STEWARDSHIP IN HAMMANSKRAAL AND ATTERIDGEVILLE

WHAT IS THE PURPOSE OF THE STUDY?

I am conducting this research to establish and compare the perceptions of water supply, water conservation awareness and behaviours of the Hammanskraal and Atteridgeville residents towards the water supply challenges faced in both these areas. The research also aims to suggest suitable recommendations to address the identified water supply challenges in both these study areas and to also contribute to promoting future water conservation awareness and actions within both Hammanskraal and Atteridgeville.

WHY AM I BEING INVITED TO PARTICIPATE?

You are being invited to participate herein to assist the researcher in conducting research on the water supply issues/challenges faced in Hammanskraal and Atteridgeville. The City of Tshwane Metropolitan Municipality has been identified as the competent local authority which provides water services to both the aforementioned study areas and is asked to participate in this research by authorising interviews with 10 Municipal officials within the Water and Sanitation Department of the said Municipality. In light of the *Protection of Personal Information Act*, Nr 4 of 2013, which necessitates the disclosure of how access was gained to the personal information of prospective participants, the City of Tshwane Metropolitan Municipality has been chosen to participate in this research as the competent local authority supplying water services to both Hammanskraal and Atteridgeville communities facing intermittent water supply challenges. This research will also have 100 participants from Hammanskraal and 100 participants from Atteridgeville

answering questionnaires and participating in focus group interviews to get an in depth understanding of the perceptions the participants have towards water supply in their communities as well as their water conservation awareness and behaviours towards water during times where the supply is intermittent. The researcher will then compare all responses from the participants residing in both study areas along with the interview responses of the 10 municipal officials and develop findings to the research project accordingly.

WHAT IS THE NATURE OF MY PARTICIPATION IN THIS STUDY?

The research involves semi-structured interviews being conducted with 10 municipal officials within the City of Tshwane Metropolitan Municipality's Department of Water and Sanitation. The researcher will furthermore engage the City of Tshwane Metropolitan Municipality on suitable times the researcher can interview any 10 municipal officials within its Department of Water and Sanitation to participate in the said semi-structured interviews. The officials will be requested to answer questions related to the supply of water to Hammanskraal and Atteridgeville. The interview questionnaire has been attached to this document for convenience and the expected duration of the municipality's participation in the interviews will take no longer than 20 minutes.

CAN I WITHDRAW FROM THIS STUDY EVEN AFTER HAVING AGREED TO PARTICIPATE?

Participation in this research is voluntary and that there is no penalty or loss of benefit for non-participation. Participating in this study is voluntary and the municipal officials are under no obligation to consent to participation if they do not want to take part. If they do decide to take part, this information sheet will be given to them to keep it and the City of Tshwane Metropolitan Municipality will be asked to sign a written consent form. The identities of the municipal officials who participate need not be revealed for purposes of this research and they may withdraw from answering the questionnaire at any time. It will however not be possible to withdraw once the interview has been conducted, however, all responses from the municipal officials will be kept anonymous. Furthermore, the officials are free to withdraw from the interviews at any time during the interviews and without giving a reason.

WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THIS RESEARCH?

The benefits of the municipality's participation in the research will contribute to the research achieving its findings and ultimately contributing to the body of knowledge.

Furthermore, the participation by the City of Tshwane Metropolitan Municipality will also ensure that the researcher can suggest suitable recommendations to address the water supply challenges faced by the Hammanskraal and Atteridgeville communities and will ultimately add to the promotion of future water conservation awareness as a coping mechanism during the times when there is a challenge in the Municipality supplying water to the said communities of which the research focuses on.

ARE THEIR ANY NEGATIVE CONSEQUENCES FOR ME IF I PARTICIPATE IN THE RESEARCH PROJECT?

The only inconvenience and/or discomfort the municipal officers may experience is that participation in the interviews requires a bit of time. There are no foreseeable risks of harm or side-effects to the municipal officials' health or security should they take part in this research.

WILL THE INFORMATION THAT I CONVEY TO THE RESEARCHER AND MY IDENTITY BE KEPT CONFIDENTIAL?

The municipal officials have the right to insist that their names not be recorded anywhere and that no one, apart from the researcher and identified members of the research team, will know about their involvement in this research. The answers of the municipal officials will be given a code number or a pseudonym with which the participant representing the City of Tshwane Metropolitan Municipality will be referred to in this way in the data, any publications, or other research reporting methods such as conference proceedings. The researcher will be the transcriber of all recordings in the interviews and thus the identities of the municipal officials need not be revealed to the researcher. The answers may be reviewed by people responsible for making sure that research is done properly, including the transcriber, external coder, and members of the Research Ethics Review Committee. Otherwise, records that identify the municipal officials will be available only to people working on the study, unless given permission for other people to see the records.

Also note that the responses provided by the municipal officials during their participation of the research will remain data and may be used for other purposes, such as research reports, journal articles and/or conference proceedings. A report of the study may be submitted for publication, but individual participants, such as the respective municipal officials will not be identifiable in such a report. Please keep in mind that it is sometimes impossible to make an absolute guarantee of confidentiality or anonymity during the

interviews although the researcher will ensure that a code number or a pseudonym be assigned to each participant to ensure that there is both anonymity and confidentiality.

A semi-structured interview is a form of data collection in qualitative research wherein the researcher may sit with participants and a discussion about the relevant topic is conducted and participants can voice out their opinions regarding the topic. While every effort will be made by the researcher to ensure that the municipal officials will not be connected to the information that is shared during the interviews, I cannot guarantee that other participants in the interviews will treat information confidentially. I shall, however, encourage all participants to do so. For this reason I advise you not to disclose personally sensitive information in the interview.

HOW WILL THE RESEARCHER(S) PROTECT THE SECURITY OF DATA?

Hard copies of your answers will be stored by the researcher for a period of five years in a locked cupboard/filing cabinet in the researcher's study room at her home and for future research or academic purposes; electronic information will be stored on a password protected computer. Future use of the stored data will be subject to further Research Ethics Review and approval if applicable. After the five year period, the hard copies of the interview responses will be shredded and electronic copies will be permanently deleted from the hard drive of the computer through the use of a relevant software programmes.

WILL I RECEIVE PAYMENT OR ANY INCENTIVES FOR PARTICIPATING IN THIS STUDY?

You will not receive any payment or incentives for your participation in the study.

HAS THE STUDY RECEIVED ETHICS APPROVAL

This study has received written approval from the Research Ethics Review Committee of the College of Agriculture and Environmental Sciences, Unisa. A copy of the approval letter can be obtained from the researcher if you so wish.

HOW WILL I BE INFORMED OF THE FINDINGS/RESULTS OF THE RESEARCH?

If you would like to be informed of the final research findings, please contact the researcher, Keitumetse Mthimunye on 0781260291 or keitumetsemthimunye@gmail.com. The findings are accessible for a period of five years only. Should any further information be required, kindly contact the researcher, Keitumetse Mthimunye, about any aspect of this research on 0781260291 or keitumetsemthimunye@gmail.com. Should the City of

Tshwane Metropolitan Municipality have concerns about the way in which the research has been conducted, kindly contact Dr A. du Plessis at duplea@unisa.ac.za. The municipality is also welcome to contact the research ethics chairperson of the CAES General Ethics Review Committee, Prof EL Kempen at 011-471-2241 or kempeel@unisa.ac.za if there are any ethical concerns.

Thank you for taking time to read this information sheet and for participating in this study.

CONSENT TO PARTICIPATE IN THIS STUDY

I, _____ (participant name and surname), confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits and anticipated inconvenience of participation.

I have read (or had explained to me) and understood the study as explained in the information sheet.

I have had sufficient opportunity to ask questions and am prepared to participate in the study.

I understand that my participation is voluntary and that I am free to withdraw at any time without penalty (if applicable).

I am aware that the findings of this study will be processed into a research report, journal publications and/or conference proceedings, but that my participation will be kept confidential unless otherwise specified.

I agree to the recording of the interview using a voice recording device.

I have received a signed copy of the informed consent agreement.

Participant Name & Surname…… (please print)

Participant Signature……..Date……

Researcher's Name & Surname……(please print)

Researcher's signature……..Date……

RESEARCH INTERVIEW QUESTIONNAIRE TO THE MUNICIPAL OFFICIALS

1. What causes the intermittent supply of water?
2. Do you inform the residents well in time of the water restrictions to be implemented in their community?
3. How do you inform the residents that their water supply will be intermittent?
4. Do you inform the residents of exactly what is causing their water supply to be intermittent?
5. Are water tankers adequately sent to the communities and positioned in places where everyone can access water?
6. Is there a standard procedure on how much water residents may receive from the tankers?
7. How would those at work and school get water from the water tankers if there is no one home?
8. Are there water conservation awareness programmes that engage the communities on how to use water sustainably?
9. Are there municipal officers that conduct observations in the communities to analyse how residents are using water?
10. Are there any negative perceptions of the residents towards the municipality while the communities face water supply issues?
11. How can the municipality maintain a civil and balanced water-supplier – water-user relationship?

APPENDIX 5 – MUNICIPAL CONSENT FORMS

CITY OF TSHWANE
IGNITING EXCELLENCE

City Strategy and Organisational Performance

Room CSP22 | Ground Floor, West Wing, Block D | Tshwane House | 320 Madiba Street | Pretoria | 0002| PO Box 440 | Pretoria | 0001
Tel: 012 358 0798
Email: NosiphoH@tshwane.gov.za | www.tshwane.gov.za | www.facebook.com/CityOf Tshwane

My ref: Research Permission/Mthimunye
Contact person: Pearl Maponya
Section/Unit: Innovation and Knowledge Management

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

Ms K.I. Mthimunye
2108
Soshanguve Block L
0152

Date: 08 February 2018

Dear Ms Mthimunye,

APPROVAL TO CONDUCT RESEARCH ON COMPARATIVE ANALYSIS OF PERCEPTIONS ON WATER SUPPLY, WATER CONSERVATION AWARENESS AND BEHAVIOURS IN HAMMANSKRAAL AND ATTERIDGEVILLE

Permission is hereby granted to Ms Keitumetse Mthimunye, a Master of Science in Geography candidate at the University of South Africa to conduct research in the City of Tshwane Metropolitan Municipality.

It is noted that the research aims to look at the perceptions and behavioural aspects of both Hammanskraal and Atteridgeville residents on water supply and awareness on water conservation. The City of Tshwane further notes that all ethical aspects of the research will be covered within the provisions of the University of South Africa Research Ethics Policy. You will be required to sign a confidentiality agreement form with the City of Tshwane prior to conducting research.

Relevant information required for the purpose of the research project will be made available upon request. The City of Tshwane is not liable to cover the costs of the research. Upon completion of the research study, it would be appreciated that the findings in the form of a report and or presentation be shared with the City of Tshwane.

Yours faithfully,

Pearl Maponya (Ms)
ACTING DIVISIONAL HEAD: INNOVATION AND KNOWLEDGE MANAGEMENT

City Strategy and Organisational Performance • Stadstrategie en Organisatoriese Prestasie • Lefapha la Thulaganyo ya Tiro le Togamaano ya Toropokgolo • UmNyango wezokuSebenza namaQhinga aHleliweko kaMasipala • Kgoro ya Leanopeakanyo la Toropokgolo le Bodiragatši bja Mmasepala • Muhasho wa Vhupulani ha Ḓorobo khulwane na Mashumele • Ndzawulo ya Maqhinga ya Dorobakulu na Matirhele ya Masipala • Umnyango Wezeqhinga Ledolobha Nokusebenza Kwesikhungo

CITY OF
TSHWANE
IGNITING EXCELLENCE

City Strategy and Organisational Performance

Room CSP22 | Ground Floor, West Wing, Block D | Tshwane House | 320 Madiba Street | Pretoria | 0002
PO Box 440 | Pretoria | 0001
Tel: 012 358 7542
Email: NosiphoH@tshwane.gov.za | www.tshwane.gov.za | www.facebook.com/CityOf Tshwane

My ref:	Confidentiality Agreement	Tel:	012 358 4559
Contact person:	Pearl Maponya	Email:	PearlMap3@tshwane.gov.za
Section/Unit:	Innovation & Knowledge Management	Date:	09 February 2018

CONFIDENTIALITY AGREEMENT BETWEEN THE RESEARCHER AND THE CITY OF TSHWANE MUNICIPALITY

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

Name of Researcher	Keitumetse Ingrid Mthimunye
ID Number	9304300117089
Research Topic	A Comparative Analysis of Perceptions on Water Supply, Water Conservation Awareness and Behaviours in Hammanskraal and Atteridgeville.

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

Qualitative interviews are to be conducted with10 Municipal officials with the aim of investigating how the municipality supplies water in Hammanskraal and Atteridgeville and to recommend suitable actions which should be taken or measures which could be implemented to address identified water supply challenges and promote future water conservation awareness and actions within the said areas.

- I will maintain the privacy and confidentiality of all accessible research data and understand that unauthorized disclosure of personal/confidential data is an invasion of privacy and may result in disciplinary, civil, and/or criminal actions against me.

- I will not disclose data or information to anyone other than those to whom I am authorized to do so.

- I will access data only for the purposes for which I am authorized explicitly. On no occasion will I use research data, including personal or confidential information, for my personal interest or advantage, or for any other business purposes.

- I will comply at all times with the City of Tshwane's data/information security policies and confidentiality code of conduct.

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

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

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

Signature

09-02-2018

Date