Measuring factors affecting sustainable water supply in the Province of Western Cape

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**DECLARATION**

I, **Carisa Guimar Camuto** hereby declare that this dissertation entitled, **“Measuring factors affecting sustainable water supply in the Province of Western.”** is the product of my own work. It is being submitted for the degree of Masters of Technology in the University of Johannesburg. All the sources that I have used and quoted have been indicated and acknowledged by means of completed references. I declare that this dissertation has not been submitted to, and has not been presented at, any other institution.

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Signature

______/_______/_2019___

Date

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**DEDICATION**

I dedicate my dissertation work to my family and those dear to my heart. I have quite a hand full of people to thank, I am sure that without them it would have been much harder to accomplish this dream. Firstly, I thank the Lord, he is worthy of all the praise and glory. It is so much that God has done for me that it's quite impossible for me to name them all.

A special feeling of gratitude to my Mom, Julia Guimar and my sister Rossana Vaz Pereira, Their words of encouragement and push for tenacity rang in my ears, I will always appreciate all they have done. I also dedicate this dissertation to my father whom is no longer with us, I believe he is super proud of me. Last but not least I thank a very special friend Floriano Manuel who has helped and supported me from the very first day I got to university, my dear friend it is with so much gratitude that I thank you. During the composition of my dedication I came across a realization that in all this I played the most important role and I just had to stop for a second, and give myself a well-deserved pat on my back, for not giving up on my dreams, for my perseverance and determination. Special mention to Mr Tshepo Mabotja for his valuable input throughout, thank so much.

## PREFACE

The work presented in this master's thesis was conducted at the Department of Quality and Operations Management within the Faculty of Engineering and the Built Environment of the University of Johannesburg under the Supervision of Dr Ndala Yves Mulongo.

**ABSTRACT**

Water is the most vital source of life anywhere in the world, however it is becoming an increasingly scarce resource especially in the Western Cape as a result of climate changes. Key adaptive strategies that might alleviate or avoid the worst impacts of climate change have also been identified.To this end, this study aimed at measuring factors affecting sustainable water supply in the Province of Western Cape. This led in developing three objectives noting that (1) to determine water usage practices in the City of Cape Town; (2) to determine the extent to which consumers have knowledge regarding water pricing policy; and (3) to examine the relationship between water saving habits, the demand for water and attitudes towards different water management policies.

To achieve the aforementionedgoal, this study adopted two approaches, firstly the study critically analyzed a set of previous studies that were conducted on the sustainable water supply strategies within various countries.This led in identifying existing gaps in the current literature. Secondly, the study adopted a quantitative approach and administered questionnaires to various respondents from different areas in the City of Cape Town.

As mentioned earlier on,the data used in this study were derived from both primary and secondary sources. The secondary data for the study were derived from the review of literature. The primary data were obtained through the use of a structured questionnaire. The data collected from various households were analyzed using deductive reasoning techniques. The participants that took part in this study were chosen by means of a convenience sampling approach. This method was preferred due to its ability to give the researcher an opportunity to select participants that were easily accessible. Findings enacting, the survey revealed that the major factors affecting sustainable water supply in the Province of Western Cape, particularly in the City of Cape Town from is lack of water reuse plants, leaking taps, lack of knowledge regarding the scarcity of water and lack of protection for Cape Town river has had a huge impact in terms of loss of water which has led to water crisis in Western Cape.

## LIST OF TABLES



## LIST OF FIGURES

**TABLE OF CONTENTS**

# CHAPTER ONE

# INTRODUCTION

This study aims at measuring factors affecting sustainable water supply in the Province of Western Cape. To this end, this chapter provides basic background information concerning the research. It begins with research regarding the contextual background and further brief supporting aspects within the literature. This chapter sets the tone of the research by outlining its context, problem statement, and objectives. It also discusses the research questions and the significance of the study.

## 1.1 Background

According to Thompson (2017), “water is one of the most precious resources in the world and its availability varies from one region to another. It is a vital resource for socio-economic development and for sustaining the ecosystem. The arid and semi-arid regions are particularly exposed to water shortages if infrastructure and water management are lacking”. This challenge of managing water resources around the world is enormous and is becoming increasingly discouraging with each passing year (Thompson, 2017).

Arlosoroff (1998) said that “population growth generally occurs in developing countries and the increase occurs mainly in the urban centers of these countries”. This is particularly true for South Africa. In 1995, twenty-nine countries with a total population of 436 million suffered water stress/shortages (Wahba et al, 2002). The World Bank estimates that by 2025, around forty-eight countries will experience water stress, and the affected population will increase to 1,400 million. In addition, by 2035 it is estimated that three (3) billion people will live in countries with water problems (Wahba et al, 2002).

At a time when the demand for fresh water is growing strongly, water-consuming processes and systems are subject to increasingly stringent environmental regulations for the control of liquid pollution, bringing issues of sustainable development to the fore (Nakagami, 2016). It is against this background that this study seeks to come up with a sustainable water demand management model.

### 1.2 Problem Statement

According to the projections of the World Meteorological Organization (WMO), two-thirds of the world's population will be under water shortage stress by 2025(Dwarf,2016). Water demand grows twice as fast as the world population, which will increase by 60% by the middle of the next century. The limited supply is on the verge of no longer satisfying the growing demand (Margerum and Robinson, 2015). According to estimates published by the United Nations (UN), more than one billion people are deprived of the right of access to safe water. In Sub-Saharan Africa, one-third of the population does not have this right, and 2.5 billion human beings do not have access to basic sanitation (Dwarf, 2016). As a result, an estimated 1.8 million children are dying yearly from diarrhea or other pathologies caused by the consumption of impure water, which makes unhealthy water the second leading cause of death in children around the world (Brown et al, 2015).

In the last decade, South Africa, particularly the Western Cape, has experienced a serious water supply crisis. The cause of this crisis has been attributed largely to the high demand for water and the inadequacy of freshwater resources. The imbalance between the demand for water and limited water resources is increasing in the municipal sector, therefore measures should be taken to limit and minimize the extraction of groundwater. The available water resources are also getting worse in terms of quality (Harris et al, 2015).

As the traditional management of urban water resources based on supply is not sustainable, water services should adopt measures to manage water demand to cope with the increase in such demand. “The developed countries are using various technological and management measures to reduce the demand for urban water as part of their integrated urban water management strategy (Keane,2011). However, all these measures may not be directly applicable to developing countries. In addition, developing countries may not have access to technologies and skilled labour, as well as the institutional configuration to adequately implement these measures” (Yoyo et al, 2016). In this context, the current study was aimed at developing a water demand management model for the South African water utility. A critical review of tools, techniques and measures of urban water demand management applied in both developed and developing countries has identified prerequisites, prospects and limitations that could be addressed in South Africa for adoption of these measures and techniques (Morton, 2013).

According to the Department of Water Affairs (DWAF), Strategic Overview of the Water Sector in South Africa (2013), “South Africa ranks as the 30th driest country in the world. The country is semi-arid with rainfall ranging from less than 100 mm per year in the west to more than 1500 mm per year in the east. The average rainfall is 450 mm per year, which is well below the world average of 860 mm per year. Climate change forecasts are for a drier western half of the country and for much greater variability with more extreme events in the east" (Department of Water Affairs National Water Resource Strategy 2nd, 2013).

### 1.3 Research Questions

To address the research problem as presented in the previous section, the following research questions were developed:

- **RQ 1:** What are water usage practices in South Africa with regard to the City of Cape Town?
- **RQ 2:** To what extent do consumers have knowledge regarding water pricing policy?
- **RQ 3:** What is the relationship between water saving habits, the demand for water and attitudes towards different water management policies?

### 1.4 Research Goal

The overall research aim of this study should be Measuring factors affecting sustainable water supply in the Province of Western Cape.This will  assist decision makers in the South African water industry regarding the factors  that can save water and also raise awareness of water as a scarce resource.

### 1.5 Research objectives

In order to achieve the research aim of this study, the following research objectives emerged:

- **RO 1:** To determine water usage practices in the city of Cape Town, South Africa,
- **RO 2:** To determine the extent to which consumers have knowledge regarding water pricing policy,
- **RO 3:** Examine the relationship between water saving habits, the demand for water and attitudes towards different water management policies.

### 1.6 Research Methodology

A quantitative methodology was employed in the investigation of specific issues related to water demand, whereas a qualitative approach allowed the researcher to access participants' perceptions, experiences and in reviewing available existing literature. The advantage of qualitative methods use in the context of this study is that, "they increase the depth of understanding; they are flexible and allow the pursuit of new areas of inquiry" (Yin, 2016).

### 1.7 Significance of study

This research has described objectives and constraints that arise for the regulator and / or managers of the resource (s) and hassles analysed their evolution over time. Initially, we sought to develop access to the water public distribution network (whether for drinking water or business); we then studied the objectives of efficiency and / or balanced budget, depending on local situations or requirements of national regulations being met. A systematic study was made of management tools by assessing their effectiveness in achieveing the objectives while respecting the practical constraints of implementation (technical, informational, institutional and social).

In developing countries, sparse literature has developed around three different socio-economic issues. Some authors have been interested in the assessment of the incentive role of the progressive and non-linear tariff system in the management of sustainable demand for water (Suárez-Varela et al 2015; Sahin et al, 2016; Pinto and Marques, 2016). Other authors have proposed social tariffs allowing reconciliation of the social pricing objectives and the financial objective that allows the operator to cover its costs (Rahman, 2017; Dinar et al, 2015). Finally, the rest of the studies focus on either the spatial mismatch between the location of the water source and that of the demand, either to determine the factors affecting the choice of the source of water supply. Indeed, a significant amount of the work has focused on the problem of the choice of the water supply in countries in Africa, Asia, and Latin America. None of these studies has focused closer to home in coming up with a sustainable water demand management model. Hence this study is filling that knowledge gap.



### 1.8 Overview of the study

This examination contains the accompanying seven chapters:

The study is organized into 7 chapters demarcated as follows;

**Chapter 1** provides an orientation to the study, research questions, aim and objectives, definition of key concepts, problem statement, significance, limitations and ethical considerations of this study;

**Chapter 2** will provide a review of the literature of water demand management and other essential variables relating to the study and explains the theoretical framework which guides the structure of the thesis;

**Chapter 3** covers the global water demand management perspective;

**Chapter 4** will introduce the Africa water demand management perspective; covers the South African perspective;

**Chapter 5** will deal with the methodology, the population, the sample and the area of study, the purpose of the study, data collection methods, and techniques of data analysis.

**Chapter 6** will discuss the results, the analysis of the results and the interpretation of the data.

**Chapter 7** presents the conclusions that are drawn from the research results and the conclusions drawn from the literature review. The chapter also provides recommendations as well as suggestions for future research.

### 1.9 Conclusion

This chapter presents the problem statement; research questions which were formulated from the problem statement, research questions, significance of the research, limitations, etc. The study establishes the primary reason for developing a water demand management model for the South African water utility. To investigate the impact of high-water usage and identify the factors that can improve water safety etc. The next chapter will focus on the discussion of the literature review on a water demand management model.

# CHAPTER TWO

# THEORETICAL FRAMEWORK

## 2.1 Introduction

The overall goal of this chapter was to critically review previous studies that were conducted on a water demand management model for the South African water utility over the last two decades in order to position this work within the body of knowledge.

### 2.1.1 Critical assessment of previous studies

To position this study within the body of knowledge on the sustainable water supply, the overall goal of this chapter was to critically review previous studies that were conducted on the significance of sustainable water supply from various authors over the past two decades. This helps in identifying gaps that exist in the current literature.

Kellen (2016) carried out an empirical investigation on the Aliwal North Community under the focus on water demand. Data collected from the respondents and analyzed revealed that water problems were common in the city because of overgrazing. Apart from that, the author also concluded that the government was supposed to embark on campaigns to educate the citizens to ensure that the scarce resource is managed. Lastly, Kellen (2016) proposed that women should be involved in technical projects to save water.



Furthermore, Mthetwa (2017) conducted research that was entitled: 'Evaluating Water Conservation and Water Demand Management in an Industrialized City: A Case Study of the City of uMhlathuze in Richards Bay'. The author concluded that water shortages were a key threat to the economic development of South Africa. Apart from that, the city was seen as inconsistent in implementing strategies to alleviate the problem. Lastly, Mthetwa commented, " wastewater reuse; pipe replacement; water pressure management; rainwater and storm water harvesting; water sensitive urban design; leak detection and repair; joint planning and research team with the Industrial Development Zone; groundwater and aquifer recharge; stakeholder engagement, education and citizen awareness are feasible options for the City of uMhlathuze to consider in relation to water conservation and water demand management." Such a conclusion demonstrated that attending to water problems requires collaborative efforts so as to ensure sustainable use.

Furthermore, Botha and Chetty (2012) carried out research that was entitled: 'is water conservation and water demand management a real option?' According to these authors, “South Africa is amongst the 40 driest counties in the world, with extreme weather conditions and beset by both droughts and floods.”

This means that this national problem has far more devastating effects on the economy at large than it may seem “The WC/SWS strategy consists of a number of components and includes development of anthropogenic aquifers, grey water balancing dams, dirty to grey water treatment plants and lining of surface water dams. For this purpose, the Lonmin Marikana Operations were divided in three specific sub-areas and a baseline water balance simulation model was developed to identify and optimize WC/SWS options” (Botha and Chetty, 2012).

Mthetwa (2017) and Botha and Chetty (2012) and Kellen (2016) therefore have common arguments with regard to the problems of water in the cities. Generally, it can be concluded that these scholars put emphasis on the need to have techniques and polices in place for managing water.

### 2.2 Critical Analysis of Empirical Studies

This section will provide a critical analysis of various empirical studies that have so far been undertaken in the global water demand management sector in order to identify a gap that justifies the conduct of this study.

Dettinger, et al (2011) expressed that California's exceptional atmosphere and developing water requests consolidate to present both water-supply and surge danger difficulties to asset directors. As of late, essential endeavors to completely incorporate the administration of surges and water assets have started, with the purpose of profiting the two segments. California appears here to encounter huge variations in yearly precipitation and stream flow sums with respect to the rest of the US. Such variations for the most part mirror the surprisingly low normal number of wet days out of each year available to collect a large portion of its yearly precipitation sums (going from 5 to 15 days in California). Subsequently, whether only a couple of substantial storms arrive or neglect to land in California can make the difference between a pennant year and a dry season. California gets a portion of the biggest 3-day storm which adds up in the nation, equaling the typhoon belt of the south-eastern US. California's biggest storms are for the most part powered via landfilling environmental waterways (ARs).

The parts of precipitation and stream flow sums at stations over the US that are related with ARs are recorded here, and in California, contribute 20 % to half of the state's precipitation and stream flow. Prospects for long-lead estimations of these parts are introduced. From a meteorological viewpoint, California's water assets and surges appear to come from similar storms to a degree that makes coordinated surge and water assets administration simply more imperative.

Raje, et al (2010) stated that generally few examinations have tended to water administration and adjustment measures, even with charging water unpaid debts to environmental change. The present work ponders the effects of environmental change on a multipurpose repository execution and infers versatile arrangements for conceivable future situations. The strategy created in this work is outlined with a contextual investigation of Hirakud store on the Mahanadi waterway in Orissa, India, or, in other words, repository serving surge control, water system and power age.

Environmental change impacts on yearly hydropower age, and four execution records are examined (dependability for three repository capacities, viz. hydropower, water system and surge control, versatility, helplessness and deficiency proportion as for hydropower). Yields from three general flow models (GCMs) for three situations are each downscaled to storm stream flow in the Mahanadi waterway for two future time cuts, 2045-65 and 2075-95. Expanded water system requests govern bends managed by the expanded requirement for surge stockpiling and downscaled projections of stream flow from the outfit of GCMs and situations are utilized for anticipating future hydrologic situations. It is seen that hydropower age and unwavering quality for hydropower and water systems are going to reduce in the future in many situations (James,2009). The deficiency proportion and defenselessness are possibly going to increase because of environmental change if the standard working arrangement (SOP) utilizing momentum lead bends for surge assurance is utilized. An ideal month to month working arrangement is then determined utilizing stochastic unique programming (SDP) as a versatile strategy for moderating the effects of environmental change on repository tasks (Morton etal,2011).

The goal of this strategy is to boo st reliabilities concerning different supply elements of hydropower, water system and surge control. In variations of this versatile strategy, progressively more weightage is given to the motivation behind amplifying unwavering quality for hydropower for two extraordinary situations. It is seen that by hardly relinquishing dependability regarding water system and surge control, unwavering hydropower quality and age can be expanded for future situations(Roelofse, 2016).

This strategy therefore proposes that supply rules for surge control must be overhauled in bowls where environmental change extends an expanding likelihood of dry spells. Nevertheless, it is also observed that power age can't be reestablished to current levels due to the huge anticipated increases in water system requests. This proposes that future water balance shortfalls may restrain the accomplishment of versatile procedure choices. (Ceaser,) 2010).

Tortajada (2006) expressed that, "water has become an issue of national security for many countries of the globe, Singapore being one of them due to its dependence on imports of water from Malaysia. So as to scale back its dependence on external sources, this city-state has developed and enforced extraordinary economical demand, and provided management practices. Additional to imports of water and land reclamation, this strategy could be a combination of precipitation storage, desalination and extremely refined technology for employment of used water. The research paper indicates that Singapore has with success managed to seek out the proper balances between water amount and water quality considerations; facility and water demand management; public sector and personal sector participation; potency and equity considerations; strategic national interest and economic efficiency; and strengthening internal capacities and reliance on external sources".

Brooks (2006) declared that, "associate operational definition of water demand management is projected with 5 components: (1) reducing the amount or quality of water needed to accomplish a selected task; (2) adjusting the character of the task, thus it may be accomplished with less water or lower quality water; (3) reducing losses in movement from supply through use to disposal; (4) shifting time of use to off-season periods; and (5) increasing the power of the system to control throughout droughts. This definition brings out the drivers of water saving and permits the pursuit of gains by the supply of the saving. It's applicable to nations at totally different stages of economic development. It additionally shows that goals of larger water usage potency are coupled with those of equity, environmental protection and public participation. Taken along, these goals ergest demand management less than a collection of techniques than an idea of governance".

Scott et al (2004) expressed that speedy growth of ground water irrigation has reworked the agricultural economy in regions around the world, resulting in important increases in agricultural productivity and rising incomes. Farmer investment in wells and pumps has driven this growth on the demand side, but the availability of low-cost agricultural energy-usually electrical power is an essential though usually unnoticed driver of the groundwater boom. One serious outcome in various regions around the world has been groundwater overdraft wherever pumping exceeds geological formation recharge.

Water tables have declined, and water quality has deteriorated. Asian and North American nations are two of the most important users of ground water within the world and each faces essential bill of exchange challenges. The two countries are compared, provided that voltage offer and rating are primary driving forces behind groundwater pumping for irrigation in Asian and North American nations alike. Each continent has tried to regulate measures to scale background water bill exchange(Mobay,2010).

However, with low energy prices and promptly accessible connections, there are few money disincentives for farmers to limit pumping. The linkages between energy and irrigation are reviewed, scrutinized and different between Asian and North American nations. Samples of legal, regulative and democratic approaches to groundwater management are assessed. Finally, the implications of linking wattage rating and current groundwater regulation efforts in each country are explored (Panto,2006).

Liu (2009) expressed that, “fast economic process in China has bestowed nice challenges to its water resource managers thanks to a scarceness of water resources, severe pollution, growing domestic and industrial water demands, and necessities for food security. This paper provides a summary of water resources in China and its management.

It describes the key water problems faced by China, because of the institutional, legal and restrictive arrangements in situ to handle these challenges. This includes approaches to water resources allocation and management, pollution management, and water use potency. The paper concludes with a discussion of the priorities and challenges for the water sector, the progress that has been created so far and therefore the enhancements that may be needed to make sure the long-run property use of China's water resources”( Sui,2018).

Tortajada (2006) explains that the “capital of Mexico metropolitan space has twenty million inhabitants, with population densities in some areas exceeding thirteen five hundred persons/km². The supply of water provided and sanitation services in an economical, equitable and timely manner presents formidable management and investment challenges that merely cannot be met underneath the present conditions. This approach has focused almost completely on providing management, whereas demand management practices have received inadequate attention. Unless these management practices are amended radically, future solutions would require higher investment prices to move a lot of water from progressively distant and pricey sources. This will occur together with serious adverse economic, social and environmental impacts on the mercantilism regions and better land subsidence rates in ZMCM and will be thanks to ever increasing ground water withdrawals, among several other factors. It is thus essential to formulate a long run integrated management setup that doesn’t exist at present and which considers linkages to policies on urban development (an issue essentially neglected so far) migration, industry, energy, public health and surroundings. It’s not an easy task but a vital one.

Hoque et al (2013) declared that, "urban water tariffs vary across cities and regions for reasons that mirror water deficiency conditions, native or regional objectives and political concerns. Comparisons of water average costs across regions aren't usually meet substantial, because the costs aren't weighted or adjusted to account for variations in socio-economic conditions. To the present, the domestic and non-domestic water and sewer water tariffs in sixty cities across forty-three countries were examined. The non-weighted average per unit domestic water and sewer water bills within the cities thought-about was USD a pair of10/m³. The typical per unit bills in Asia and Africa were usually under those in western Europe, north America and Australia.

On average, households pay regarding 1.5% of their monthly incomes on water and sewer water bills. In Asia and Africa, however, the typical unit bills for the non-domestic sector were above those for the domestic sector, suggesting cross-subsidy. The study conjointly analysed the elements of a metered tariff schedule with relation to the goals of value recovery, demand management and affordability. The article conjointly discusses the effectiveness of existing tariffs in addressing native challenges within the context of water rating examples from Singapore and Manila.

Islam et al (2011) stated that, "loss of water due to leakage is a common phenomenon observed practically in all water distribution systems (WDS). However, the outflow volumes are often reduced considerably if the incidence of outflow is detected at intervals' lowest time when it happens. This paper proposes a completely unique methodology to observe and diagnose outflow in WDS. Within the projected methodology, a fuzzy-based algorithmic program has been used that comes with varied uncertainties into totally different WDS parameters like roughness, nodal demands and water reservoir levels. To demonstrate the effectiveness of the project methodology, little distribution network was investigated that showed encouraging results.

Jacobs, et al (2004) said that, "the structure and information needs of an end-use model for residential water demand and flow are bestowed during a companion paper. This paper focuses on the sensible application of the model. The model is initially applied to verify some normally ascertained water demand patterns. These include seasonal variation in demand, the direct correlation between average annual daily water demand and stand size, and therefore the increase in water demand, quandary demand and waste material flow with a rise in management size. The convergence between the expected model results and severally ascertained values by others encourages sensible use of the model. Secondly, the consequences of some specific water demand management measures are evaluated by adjusting elite model parameters. The measures embody xeriscaping, the installation of dual-flush bogs and low-flow showerheads, pool possession and pool cowl use. The model also provides a speedy suggestion to get initial estimates of the doubtless effects of various water demand management measures".

Stephenson (1999) declared that, "demand management is another exaggerated installation to satisfy growing demand. Management of water usage will be established by the provider or the patron. The provider will use physical ways to limit offer or economic, and also, the shopper will alter his approach of living either voluntarily or struggling by the provider. The classical supply-and-demand curves are applied to installation, considering additionally the results of metering, and marginal vs. average cost accounting".

Horne(2013) expressed that, "this paper focuses on the employment of 3 economic approaches to water management in Australia which will increase the potency of water use and water security, providing a positive stimulus to property and economic growth: the institution of water markets and water pricing, government spending, and also the adoption of legislation and economic rules promoting the event of water markets. Australia is well down the reform path, however has to complete implementation. Australia's challenge has relevancy to several countries scuffling with demand and water imbalances, and also the import of declining environmental outcomes in rural areas and protracted water shortages in urban areas".



Araral (2013) declared that, "this paper reviews the literature on urban water demand management and compares practices in South-East Asia. Existing literature is generally from developed economies and is concerned principally with impulsive studies, that don't seem to be relevant to developing countries and as a result their main downside is non-revenue water. Cities in South-East Asia use worth and non-price mechanisms to control demand. Worth mechanisms embrace increasing block tariffs, fixed, volumetric, raw water, and conservancy charges, rebates, cross-subsidies and periodic rebasing. Non-price mechanisms like management, engineering and regulative mechanisms as well as public education and community involvement play necessary roles. A lot of studies are required to ascertain their effectiveness and cost-effectiveness".

Meyer, et al (2014) declared that, "the Waterloo ground has been a drinkable supply for the individuals of Waterloo Region for over a century, and as such, it's been the topic of diverse earth science and hydro geologic studies for over five decades. Two of the companion papers during this special issue describe severally the evolution of the hydrogeological conceptualization of the ground sediments and also the history of modelling of the groundwater flow system. This paper builds on those findings and describes the events and activity of a three-dimensional finite-element groundwater flow model. A key facet within the development was the implementation of a special geodatabase that links the abstract hydrogeological framework with the numerical groundwater flow model.

The model supported a close characterization of the groundwater and surface water systems to obtainable information beneath average (steady-state) and variable (transient) pumping and climate conditions. “Following model development and activity, the model was adapted to conduct a close water budget and risk assessment study that compared groundwater demands to obtainable results. Many eventualities involving future municipal water demands and potential reductions in groundwater recharge because of planned land-use development were simulated. This resulted in the conclusion that the projected municipal water demand to 2031 will be equipped by the present system of wells while not inflicting a big reduction in ground water discharge to ecologically sensitive streams and wetlands(Dwarf,2011). The model was conjointly applied to delianate the capture zone for a well field within the region beneath conditions of uncertainty, demonstrating a technique that might be applied to different well fields. The model provides a well-organized and efficient tool for regional water manager for long property management of the ground water resources of the waterloo ground (Meyer, et al,2014).

(Bichai et al,(2015) states that innovative analytical tools are required to handle advanced property challenges in securing water for water-stressed, developing cities worldwide. Melbourne's different Water Atlas may be a special analytical model that integrates broad knowledge to gauge the cost-effectiveness of other provider choices and their environmental and social advantages. This study presents the methodology used within the Atlas model to gauge provider choices from four sources (rainwater, storm water, centralized waste utilisation, sub-urbanised recycling) to satisfy the long water demand for a spread of non-drinking uses in Melbourne. The results of the Atlas analysis highlight preferred choices at the native scale with regard to multiple criteria, so as to guide strategic decision-making. Site-specificity and exchangeability of the Atlas approach are mentioned. The Atlas approach will function as a basis for different international locations to make a regionally custom-made analytical framework to gauge the potential of other water security”

(Lee et al 2016) state that, “NEWater, Singapore's saved water, has enabled Singapore to sustainably meet its growing water demand, despite restricted land for water construction and storage. Whereas technology provided an answer to this water use, sturdy politics, sensible governance and effective public engagement were key to Singapore's success in activity NEWater for indirect portable use and direct non-portable use. A multiple-barrier method together with dual-membrane filtration and UV medical aid, complemented by a strict operational philosophy and comprehensive water quality management programme, ensures reliable delivery of good-quality NEWater when the provision capability expands".

Sanders, et al (2010) stated that, "geography knowledge is progressively offered at high resolutions (<10 m) over massive special extents to support careful flood inundation modelling and loss estimation analyses needed for flood risk management. This paper describes ParBreZo, the parallel implementation of a two-dimensional Godunov-type, shallow-water code, to handle the machine demand of high-resolution flood modeling at the regional scale [10(2)-10(4) km (2)].

A scientific approach to unstructured grid partitioning (domain decomposition) is conferred, and also the Single method Multiple knowledge (SPMD) paradigm of distributed-memory similarity is enforced, therefore the code is often dead on PC clusters with distributed memory, shared memory, or some combination of the two (now common with multi-core architectures). In an exceedingly fully wetted, load-balanced taking a look at drawback, the code scales o.k. with a parallel potency of nearly one thousandth on up to 512 processes (maximum tested)". Thus, a "weighted grid partitioning is employed to partly address the load equalization challenge displayed by partly wetted domains related to flooding applications, wherever the flood extent varies over time, whereas the partitioning remains static. Associate in nursing urban dam-break flood take a look at drawback shows that weighted partitions bring home the bacon a parallel potency surpassing seventieth consumption to forty-eight processes(Tammy-more, 2010).

This corresponds to a ninety-seven reductions in execution time, therefore results are obtained in an exceedingly matter of minutes, that is engaging for routine engineering analyses. A cyclone storm surge takes a look at drawback shows that a ten resolution, twelve inundation forecast for a forty kilometre length of lineation are often completed in underneath two exploitation 512 processors. Hence, if coupled with a cyclone forecast system capable of partitioning storm surge, inundation forecasts may be created at ten resolution with a minimum of a ten interval" (Sanders, et al, 2010).

Scott, et al (2004) declared that, “fast enlargement of groundwater irrigation has remodelled the agricultural economy in regions round the world, resulting in vital increase in agricultural productivity and rising incomes. Farmer investment in wells and pumps has driven this enlargement on the demand side; but the availability of low-cost agricultural energy-usually electrical power-is a crucial thought typically driven of the groundwater boom. One serious outcome in various regions round the world has been groundwater overdraft; wherever pumping exceeds geological formation recharge, water tables have declined, and water quality has deteriorated.

Bharat and North American countries are two of the biggest users of groundwater within the world and each faces crucial draft challenges”. “The 2 countries are compared, as long as power offer and valuation are primary driving forces behind groundwater pumping for irrigation in Bharat and North American countries. Each country has tried regulative measures to cut back groundwater draft (Kewel,2016). However, with low energy prices and without delay offered connections, there are few monetary disincentives for farmers to limit pumping. The linkages between energy and irrigation are reviewed, scrutiny and contrastive Bharat and North American country. Samples of legal, regulative and democratic approaches to groundwater management are assessed. Finally, the implications of linking electric power valuation and provide current groundwater regulation efforts in each country is explored” (Scott, et al, 2004).



Horne (2016) states that water security in Australia’s major cities are higher, reflecting partly recent policy interventions. Vital indirect portable water utilization comes completed however, no direct portable utilization projects were undertaken, and none looks possible within the close future. Government have a lot to find out from choices to make very massive desalination and employment plants.

Van der Laan, et al (2012) declared that, “proper cultivation of crops beneath irrigation needs water of acceptable quality, particularly with regard to salinity and solicit. Agriculture will impact negatively on water quality, typically through the export of nutrients (particularly chemical element (N) and phosphorus (P)) from the basis zone, leading to eutrophication of surface water and pollution of groundwater. Sugarcane is the major irrigated crop with regards to space cultivated within the Komati-Lomati and Pongola watercourse catchments. Increasing demand for and use of water resources in these catchments has light-emitting diode to considerations regarding deterioration in water quality. During this study, chemical water quality information obtained from department of water affairs and forestry was accustomed assess the standard of water course within top catchments.

Irrigators set further downstream can thus typically pay a lot of attention to the standard of their irrigation water and on-farm salinity management. For the lower elements of the Komati-Lomati and Pongola watercourse catchments, hazards thanks to solicit would like attention. Apparently, acidifying effects of mine water emptying are probably being countered by high salt input from agricultural come back flow. Nutrient enrichment was evident at several of the watercourse sampling points.

**2.3 Water demand**

(Tyron et al,2013) state that the demand for water is highly diversified: some applicants consume water; others use it as a living environment or leisure support. Some people consume water. However, many other economic users value physico-chemical characteristics of water in its environment without consuming it: sometimes without modifying its environment (tourist activities); other times by arranging its circulation (sea freight, cooling of nuclear power plant); sometimes by subtracting it very temporarily from its natural context (hydro-electricity); others by altering its characteristics (self-cleaning capacities of the environments for the stations treatment) (Cominola et al, 2015). Finally, some requests refer to non-explicitly economic uses: maintenance of the viability of hydro-systems, landscape quality, leisure activities. These uses in multiple interactions on different characteristic parameters of water and ecosystems associates is one of the factors of complexity of their management, even when we focus on the management only "consumers" of water. In this last category,It can also be distinguished (Tyron et al, 2013)



**Current economic users** who are identifiable by their measurable water needs. They can at least accept the introduction of management tools to spread this resource, if the latter proves to be insufficient to satisfy all of their need (Tyron et al, 2013)

**Future economic users.** The water can thus be in sufficient quantity to satisfy the current uses, but not for future uses by user's already present or new users. This is the case for underground resources and, to a lesser extent, for surface resources (a dam that may take several years to fill) (Mouratiadou et al, 2016).

To carry out an ex-ante evaluation of the effectiveness of economic management instruments for water, economists are led to make assumptions about demand functions of different users. Unlike many theoretical works, most of my work researches on economic instruments are based on demand functions calibrated on study grounds (Quesnel et al 2017). The methodological approaches that I mobilize thus seek to render an account of the heterogeneity of users, both in business and in the field of water consumption.

In South Africa, due to the scarcity of water resources, the supply becomes unable to satisfy the galloping demand. This scarcity, linked to a rainfall deficit, is accentuated by a rapid growth in demand as a result of economic, urban and population since the country became independent in 1994. In this context, several solutions appear (Martin, 2005). However, the use of other resources, such as desalination of seawater and water purification is limited. Indeed, these non-conventional resources are characterized by a higher mobilization cost than the usual natural resources. The South Africa economy, which is still emerging, could therefore be handicapped by the negative consequences of this sharp increase in the cost of mobilization and water supply (Clifford et al, 2018).

The main sustainable alternative lies in the control of demand. This alternative saves time before resorting to conventional non-resource mobilization. One of the tools of water demand management is economic; it is that of the incentive pricing of drinking water(Almas, 2016). Systems or tariff modes best suited for water demand management, their role in curbing the growth of water demand and the results of this method of pricing in terms of resource conservation are issues that have been the focus of much socioeconomic empirical research in water economics. Progressive pricing, adopted by the majority of countries, can be an effective tool for managing water demand in the long-term to ensure that it can best reconcile its social, financial and economic objectives. Dinar and Subramanian (1998), in a study of 22 countries, have shown that the fixed part of the progressive tariff varies considerably between countries while the variable part or the variable price per m3, which increases according to volume consumed, is similar in the 22 countries(Arlosorof, 1998). Moreover, the authors show that in developing countries, the authorities define the price of water according to the average cost of supply and not marginal cost. Dinar and Subramanian (1998) recommend the reform of the tariff system in these countries in order to reconcile social and economic aspects of price policy. The authors recommend pricing based on the marginal cost of supply(Kinyenje, 2013.

In developed countries, several studies have been undertaken, since that of Gottlieb (1963), for the cases of the United States, Canada, France, Germany, Spain, Italy, Australia, and Cyprus. Estimating residential water demand in countries has been the subject of vast literature in published articles such as than those of Arbuès et al (2003), Dalhuisen et al. (2003) and Worthington and Hoffman (2008). The purpose of these studies is to determine price and income elasticities of water demand on the basis of aggregated or individual data by adopting an estimation methodology. The double-log form, which expresses the water consumption according to the price, consumer income and control variables, is often retained in the measure, where it makes it possible to interpret the estimated parameters as elasticities. Authors generally use estimates by OLS or instrumental variables. Researchers point out that the traditional empirical methodology that manifests itself in estimating the demand function of water in the linear form requires the stationary character of the data(Kings,2017).

**2.5 Background to water resources management**

The hydrological cycle is variable by nature and distributes water on the planet independent of human will (Lundqvist & Gleick 1997). Water, however is essential for human life. For thousands of years humans ingeniously secured their water either building settlements near water or by channeling, redirecting, transferring, transporting or demanding it (World Humanity Action Trust 2000).Solution seeking for the balancing of tensions between natural water availability and the human demand for water is commonly referred to as Water Resources Management (WRM) (Koch 2001). In the period of industrialization, WRM was led by perceptions that water is a basic human requirement that must be met with the help of supply augmentation (Tate n.d 1992). This is the development of new supplies and structures such as large dams, water diversions, central water supply and wastewater supply treatment works to manipulate available water supplies (van der Merwe 2000).The objective was to support increasing levels of development, boost food production and to improve human health by providing basic water to humankind (Lundqvist & Gleick, 1997).Water source planning, development, control and distribution was typically done through institutions that opened much like public work industries, delivering required amounts of water to people and industries at subsidized rates(Vickers 1991).The supply oriented approach was introduced to the developing world only in the second half of the century as means of promoting development, food sufficiency and the provision for basic human needs(Allan 2001).

The 1970s marked the rising concern of the environment and concern for sustainable use of natural resources (Furgie & Rabie, 1998). Environmentalists contend that supply schemes, such as dams disrupt the ecological functioning in the constructed area and downstream, endangering riverine species, disrupting the transportation of fertile silt and flooding large parts of fertile land(Davies & Day 1998).The over abstraction has to led to a lowering of groundwater tables, resulting in drying of groundwater dependent vegetation. At times, over abstraction led to the complete drying up of aquafers (Heyns et al. 1998). The supply oriented approaches have neglected and ignored the basic environmental and ecological water requirements, as well as the fact that water is a finite resource (Lundqvist & Gleick 1997).

Despite the objective of providing access to water for all by the 1980s, the supply-oriented approaches fell short of providing water for 20% of the world`s population by the 1990s (Lundqvist & Gleick, 1997). Furthermore, they ignored the fact that large water supply schemes such as dam transfer schemes restrict the access to safe water for downstream users. The supply schemes also brought with it the relocation of people living in the areas of development. The Three Georges Dam Project in the Republic of China displaced more than one million people when it was completed in 2012. Supply oriented solutions are thus questioned in terms of their social benefit (Awal,2012).

The construction of initial supply schemes was relatively easy with an available choice of sites at which water resources could be harnessed. With time, the more conventional supply opportunities were exploited, and more ingenious and inexpensive ways had to be found to supply further water resources, for example: desalination plants and large-scale transfer schemes, transporting water over vast distances (Awal, 2012). The costs for such supply schemes are increasing daily due to market changes and very high interest rates, making economists question their financial variability (Tate et al, 2016)).

A further criticism is the lack of appreciation of economic value of water, resulting in inefficient water consumption. Since water was perceived as a free good, it was delivered to consumers at subsidized rates without involving consumers in the management or decision-making process (Global Water Partnership 2000). In 1995 and 1996 the water supply to most Namibian towns were heavily subsidized by government. The actual cost (N$/m3) was between two to six times higher than the water tariff, such as Windhoek (actual cost N$2.77/m3 to a tariff of N$ 7.07/m3) (Jacobson et al. 1995). Lack of responsibility and the subsidization of water services had led to an irresponsible public attitude towards water that lacks recognition for the true value of water as a scarce resource (Turton, 1999). Furthermore, the lack of recognition for the economic value of water has led to water allocations for the production of goods, without considering economic value in relation to their water input. The view that all countries should be responsible for their own food production has promoted water allocation for irrigated agriculture, typically producing low value, water intensive goods (Lundqvist & Gleick, 1997). Arid countries particularly cannot meet all their demands and as a result, unrecognized water cannot be reallocated to sectors in which goods with a higher value per unit of water input are produced (Lundqvist & Gleick, 1997).

Over the past two decades, water sector specialists have come to agree that the traditional supply-oriented approach of water resources management is not the solution to long term environmental sustainability, social equality and economic efficiency. Supply oriented approaches were responsible for overusing water resources, overcapitalization, resource wastage and a distorted public perception on the value of water. This realization has resulted in a common vision to take a more sustainable approach to water management, namely one that involves water demand management (Lundqvist & Gleick, 1997).

### 2.5.1 Sustainable water supply

SWS is a new concept that originated in the 1970s (Vickers, 1991) and is still in the process of evolving. The literature related to SWS is still fragmented which makes it difficult to define accurately. Winpenny (1994) tried to define it as a strategy seeking to improve the efficiency of existing water supplies by reducing demand in order to delay the development of new supplies. He lists a selection of methods to achieve the objective. They include awareness in raising efficient technology, economic instruments and legislation.

Winpenny (1994) probably provides the suitable explanation for the difficulty of clarifying SWS. He notes that the water sector typically distinguishes between the appropriate unit for analysis of problems and that for implementing solutions. The analysis of problems is done through academic debates around the aims and principles behind SWS. However, the practical solutions are sought in a decentralized fashion, subject to specific conditions, which can vary according to institutional capacities, human resources, cultural settings and the scale of implementation.

The aims and principles of SWSare embedded in the debate around sustainable water resources management, while the methods of SWS and their individual effects are found in a wide array of economic, educational, engineering, gardening and plumbing journals and manuals. Notably absent in the literature are theoretical models and guidelines on how to implement a complete SWS strategy(Dwarf, 2016).

Tate (1989) defined water demand management as “any socially beneficial measure which reduces or reschedules average or peak water withdrawals or consumptive use from surface or groundwater while maintaining or mitigating the extent to which return flows are degraded”. Apart from that, Brooks (2006) posed that, “water demand management comprises of five key facets: (1) Adjust the nature of the task or the process it is undertaking so that it can be accomplished with less water or with lower quality water; (2) Reduce the quantity or quality of water required to achieve a specific task; (3) Reduce the loss in quantity or quality of water as it flows from source through conveyance systems and use to final disposal; (4) Shift the timing of use from peak to off-peak periods; and (5) increase the ability of a water system to continue to serve society during times when water is in short supply”. All these definitions were made use of in this empirical study.

### 2.5.2 Demand management

The concept 'demand management' originated in the 1970s in the electricity sector, in response to the spiraling cost of energy due to the oil crisis (Vickers, 1991). Since then it has been adopted in other industries which provide natural resources for public use, including water and gas industries (White & Fane, 2001). The aim of demand management is to improve the efficiency of resources use (Vickers, 1991). "Demand management is based on the notion that demand for a resource such as water is not demand for the resource itself, but rather for the service that the resource provides" (White & Fane, 2001). In this context, demand is regarded primarily as an economic good, and its aim is to reduce the amount/volume of a resource used per unit of output (Winpenny, 1994).

### 2.5.3 Social equality issues

There is debate around the implications of changing water from a social resource to an economic good. This is because it is felt by some that social equity is at stake when charging people, the full price for water they consume. They argue that the poor will be unable to access water (Allan, 2001).

Supporters of SWS argue that the basic human needs are taken into account by recognizing the 'need' and 'want' for water. The 'want' for water presents the request for services that the use of the resources provides (Lundqvist & Gleick, 1997). When managing water demand, water use efficiency is improved by reducing the volume of water per unit of output without imposing on the required volume of needed water. Water utilities, once they gain financial independence by charging consumers, are maintained by having the availability of cross-subsidies from the relatively wealthy to the poor, thus meeting basic water needs. The idea of cross-subsidies is argued to be of special importance for developing countries, where large groups typically lack access to water, while other groups have unrestricted access to cheap water. Demand management is contented to improve water efficiency and to make the 'freed' amount of water as well as the generated profits from water sales available to speed up the process of service delivery and access for all. Thus, it is argued that demand management supports equity and social development (Lundqvist & Gleick, 1997).

### 2.5.4 Benefits of SWS over supply-oriented solutions

By reducing water consumption, SWS provides an equivalent share outcome to supply argumentation while avoiding its negative environmental, economic and social implications (van der Merwe, 2000).It promotes the sustainable use of finite water resources by reducing water abstractions from groundwater and surface water resources (Lundqvist & Gleick, 1997). SWS further reduces the impact on ecosystems by delaying the construction of environmentally damaging supply schemes (such as dams) and by reducing water abstractions, leaving essential water reserves needed for ecosystems to function (Davies & Day, 1998).Decreased water consumption through SWS furthermore reduces the negative social impacts associated with the development of supply schemes (Davies & Day, 1998).

SWS implementation costs are generally less than the construction of supply schemes (Vickers & Markus, 1992). For example, a study undertaken in the Vaal River Area (South Africa) evaluated the anticipated savings incurred by reducing water consumption by 10% (with the help of SWS), thus delaying the construction of the next supply scheme. The results indicated a delay in construction by six years and cost savings amounting to U$1 000 million over the period (Radermeyer, van Rooyen & Mckenzie, 1997). SWS is economically more viable than water supply solutions, since it reduces the investment costs per unit of water. Furthermore, it reduces the cost of pumping and wastewater treatment due to a reduced consumption volume (Vickers & Markus 1992).

In the context of sustainable development, SWS appears ideal to promote sustainable water resources management however, SWS can however not be seen as the single solution to meet the WRM challenges of today (World Humanity Action Trust, 2000). It is still hoped that internationally there will be growing recognition of SWS as a complementary tool to supply argumentation. With growing support, it is anticipated that SWS will be increasingly considered as the first option in the modification, curtailing and management of water demand until further supply argumentation can no longer be postponed (Alderin, (2014).

### 2.5.5 Sustainable water supply strategy

SWS is repeatedly defined as a strategy, including policies and initiatives to achieve efficient water consumption (Winpenny, 1994; Republic of Namibia 2000). There however is little theoretical literature available about planning, design, content and implementation of SWS strategies. Turton (2002) states that authorities and decision-makers have to implement SWS without being led by any widely acceptable model based on sound theory and empirical evidence, simply because the theory development on SWS is lagging. There is a selection of case studies that describe situations, applied methods and measured effects. One such case is presented later in this chapter (section 2.4).

What the literature does provide is a list of approaches that all have potential to improve water use efficiency. They can be broadly categorized into economic, educational, regulatory and technological approaches (dealt with in section 2.3.1). It is typical for SWS strategy to apply a combination of these approaches to the site-specific solution in order to incur maximum water-use efficiency (Winpeeny, 1994; Lundqvist & Gleick 1997; Davies & Day, 1998).

The literature does not clearly state who should be responsible for SWS strategy. However, it is argued in some papers that SWS, as a complementary tool to supply argumentation, should be planned, designed and implemented by the same functional organizations that have always been responsible for policy-making, water allocation, and water management and monitoring of users (Department of Water Affairs and Forestry 1999; Tate n.d.). Since SWS focuses on reducing the water demand of consumers, one can reason that the latter also plays an important role as stakeholders in a SWS strategy (Department of Water Affairs and Forestry, 1999).

The scale of a SWS strategy is situation specific. It can be national, regional, for a catchment area, an industrial sector, a town or organization or even household (Department of Water Affairs and Forestry, 1999).

## 2.6 Objectives of water demand management

Different objectives are pursued in terms of resource management (Aftab et al., 2010). These can encompass an efficient allocation of the resource to maximize community well-being, an allocation that allows everyone access ("access to water for all"), a balanced budget of the managers ("water pays for water"). However, these objectives must be achieved by taking into account different constraints. The two main ones are the acceptability of the instruments and their possibility implementation technique. The objectives differ from the constraints by the fact that an objective calls for the establishment of an instrument to be achieved, while constraints only give the framework which can register the imaginable instruments (Postel, 2014).

Water challenges continuously affect the lives of human beings. Apart from that, the wildlife also depends on the same water. The use of water is not only limited to domestic use. It is evident that a lot of economies use water to generate power through hydro-electric plants though such investment is very expensive. Since water is a basic need for human survival, the acute shortages of it exerts pressure on the government since it is the duty of the government through the local government to ensure that water and sanitation services are provided for a healthy community. Apart from that, water is essential for other recreational activities which if it is tourism related helps to bring foreign currency (Postel, 2014).

Xiao (2017: 24) postulated that, “The need for water for a specified purpose is commonly referred to as water *demand* or water-*use*.” Therefore, these terms will be used also in this empirical study interchangeably. Furthermore, Xiao (2017) posted that, “water use can be categorized. For example, according to the purpose of water use, there are residential, commercial, industrial, agricultural, hydropower, recreational, and environmental uses. Depending on their impacts on hydrologic cycle, water uses are classified into two main categories: consumptive and non-consumptive uses. Consumptive use refers to “water that is unavailable for reuse in the basin from which it was extracted due to evaporation, incorporation into plant biomass, transfer to another basin, seepage to a saline sink, or contamination” (Gleick et al., 2014). From these sentiments it is therefore clear that water has various uses and its shortages have serious effects on all the different users. There can be consumptive and non-consumptive users of water and the table below summarizes this idea.

Table 2.2: Hierarchical classification of water uses.

| Water uses | | | Objective |
|---|---|---|---|
| Urban uses | Municipal uses (C) | Domestic | Use for cooking, washing, watering lawns, and air conditioning |
| | | Public | Use in public facilities and for firefighting |
| | | Commercial | Use in shopping centres, hotels, and laundries |
| | | Small industries | Use for industrial production |
| | | Conveyance loss | — |
| | Industrial uses(C) | | Use for large water-using industries such as steel, paper, chemicals, textiles and petroleum refining |
| | Water dilution (NC) | | Serve as the source for self-purification of the water |

| | | |
|---|---|---|
| Agricultural uses(C) | Irrigation | Used for raising crops |
| | Factory farm uses | Used for livestock |
| | Conveyance losses and waste | — |
| Hydropower use (NC) | Hydropower generation | Produce hydropower |
| Navigation uses (NC) | River regulation | Water release from upstream reservoirs to raise water depth |
| | Lock-and-dam | Increase water depth for navigation through ship locks and dams |
| | Artificial canalization | Use for artificially constructed channels with a number of ship locks |
| Other uses | Flood storage (NC) | Control floods |
| | Recreation (NC) | Provide a place for swimming, fishing and other recreational activities |
| | Water export(C) | Large diversion and export for commercial purposes |
| | Ecological uses(C&NC) | Conservation of endangered aquatic life, use for forestry, filling wetlands, etc. |

Key: C: Consumptive use; NC: Non-Consumptive use.

The above table shows that in urban places, the municipalities have the role or oversight of water provision. This may also include other sanitation services, and as such, the water is used for different purposes as is shown and as was explained earlier.

Water demand management is seen as a good way to achieve the sustainable development of water resources (Tate, 1989; Gleick, 2003a; Brooks, 2006; Butler and Memon, 2006). Apart from that, it is believed that a lot of water conflicts are a result of the imbalance between water supply and water demand (Wolf, 2002; Gleick & Heberger, 2014). If this continues unmonitored it may worsen and a lot of lives will be affected.

## 2.7 Sustainable water supply policies in urban areas.

Developing and developed countries face growing problems in providing water services. As a human right, Gleick (2000) prescribes that, “Legislatures have to consider efficient water allocation among users for sustainability. Thus, developing economies still attempt to achieve MDGs that add pressure to expanding urban water supply. Many urban areas face water stresses that will oblige extension of water supply and dissemination facilities. Moreover, they only have the choice to expand supply through adding new water resources. Water sources such as seawater, profound aquifers and polluted surface water are frequently accessible for domestic use when there is enough money to invest in their extraction, treatment and distribution”. Current examples include:

- Beijing must transport water more than 1,000 km from the city.
- Riyadh, in Saudi Arabia, along with Mexico City, will soon be forced to pump water to a depth of 2,000 meters.
- In Amman, Jordan, the incremental average cost of groundwater supplies increased from R5.97 to R14.37per cubic meter, while groundwater resources decreased.

“Increasing demand may require more costly supply-side solutions and, perhaps, a reluctance or incapability to pay for those solutions (Baumann et al., 1998). So, in the short term, water shortage may be mitigated through expensive supply-side solutions. These are not suitable in the long term for semi-arid and landlocked countries such as Zimbabwe or Botswana. Typically, the rate of renewal is much slower than surface water. China and India are seeing growth limited by reduced water supplies from depleted groundwater and shrinking glaciers that sustain key rivers” (Sorensen et al., 2016).

In “Urban regions which face water dearth or stressed places it may be necessary to augment supply methods through constructing dams and building desalination and reusing plants” (Sorensen et al, 2016). The next segment or discussion will be based on the dam construction.

## 2.8 Dam Construction

Dams play a pivotal role in water conservation. However, their construction is often associated with high costs from a financial perspective. Apart from that, dams are seen to be useful also for supporting the irrigation and fisheries which may be useful for some income generating projects. The increase in these projects will ensure that poverty alleviation takes its course, since the local community will have access to self-help projects. Dams are seen as advantageous for water harvesting and they reduce floods in some areas though if they are not well built, they may collapse (Zarfl et al, 2015). The desalination of plant construction is going to be discussed below.

### 2.9 Construction of Desalination Plants

Desalination plants are very expensive to set up and they require expertise. “The production capacity of such plants globally was 44.1million m3/d in 2007 with a doubled prediction by 2015. The largest producer of desalinated water in Gulf countries produces 19.4 m3/d, which is 25% of worldwide seawater desalination capacity”. The use of such plants can be seen as a lasting panacea to cities facing severe water challenges (Scarborough et al., 2015).

### 2.10 Lesson learned

Although there are some constructive spaces where politicians and technocrats engage, during the Cape Town drought it became clear that there were tensions around this engagement that undermined trust. Some technical experts found it hard to get their points across to politicians and some politicians found it hard to understand the technical issues holistically. Strengthening the engagement and understanding between the two groups is important for ensuring that drought-related responses address citizens’ concerns as well as technical, resource and institutional imperatives and constraints. Support is needed to help technical officials to communicate better and to understand the political dynamics better. The important lessons are as follows: Develop a water sensitive city vision and plan for implementation, integrate climate change into water planning, Strengthen capacity for engagement between politicians and officials.



### 2.11 Conclusion

In this chapter, the Western Cape drought has been described, interrogated and carefully probed. The ‘messy’ realities of what the drought exposed are useful to interrogate. Outsiders have been quick to voice their opinions on what the Provinceshould have done, including listening to earlier warnings about climate change and putting in place various measures. What has emerged through this paper are, however, the need for a more nuanced and holistic response that recognizes the role of people, partnerships, leadership and the holistic water system. This is not a story that describes the Province of Western Capeas having adapted well to such challenges. Rather, there are parts that show the competence and capacity in some regards as well as the challenges and gaps in other regards**.**

# CHAPTER THREE

## Sustainable Water Supply Strategy From Global Perspective

### 3.1 Introduction

Sustainable development, originally introduced in the Brundtland report (1997) at the Earth Summit, is described as, “a development that strives to meet the needs of present generations without compromising the ability of future generations to meet theirs”. The management and control of water resources are issues, policies and strategies that are extremely important for the growth and development of all nations.The objective is to determine water usage practices in the city of Cape Town, South Africa, to determine the extent to which consumers have knowledge regarding water pricing policy, and also examine the relationship between water saving habits, the demand for water and attitudes towards different water management policies.

### 3.2 Overview of the global water industry

Water is a scarce resource, precious and unequally distributed in space, both at a national and global scale. Spatially, the water is distributed very unequally on the planet. Only six countries such as, “Brazil, Russia, Canada, Indonesia, China and Colombia” consume half of the world's drinking water reserve. To East and North Africa water has become a determining factor in development. Indeed, in this Pregion, the population growth rate is estimated at 2.8%. According to UNDP (1998), the overall growth rate of urban areas of developing countries was estimated at 2.9% for the period 1995 to 2015 (Alcamo et al, 2017).

On the other hand, renewable freshwater resources which should meet the needs have fallen from an average of 3000 m3 per year per inhabitant in 1960 to 1000 m3 per year in 1996. They should reach the level of the most serious shortage in 2025 or 700 m3 per year and per capita. Countries like India, Sudan, Chad and Germany are under relatively less severe water stress. In Asia, several countries are below the threshold of 500 m3 / year / inhabitant. Among these countries Tunisia has a renewable freshwater endowment of 434 m3 / year / inhabitant, the Jordan has an allocation of 148 m3 / year / inhabitant, and Yemen has a water endowment of 241 m3 / year / inhabitant. Below the threshold of 1000 m3 / year / inhabitant, countries suffer presumably a severe water shortage (Alcamo et al, 2017).

### 3.3 Trends in Global Sustainable Water Supply

In theory and in practice, natural resource management policies are evolving to define the best strategy for politicians and decision-makers. Current hydrological politics, which is based on increasing the supply of water to meet the growing demand, has ended in failure. Since then, a reflection has developed in all scientific disciplines to solve the problem of sustainable water management(Moonsar,2018). Economics is part of this debate, and the water economy has emerged as a new discipline that tries to study the problem of water management. The world is changing and renewable resources have become increasingly scarce due to poorly managed intensive use. In addition, the global management strategy regarding water has moved towards the definition of water as a social and economic goods and towards the need to build a new model of water allocation, based on the demand management (Kummu et al, 2016).

In September 2000, the UN set the Millennium Development Goals in insisting very clearly on the issue of access to water. The goal was by 2015 to reduce by half the %age of the population that does not have sustainable access to a provision of safe water for drinking as well as basic sanitation services. Thus, access to water is considered a fundamental issue for the millennium (GPW,1996).

### 3.4 The demand for drinking water in developed and developing countries development: specific issues

Water is at the base of all sustainable socio-economic development. It could constitute the next shock of the 21st century, like the oil crisis. On the one hand, according to projections by the World Meteorological Organization (WMO), two-thirds of the World population will be under stress or water stress by 2025. On the other hand, because of economic development and the urbanization that accompanies it, needs have increased twice as fast as the world population which will grow by 60% by the middle of the next century. The limited supply is therefore on the verge of no longer satisfying demand. One can even fear future wars over water (Kummu et al, 2016).

Political tensions and the risks of military conflict are therefore likely to be aggravated by tensions over water resources. Among the conflicts that are looming in the horizon, we can mention those between China and India, with projects to capture waters of the Brahmaputra, or between Egypt and Ethiopia with construction of the Ennahdha dam by Ethiopia, or the Israeli-Palestinian conflict and the sharing of West Bank. In order to address these risks of conflict, the international community should promote cooperative actions in the exploitation and equitable sharing of the water. This could purge political tensions and make water a factor of cooperation in through the establishment of what is now called a " Hydrodiplomatie ' (Alcamo et al., 2017).

In addition, the very expensive costs of mobilization, treatment, distribution and protection of water constitute an obstacle to development, especially in poor countries. In total, the global strategy for residential water management focuses on the mobilization of conventional and unconventional water resources, and on the management of water demand through rational and efficient use (Kummu et al., 2016).

One of the main economic tools for managing the demand for drinking water is the pricing. Thus, the tariff structures best suited for management of sustainable water demand and their role in resource conservation are as much questions that have been the focus of much empirical research in the field of literature. There are several models of water pricing applied around the world (Alcamo et al., 2017).

In several countries, especially those with a water crisis, the tariff system of the most suitable water consists of two parts: a fixed part that does not vary with the volume consumed and a variable part whose unit price of m3 of water increases with the quantity consumed. If one is interested in the variable part of the pricing, the application of progressive pricing adopted by the majority of developing countries and by a large number of developed countries can be an effective tool for managing water demand, provided that it can best reconcile its social, financial and economic objectives(DWM,1996). For this, we must build a first consumption slice covering the essential needs, taking into account the size of the family, at a very low price, lower than the marginal cost. The upper tranches correspond to excessive consumption and are characterized by a high or even dissuasive tariff (higher than the marginal price). Therefore, variable charges make it possible both to subsidize household consumption low incomes and to penalize large consumers in order to encourage them to reduce their excessive use of water. Although this pricing policy is used in several countries, its implementation is complicated by the need to install a consumption meter of water for each subscriber(Bazza et ak, 2003). The installation cost of this meter is very high compared to the price of water paid by small consumers. Therefore, some countries like Argentina and England opt for the distribution of water with a package fixed in advance, regardless of the amount consumed for consumers who do not want to install a meter. This tariff mode is criticized because it does not represent a tariff incentive (Kummu et al., 2016).

**3.5 Analysis of determinants of residential water demand in developed countries**

Integrated management of residential water demand has long been considered to be the only alternative that could delay the use of non-core resource mobilization conventional devices characterized by a very high mobilization cost. In the developed countries, a water management policy specific to the local context was developed. The gap between supply and demand for freshwater and high-quality resources motivated empirical research to analyse the sensitivity of residential water demand to its price (Morote et al., 2016).

### 3.6 Issues of Residential Sustainable Water Supply Policies

The demand for residential water in developed countries has been the subject of extensive literature synthesized in recent reviews published by Dalhuisen et al. (2003), d'Arbuès et al. (2003) and Worthington and Hoffman (2008).

Thus, many studies have been undertaken during the last decades to implement an effective water management policy. The first studies were conducted in the United States by Gottlieb (1963), Howe and Lineaweaver (1967), then by Foster and Beattie (1979), Chicoine and Ramamurthy (1986), Nieswiadomy and Molina (1989) and Hewitt and Hanemann (1995) in particular. But since then, studies now concern all countries, including Canada, Australia, and European countries (including France, Germany, Spain, Italy) thus showing the universal dimensions of the water management problem. Since these countries are the most endowed with water resources on the planet, it is too early to talk about a possible global supply crisis. The freshwater reserve in France is in effect of 7000m3 / year / inhabitant in 2005, against 420m3 / year / inhabitant in a country with semi-arid climate like Tunisia. More generally, the spatial distribution of resources in water on the planet endows Arab countries with 0.005% and rich countries with 49% of the resource (World Bank report, Matoussi (2001).

Nevertheless, the water management policies in force in all developed countries rely on well-identified institutional players specific to each country. They also rely on a diagnosis to identify the specific determinants of residential consumption of water in the territory. In France, the Basin Committees adopt the broad guidelines for water management at basin level in accordance with the European and national legislation. They adopt the SDAGE (also approved by the prefect) and the SDAGE (Master Plan of Development and Management of Waters) which is a planning document which sets out for each basin the basic orientations of a balanced management of water resources (current SDAGE established in 2009, revised in 2015).

It contains a diagnosis and a program of measures that are developed by the basin to reach:

- quantitative and qualitative management objectives for each water body in the basin.
- targets for reducing the discharge of polluting substances.

This diagnosis can be fed by econometric studies, such as that of Binet et al. (2006), intended to propose residential water saving policies of up to 30% to 20 years on the island of Reunion.

This study, like many others, is developing an estimate of the residential water demand function taking into account the specificities locally.

### 3.7 Issues in Residential Sustainable Water Supply Studies in Developing Countries development: methods and results

Given the different economic and climatic contexts, the stakes of the work dedicated to residential demand for water in developing nations differ in general from those concerning developed nations. Thus, with the exception of the theme of water savings in a non-linear tariff system, the other themes concern mainly the social pricing of water, the problems of accessibility to a drinking water source, and the determinants of the choice of water supply source (river, tap well). In the first section, we present these themes and the question of available data for studies of developing countries developments(Nauges et al, 2009). Then, in the second section, we will summarize the main contributions of these studies and present the econometric methods used to estimate the residential water demand function (Morote et al, 2016).

### 3.8 Thematic and specific data

Empirical studies of residential demand for water in developing states began with works by White et al (1972) and Katzman (1977) and have been synthesized recently by Nauges and Witthington (2010). After describing themes developed in this work, the question of the accessibility of data is mentioned.



#### Main themes

Common and specific socio-economic issues have been mentioned in several studies in the literature on residential demand for water in developing states. To understand the behaviour of households in these countries and to advocate for optimal economic policies, the authors focused on the problem: saving water in a progressive tariff system and not linear, the design of social pricing, accessibility issues and the choice of source of supply in the context of water scarcity (Morote et al, 2016).

First, regardless of the country's level of development, any policy designing optimal conservation of the water resource requires a preliminary step involving the formulation and estimation of an appropriate model of the behaviour studied. However, the goal of saving water and optimally allocating freshwater resources and high quality are key economic issues in developing countries, especially for those “suffering from a water crisis”. Indeed, acute scarcity of water resources in these countries is accompanied by a semi-arid climate and drought conditions (Ivanova et al, 2016).

The progressive non-linear tariff policy and subsidized tariff are often considered as the only tools likely to control the demand for running water while allowing the entire population to cover their basic needs. So, in most developing countries, the tariff system of water is kept non-linear to reduce the excessive use of drinking water. In other words, the price of the last cubic meter of water increases with the total volume consumed. This practice makes it possible to cover the enormous cost of production and distribution of water and to encourage the user to control consumption (Morote et al, 2016).

Second, the incentive tariff system is supposed to reconcile three objectives. Firstly, a financial goal to cover a portion of the cost of water mobilization, then an incentive goal that can be just mentioned and finally, a social goal to mobilize water with a lower price for low-income households. Therefore, social pricing which guarantees a certain level of social welfare for the least advantaged households remains an important challenge in the literature on developing countries(Whittington et al, 2002). For example, in the city of Dubai, whose total water resources come from desalination of seawater, a plus minus 3 billion contract was signed with an investor. He undertakes the construction and operation over 10 years of a plant to produce 220 000 m3 / day drinking water from seawater. Large families usually have low water income and are therefore penalized because they pay water at the price of the last cubic meter consumed which is very high. The implementation of social pricing is therefore required (Ivanova et al, 2016).

Finally, the main theme specific to developing countries concerns accessibility to the water resource. Given the acute scarcity of freshwater resources and high quality, and the fragility of public infrastructure in developing countries, many households in these countries do not have access to tap water. They then resort to other sources of water supply such as the use of water from river, water transferred by trucks, wells, water from public taps. Therefore, many studies have examined the determinants of source choice in order to know what policy to implement in order to promote access to drinking water (Ivanova et al, 2016).

### 3.9 Introduction to the Global Water Fresh Water Resources

Population growth, especially the increased urbanization with better living conditions, has negatively affected water demand (Loucks and Van Beek, 2017). Water supply can be increased by dam construction, desalination and recycling plants. However, all these facilities are too costly, especially for developing and ailing economies such as Zimbabwe and Sudan, among others. "These are often not appropriate solutions for developing economies particularly in semi-arid regions, which face water scarcity. Developing economies must address issues to achieve the Millennium Development Goal (MDG) of safe and equitable water access to all users, through urban water resource management". Changes in the climate have also had an impact on the water levels across the globe. In this empirical investigation, it is essential that the researcher looks at the variables that affect water supply in the cities. This is essential in this investigation since the case study is also focusing on the urban area of Cape Town(Daniere 1994 and Komives 2003).

### 3.10 Factors Affecting Water Resources for Urban Water Supply

Globally, water resources have been depleting in cities. Supply-side factors for increasing water scarcity in urban areas are "shrinking". This is also attributed to human activities, such as deforestation and stream bank cultivation, just to mention a few. Apart from that, the various changes in the climate over time have also played a crucial role. Pollution and degradation have affected underground water levels especially for semi- arid and arid regions. This automatically puts pressure on the limited available water. The following figure depicts supply side pressure determinants to water scarcity in towns (Loucks and Van Beek, 2017).

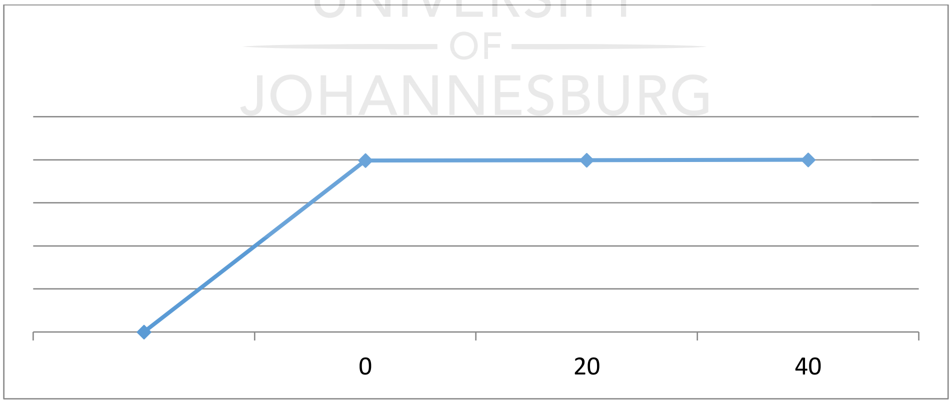


Figure 3.1: Supply side pressure factors to water scarcity in urban areas (Paarat,2017)

**Key:** P-price Q-quantity

From the graph, it is clear that the urban water supply should be less than the natural resource endowment, therefore supply-side management solutions are now irrelevant. This is so, especially as groundwater levels in key aquifers are falling rapidly. The last section of this empirical quantitative study is going to be based on the global water resources (UN-Water, 2007).

### 3.10 Global Water Resources and Climate Change

Of all the water on earth, 97.5 % is found as saltwater in oceans, and there are around 35 million km3 of fresh water. Apart from that, 69% of that water exists as ice and permanent snow cover especially in mountainous areas. “On an international scale, if all freshwater is equally divided among the global village population, there would be 5,000 – 6,000 m3 of water available annually per individual (UN-Water, 2007). However, both populations and freshwater resources are distributed unevenly over the globe” (Kummu and Varis, 2011).

In addition to that, Global warming plays a key role in water shortages. Observational confirmation – the twelve warmest years from 1850 happened between 1995 and 2006 – affirm that, “global warming effects global average temperature. UN-Water (2007) reported that in this century global warming is expected to account for around 20% of water scarcity increase the world-over”. Apart from that, global average temperatures will be expected to increase more than 5°C. Furthermore, evolving climates, in particular global warming, affects precipitation, and liquefying of mountain glaciers that has a bearing on the greater part of water sources, and they exacerbate dry seasons and floods in many economies (UN-Water, 2007, UNDP, 2007).



### 3.11 Lesson learned

From the review of literature on China, Russia, the Mediterranean etc., a number of lessons can be learnt regarding factors affecting water crisis. The decision-makers and economic stakeholders are often subject to daily constraints and short-term logic. Water management, by contrast, thinks in the medium to long term. This means predictive approaches play an important role. The scenarios produced by Plan Bleu since the 1980s have made it possible to quantify the imbalances between water supply and demand. They have drawn attention to the risks of shortages in the Mediterranean. Finally, by proposing ways and means of water saving, they have helped some Mediterranean countries to progress in their visions and encouraged them to follow a SWS approach.

### 3.12 Conclusion

This study has mapped out the key principles, legislative, economic and social frameworks that would guide a global water conservation and demand management strategy. It has comprehensively reviewed the different components of the framework as advised by the current perceptions of sector knowledge. These perceptions are being tested through this consultation process.

## CHAPTER FOUR

## Sustainable Water Supply Strategy From African Perspective

### 4.1 Introduction

This chapter will focus on overview of sustainable water supply in Nigeria and South Africa. The background of both countries is presented. In addition, detailed literature is reviewed on the the Nigerian water industry market, major trends in Nigeria's water industry, Economic performance of Nigeria's water industry, Factors affecting Nigeria's water market. Moreover, the economic performance of Nigeria's water industry. This chapter further reviews the water industry in South Africa, Challenges in the South African water industry and lastly lesson learned along with conclusions.

### 4.2 Water industry in Nigeria

Located in West Africa and named for the Niger River, according to Tylor et al (2016), "Nigeria is one of the most developed countries in Africa. The country has an extensive and spectacular coastline on the Atlantic Ocean in addition to sharing borders with Niger, Chad, Benin and Cameroon. The southern part of the country is wetter and more wooded, and the northern part of the country is dry savannah. There is also a forest in the eastern part of the country. The rainforest region provides production of timber and fruit trees, including citrus, palm, cocoa and rubber. Nigeria has enormous natural resources, including agriculture, minerals, rivers and forests, and is the world's sixth largest oil producer. The country has a well-educated and globally respected population as one of Africa's leading energy players, along with South Africa" (Loucks and Van Beek, 2017).



### 4.3 Nigeria economy

As Marshal and Solomon (2017) indicate, "the Nigerian economy continued to show signs of recovery after the 2016 recession, with GDP growth estimated at 0.8% for 2017 against -1.5% in 2016 and projected at 2.1% for 2018 and 2%-5% for 2019. This positive outlook is justified by the increase in oil prices and production as well as by improving the performance of the agricultural sector. Oil prices were expected to rise to +-R400 per barrel (Brent crude) in 2017 and US $ 54 in 2018, up from US $ 43 in 2016. Oil production has also improved following the de-escalation of hostilities in the delta. This was from 1.45 to 2.03 million barrels per day between the first and third quarters of 2017 and was expected to remain at this level in 2018 and 2019, in line with the production restrictions of the Organization of Petroleum Exporting Countries".

Fiscal policy remained expansionary in 2016 and 2017. Total spending declined from 13% of GDP to 10.3% between 2014 and 2017, while revenues, according to Marshal and Solomon, (2017), "fell more significantly from 11.4% to 5.6%. The budget deficit is estimated at 4.8% for 2017 against 4.7% in 2016 and projected at 4.3% for 2018 and 4.1% for 2019, as revenue performance improves. Unemployment remained high at 14% in 2017, at the same level as in 2016, and is only expected to decline slightly to 13.5% in 2018, with the recovery easing production constraints in the manufacturing and agricultural sectors." (Marshal and Solomon, 2017)

The austerity monetary policy continued in 2017, and according to the Central Bank, "should continue in 2018; the key rate has been maintained at 14% since July 2016 to support the naira and control inflation. This has stubbornly remained at double digits and is estimated at 16.2% in 2017 compared to 15.6% in 2016 but could decrease to 13.7% in 2018 and 12% in 2019. The availability of foreign exchange has improved with the administrative measures taken by the Central Bank in early 2017. They provide that for investors in the portfolio a commercial counter can determined by the market through the autonomous fixing of exchange rates allowing commercial banks in Nigeria to offer rates close to those of the parallel market. The Naira has remained stable for most of 2017 and is expected to strengthen slightly with the recovery of the economy(Rietveld et al,2017)."

**4.4 Historical background of Nigeria's water industry**

The water supply history and development in Nigeria goes back to the colonial times when there was a ten-year plan (1944 to 1956) that included its overall budget of about 5.7% of the sector's total expenditure. Open wells were built under public works department supervision and the regional regimes were accountable for provision of safe, clean water to the community, especially the communities in the rural. However, over the years, national rural water supply programs have been put in place by the World Bank, United Nations International Children's Emergency Fund and others that have contributed to the development programs. However, UNICEF prominently focuses on rural supply of water and Nigeria's sanitation (Okeola and Balogun, 2017).

From 1989 to 1992, the UNDP program put in place was operated by Rusafiya and it focused on the local government as it was closer to communities. The program ensured that a rural water and sanitation action plan and strategy was developed.

### 4.5 Nigeria's water industry and market

Tylor et al (2016) opine that, "the lack of access to safe drinking water and sanitation is probably directly related to poverty and in many cases to corruption and the inability of governments to develop the political will to provide water and sanitation systems for their citizens. Hence, the public sector has not been successful in meeting more than a small portion of the demand for water for residential and commercial uses. For example, out of the 85 million people living in urban and semi-urban areas, less than half have reasonable access to reliable water supply" (Okeola and Balogun, 2017).

The Nigerian population therefore suffers from insufficient access to water. In 2014, in line with the World Bank submission, "more than 30% of the population did not have access to an improved water source". This situation is due to complex management of the sector and lack of infrastructure (Okeola and Balogun, 2017).

### 4.6 Major trends in Nigeria's water industry

The Vision of Nigeria for 2020, which is the development strategy Economic Outlook for the 2010-2020 periods, stresses the importance of improving "access to drinking water and sanitation" as a determinant of development economics. The proposed project contributes directly to the realization of Pillar I of the Vision of Nigeria by 2020, entitled "Ensuring the well-being and productivity of the population". This recognizes that "access to water and sanitation is one of the most important factors of public health." The type of access, the volume of water supply, and the quality of available sanitation facilities have an impact on the quality of life of populations and the potential for reducing poverty (Vapnek and Williams, 2016).

However, instead of moving towards the achievement of the Millennium Development Goals (MDG), as expected, the service coverage rates provision of water and sanitation in Nigeria has declined over the last period 1990-2006. This is why the Vision gives priority to these services, in focusing on community participation, public-private partnerships (PPPs), rehabilitation and modernization of systems, operations favouring optimal practices, as well as the protection of the environment and the fight against pollution. All these aspects have been taken into account in the project (Adenikinju,2008). Proof of the commitment of the Federal Government is also administered by the 2011-2015 National Transformation Program, which confirms the focus on infrastructure development and human development. In addition, the budget for 2013 allocates to the water sector an allocation of 81 billion NGN (USD 529 million, or 5% of the investment budget), thus doubling the level of this allocation compared to 2012 (Vapnek and Williams, 2016).

At Rivers State level, the project is specifically presented as a priority in this State's Vision 2020 and in the Medium-Term Development Plan 2010-2013. These two instruments emphasize sustainable service delivery water supply, sanitation and hygiene, as well as on the safety of the environment as important factors for improving health and sustainability economic (Okeola and Balogun, 2017).

The following graph depicts the trend and coverage of water supply and sanitation over the period of 1990 to 2020. After 1990, there has been a decrease; however, by the year 2020, Nigeria wants to focus on increasing the coverage of water supply and sanitation.

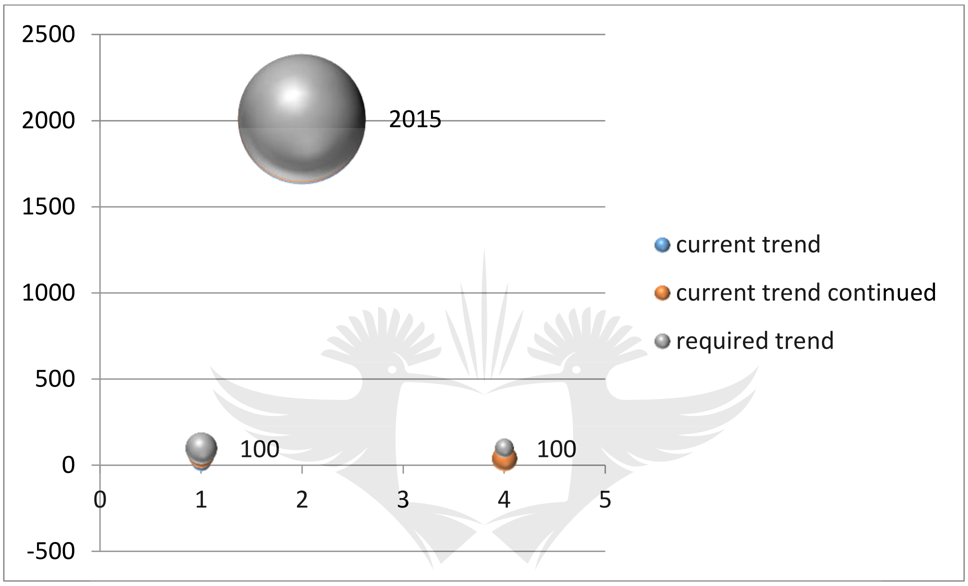




Figure 4.1 Major trends in Nigeria's water industry(Anudu, 2013)

### 4.7 Economic performance of Nigeria's water industry

Nigeria lagged far behind in water management; in 2014, according to the World Bank, more than 30 % of the Nigerian population did not have access to better-quality water sources. This figure was 44% in rural areas compared with 19% in the city. The connection to the network, according to the States, is also very disparate (55% in some southern states, while some northern states do not exceed 18%) (Farole, Reis, & Wagle, 2010). Less than one-third of the Nigerian population has access to sanitation facilities. Water management is bureaucratic and very complex (Federal, Federated and district level). Furthermore, the development partners of this sector (mainly the World Bank, AFD, AfDB) work regularly with the Ministry of

Water Resources for the development of infrastructure with little or no profitability, especially in rural areas or in urban areas in the North region (Okeola and Balogun, 2017).

### 4.8 Competitiveness of Nigeria's water industry

Management of the sector should be entrusted to the private sector. As part of its so-called "Transition", the Government intends to entrust management to companies operating and cleaning water and private distribution companies, either through privatization or as part of a PPP. Several southern states have passed laws allowing private management of their infrastructure. The federal state would also be in the final stages of preparation of a new water law which will make it possible to organize management of water networks by the private sector. This reform opens a period of disorder in terms of planning (Aminu, 2018).

However, significant public investment would be required which has not been funded at this stage. While public water management institutions have delayed the necessary investments for the rehabilitation of existing infrastructure for too long, there is talk in the Federal Ministry of a need for quadrupling the treatment and distribution of water in developing states such as Lagos, Ogun state in the southwest, Rivers, Cross River in the south-east, Kano-North of the country, to which should be added the Federal district of Abuja. However, the investment needs are not quantified financially by the Nigerian authorities, which rely on the international financial institutions on this point (Onyemenam, 2016).

The National Planning Commission (NPC) considers that the Nigerian Government will have to mobilize USD 107.5 billion by 2020 to upgrade its infrastructure - USD 99 billion in water and USD 8.5 billion in water. The irrigation sector (which depends on the Ministry of Agriculture). Much less ambitious than the NPC, the World Bank considers that if Nigeria wants to reach the millennium goals, 10 billion USD of investment would be needed over 10 years in the areas of distribution, sanitation and wastewater treatment, not including current operating expenses (Okeola and Balogun, 2017).

### 4.9 Factors affecting Nigeria's water market

In early August 2016, Solidarities International opened a new mission in the state of Borno in northern Nigeria. The goal is to meet the needs of thousands of displaced people fleeing rural areas where fighting between the Boko Haram sect and government forces is raging. A few days after the opening of the mission the first activities were put in place. According to UNICEF, what is happening in Nigeria today is "one of the worst food crises ever known in the world. A total of 4.5 million people are in need of emergency food assistance, and one million of them are suffering from extreme malnutrition(Demotanyi et al, 2012)."

In order to take part in this fight, the “Solidarities International” teams, deployed for a month and a half in northern Nigeria, mainly in the cities of Monguno and Maiduguri, have successfully started their activities. " According to Thierry Benlahsen, head of the emergency team, the priority has been to provide access to safe drinking water for both host and displaced communities. Due to the growing number of displaced people in cities, the pressure on the water resource is such that there is not enough for everyone. Many people find themselves forced to use water that is unfit for consumption. Waiting at water points is also a big issue that makes people potential targets for Boko Haram (Okeola and Balogun, 2017). Therefore, the Solidarities International team set up a first tank to which they connected faucets in the district of Muna Garage in the city of Maiduguri. Now operational, it will allow several hundred people to have access to safe water, which will also help stem the food crisis.

Pollution is one of the factors that affect Nigeria’s water and sanitation scarcity, because underground water is polluted through seepage from waste dumpsites. This also contributes to major health issues because poor quality affects people, the economy and the environment. Hence, the government must take charge of the way they manage water by developing a water-quality database. Nigeria also has to realize the importance of raising awareness about the value and increase to public participation in water supply schemes (Okeola and Balogun, 2017).



The challenges of Nigeria’s water industry are as follows

- Poor fund management
- Government insincerity
- Inadequate information or education
- Artificial water scarcity
- Maintenance

## 4.10 Lesson Learned

As per literature reviewed, Countries in Southern Africa and West Africa are at different stages of implementing SWS. Large-scale, region wide SWS implementation has, however, not yet begun, although a number of unaccounted for water (UAW) projects have been undertaken by local authorities in Nigeria, South Africa and Namibia. Botswana is in the process of formulating and consolidating policies and strategies, whereas Zimbabwe has approved a new Water Act and a new Integrated Water Management Strategy, which creates a good platform for SWS implementation. Most other countries have not yet formulated specific SWS policies and strategies but are exploring opportunities to do so. Considerable knowledge exists on putting SWS based principles and practices into action. In South Africa and Namibia there are successful and concrete examples of how a relatively small technical or organizational change can save large amounts of water and related financial resources. Further, as water is scarce in the region, unproductive losses and inefficiencies must be addressed with the purpose of making more water available to priority needs. Priority will often be given to water use by the urban sector. SWS is a very potent option, but as with any strategy, it depends on the existence of a conducive framework and support from practitioners within the water profession and the countries' governments.

## 4.11 Conclusion

The purpose of the current literature has been to improve the understanding and knowledge of water demand management in Africa (Nigeria etc.) among decision makers and practitioners. It hopes to influence national and regional water policy and strategy in SWS; improve technical capacity; and produce guidelines and to a limited extent also test these in a field application.

## 4.12 WATER INDUSTRY IN SOUTH AFRICA

### 4.12.1 Introduction

In South Africa, water is critical to winning the fight against poverty and its shortage could be a restricting component to development. No economic growth can occur without water. South Africa's water resources are undoubtedly constrained and scarce. The situation is exacerbated by the occurrences of dry spells and the expanding demand related to the growth of population and a developing economy (Ozturk, 2015). As a nation, the country is moving toward the full use of its accessible water resources. Additionally, water augmentation plans will be expensive and are probably going to be inconvenient for the environment. South Africa in this manner therefore requires a key change in the utilization and protection of its water resources. South Africa water is a valuable asset that must be utilized as effectively as possible before considering any new water resources improvement.

## 4.13 South African Water in Context

Rabe, et al (2012) posted that water is essential for developing economies, especially from an investment perspective. Furthermore, a number of challenges are affecting the South African economy such as high unemployment, extreme poverty levels, poor settlements and poor housing and sanitation to mention but a few. In addition to that, Otieno and Ochieng (2004)This should be stated that, "*South Africa, currently categorized as a water stressed country, is forecasted to experience physical water scarcity by the year 2025 with an annual freshwater availability of less than 1000 m3 per capita. With the trends in population growth and its attributes and continuous pollution of the available water sources, there is bound to be increased pressure on the available water probably resulting in increased conflict over its allocation and a further stress on this resource leading to scarcity.*"

From the above sentiments it clearly shows that water shortages threaten the lives of all citizens, and it affects different sectors such as agriculture, fisheries, as well as fauna and flora. The next discussion is going to be centered on the different or diverse acts of water management as is explained below.

## 4.14 South African Acts on Water Management

There are various acts responsible that govern water use in the economy and they are clearly explained and listed below:

- The South African Supreme Law (Act 108 of 1996).
- The National Water Act (NWA) (Act 36 of1998)

- The National Environmental Management Act (Act 107 of 1998) (NEMA).
- The Water Services Act (Act 108 of 1997).

Municipal Structures Act (Act 117 of 1998)(NWL,1997)

**4.15 The South African Supreme law (Act 108 of 1996)**

- The law, particularly Section 24, outlines that all South African citizens must have access to a safe environment that promotes their well-being, a protected environment that is safe and sustained by some legislation (RSA 1996). These legislative measures are:
- Pollution prevention and ecological degradation
- Promotion of conservation
- The securing of sustainable development of natural resources for overall economic development

Various other acts enshrined in the supreme law of the country are going to be looked at below(NWL,1997)

**4.16 The National Water Act (NWA) (Act 36 of1998)**

This Act is run solely by the Department of Water Affairs (DWA). The act provides "a legislative guideline of the management of water in the country. In addition to that, there are crucial factors such as surveying, the geo-hydrological activities of identifying and mapping the nature of a specific water resource(Dwarf,2016). These require being looked at even before the water resource can be used, conserved, protected, developed, controlled and managed" (Neale & Raga, 2008b). The Water Services Act of 108 of 1997 is discussed below.

**4.17 The Water Services Act (Act 108 of 1997)**

This Act explains the role of water service entities such as water boards and municipalities. The act is based on the minimum benchmarks for water services in the nation. The key objective of the Act is the right of access to clean water for everyone. This implies that all responsible authorities must operate observing this law to ensure a healthy community too. The following Act 107 of 1998 is discussed clearly below(Dwarf,2016).

### 4.18 The National Environmental Management Act (Act 107 of 1998) (NEMA)

The act outlines certain principles that must be adhered to from an environmental perspective. These are: Principles such as Polluter Pays, Duty of Care and Sustainability are promoted (Anon, 2009). These principles are very important since they help in the management of water in the economy. Furthermore, this act defines pollution as any alteration in the environment by people which will have ruinous effects on the community's well-being. Next, the Municipal Act is discussed;

### 4.19 Municipal Structures Act (Act 117 of 1998)

Under Category C (district) municipalities have dominion over the administration of water and its supply and disposal services. Apart from that, under Category B (local) municipalities have powers to focus on storm water issues only in their respective areas. This implies that local governmental structures have a key role in the water affairs of the nation. The following discussion is on Act 32 of 2000(Dwarf, 2016).

### 4.20 Municipal Systems Act (Act 32 of 2000)

This Act outlines the main principles, mechanisms, and processes essential for local authorities to achieve socio-economic development on their communities. In this Act, the integrated development plan of a municipality is defined (Joubert, 2008).

### 4.21 Challenges in the South African water industry

Water shortages in South Africa could quickly worsen with the intensification of "supply contracts and demands due to growth, urbanization, unsustainable use, degradation of wetlands, water losses and reduced rainfall due to climate change" (Bijl et al, 2016). Public water authorities cannot attract an adequate number of specialized technical personnel necessary to manage and maintain water regimes effectively. The situation is aggravated by a low revenue recovery which further impedes the effective implementation of operational plans. The deterioration in the quality of water resources is often due to the lack of networks and collectors of sewage pumps and to the improper functioning of wastewater. "Most of these failures are due to the fact that wastewater treatment plants are managed beyond design capacity or are managed by process controllers who do not have the necessary skills" (Bijl et al, 2016).

### 4.22 Lesson learned

Water is critical in South Africa and currently water resources are undoubtedly constrained and scarce. This is caused by occurrences of dry spells across the country more specifically in Western Cape, this situation will worsen with the intensification of “supply contracts and demands due to growth, urbanization, unsustainable use, degradation of wetlands, water losses and reduced rainfall due to climate changes. Although there are policies in place on water utilization, dry spell will cause major problem for the country as whole if situation doesn’t change.

### 4.23 Conclusion

South Africa's water resources are undoubtedly constrained and scarce and with the current continuous increase in population; The South African national water act must install strict legislative guidelines of the management of water in the country. Furthermore, The National Environmental Management Act must promote principles such as Polluter Pays, Duty of Care and Sustainability because such principles are very important and they will help in the management of water in the country. If the major plans are not in place and above principles are not promoted then South Africa could quickly worsen with the intensification of “supply contracts and demands due to growth, urbanization, unsustainable use, degradation of wetlands, water losses and reduced rainfall due to climate change and other measures such as leakes.

# CHAPTER FIVE

# RESEARCH METHODOLOGY

## 5.1 Introduction

This chapter analyses the techniques and method by which the data was gathered, when and where as well as from whom it was gathered, as well as the size of the sample used. It also includes a study project plan, population, and sample, tools for collecting data, sources as well as procedures for analysing data.

## 5.2 Research Methodology

"Research methodology is a framework of procedures, practices and rules that are employed by researchers in order to solve research problems. It is a way that explains how research can be undertaken. It focuses on research design, sampling techniques and data collection methods as well as data analysis" (Kumar 2005). In order to explore answers to the research questions this study embraced both qualitative and quantitative methodologies. The quantitative methodologies were employed in investigation of specific issues related to water demand, whereas a qualitative approach allowed the researcher to access participants' perceptions (questionnaire) and experiences through reviewing available existing literature. The advantage of qualitative methods in the context of this study is that, "they increase the depth of understanding; they are flexible and allow the pursuit of new areas of inquiry" (Yin, 2015).



## 5.3 Research Design

The research design for this study was a mixed methods research design, utilizing a descriptive and interpretive case study that was analysed through both qualitative methods and quantitative component on necessary areas. This study followed both quantitative research design and qualitative research design. "A quantitative research method derives empirical generalizations which may be used to determine future courses of action. This type of research design involves obtaining data from a large group of respondents and is used in descriptive studies to quantify data and generalize the results from the sample to the population of interest" (Yin, 2015). A "quantitative research design requires statistical summarization" (Tustin, 2005). The study at hand needed statistical summarization for investigating water demand management strategies among households and non-household entities.

A case study research process is, “an investigation that explores a phenomenon inside its actual natural context. It is mostly applied when the margins between phenomenon and its context are not noticeably marked, and in which several bases of proof are utilized” (Yin, 1984: 23). It allows for an in-depth investigation and thorough analysis and understanding of a phenomenon which are commonly prepared in a real-life context. Case studies permit more data to be gathered than by other research approaches. The facts gathered are generally richer and of better depth than detail gathered through other investigation designs (Gerring, 2006; 36).

### 5.4 Sample and Sampling

Cooper and Schindler, (2003) describe sampling as, “the procedure by which some elements of a given population are selected as representative of the entire population. The primary idea of sampling is that by selecting some elements of a population, the researcher can draw conclusions about the entire population. A sampling method can be classified as probability or non-probability”. This study covered Cape Town in South Africa. The researcher chose this town as a study area because of its proneness to water challenges.

The study sample was based entirely on multistage sampling and representative sampling. Multistage sampling is, “a complex form of cluster sampling in which two or more levels of units are embedded one in the other. During the first stage, a random number of locations were chosen in a district, followed by a random number of streets. The third stage units were houses. All ultimate units (houses, for instance) selected at the last step are surveyed” (Flick, 2007: 7). “It allows the researcher to concentrate on units of the population that are relevant in providing answers to the research questions” (Flick, 2007; 7). This technique was used to identify households to participate in the study. The study used information from 80 households and 15 business entities and 5 government officials from the Cape Town. This sample size has been chosen specifically for convenience reasons, as any figure above that will be costly to the researcher.

### 5.5 Data Collection

#### 5.5.1 The Structured Interview Schedule

A structured questionnaire consisting of closed and open questions was designed and administered to households for the collection of primary data. The advantage of the structured interview is that it takes place in a short period of time (Yin, 1994). The questionnaire was designed with the aim of collecting both quantitative and qualitative data. The questionnaire was self-administered to the sampled respondents by the researcher. “A questionnaire is a form containing a set of questions, especially one addressed to a statistically significant number of subjects as a way of gathering information for a survey" (Martins, 1999). "The questionnaire used herein consisted of open-ended questions and closed-ended questions" (Cooper & Schindler, 2003). There are other ways to administer the questionnaires, such as online-administered questionnaires and telephone surveys (Leedy and Ormrod, 2004).

However, face-to-face interviews were chosen because they have many advantages over other methods. According to Bless and Higson-Smith (2000), "an interview given by an interviewer reduces the omission of difficult questions by respondents. In addition, it reduces the problem of incorrect interpretation of words or questions (misunderstandings) by respondents and can be given to respondents who cannot read or write. Furthermore, the presence of the interviewer increases the quality of the answers because of the opportunity for the interviewer to probe for more specific answers" (Leedy and Ormrod, 2004). In other words, the questionnaires used managed by the interviewer guaranteed a "minimum loss of data compared to the other methods" (Yin, 2015).

In the household's head absence, the spouse or another member of the household directly involved in water management was interviewed. After collecting the data, a codebook was prepared to assign numerical values to the answers obtained from the study respondents. The questionnaire data was coded and transferred to a spreadsheet (Microsoft Excel, 2017). According to Bless and Higson-Smith (2000), it is important that the information obtained is in the language that the computer will assimilate when it is used to analyse the information.



### 5.5.2 Administration of Questionnaires

The research method used to gather primary data was a "self-administered questionnaire". "A self-administered questionnaire is a form containing a set of questions, usually presented to the respondent by an interviewer or a person in an official capacity that explains the purpose but does not actually complete the questionnaire" (Cooper & Schindler, 2003). "The provision of the questionnaire was kept very simple to encourage a meaningful participation of the respondents. The questions were concise, and attention was paid to the actual formulation of the questions. The study literature was used as a guide for the development of the questions in the questionnaire" (Yin, 2015).

### 5.5.3 Open-ended questions

The researcher used the open-ended questions. "It is a free response, that is, it calls for a response in the respondent's own words and it is normally independent. Open-ended responses are great value in exploring complex and variable topics. They are often used to search for additional information through questions such as 'Why?' and 'Please explain?'" (Tustin *et al*, 2005; Cooper & Schindler, 2003).

### 5.5.4 Closed-ended questions

These types of questions provided the respondents with different options. "The majority of the questions in the questionnaire were closed-ended because the question did not require an explanation from the respondents, and it increased the chances of participation by the respondents. Closed-ended questions are easily analysed since every answer can be given a number or value so that statistical interpretation can be assessed" (Wheather & Cook, 2000).

### 5.5.5 Dichotomous questions

"A dichotomous question is a question which offers two alternatives to choose from" (Cooper & Schindler, 2003). "Dichotomous questions were used because some of the questions in the questionnaire had only two possible answers. For example, questions about the gender of the respondents" (Yin, 2015).

### 5.5.6 Multiple choice questions

"A multiple-choice question is a fixed question with more than two alternative answers" (Cooper & Schindler, 2003). Multiple choice questions were used in the research since they are easy to answer by the respondents thereby reducing non-response.

### 5.5.7 Five-point Likert scale type questions

According to Asún et al (2016), a "Likert scale is a verbal scale that requires the respondent to indicate a degree of agreement or disagreement". The researcher used the five-point questions because it eliminated the development of response errors among the respondents; and attitudes, perceptions, beliefs and opinions were also evaluated. The Likert scale used standardized the response elements and made them comparable among respondents.

### 5.5.8 Secondary data

Several secondary data sources were utilized, like reviewing accessible printed literature. This included magazines, books, internet sources, conference reports and dissertations related to water demand management. Other pertinent information sources, such as published data obtained from internet sites and government websites were also evaluated and information applied in a deductive manner.

## 5.6 Data Analysis

"Data analysis consists of running various statistical procedures and tests on the data" (Barrow, 1999). "It is the conversion of meaningless data into something which can easily be understood. The purpose of any research is to deduce information from the data gathered.

Data analysis involves the extracting and assorting of data obtained so as to obtain processed information used to reach conclusions, predict results and supporting decision-making" (Wellman et.al, 2005).Quantitative data collected was examined with the use of SPSS (Statistical Package for Social Sciences) method. This is a "standardized statistical procedure widely used for quantitative and qualitative data analysis. SPSS made it easier in comparing data between different variables in this study, demographic and income data" (Grey and Kinnear, 2012).

Descriptive Statistics were used to summarize and describe the findings and results of the survey. According to Minor (2008), "there are two subdivisions of statistical methods. The first one is descriptive statistics which deals with the presentation of numerical facts, or data, in either tables or graphs form, and with the methodology of analysing the data. The second one is Inferential Statistics which involves techniques for making inferences about the whole population on the basis of observations obtained from samples". The econometric models or statistical models below were utilized in analysing the collected data.

The study made use of frequency distributions and graphical displays. "This involved calculating the incidence or the number of periods in which a particular phenomenon occurs and presenting the data in a chart or graphical way" (Robinson, 2002). "They are swiftly and simply understood by a diversity of audience. Summary statistics will also be used in the study. This involves defining the level of spreading of the statistics, using measures of central tendency. Three measures of central inclination are used, namely the average median and mode" (Krivtsov, 2009).

Qualitative data was analysed using the, "thematic approach where different themes were identified. Thematic approach is a qualitative investigative method for: 'detecting, examining and recording patterns (themes) within data" (Clarke, 2006, 79). Qualitative data was sorted and organized into different thematic areas and analysed using content analysis.

### 5.7 Factor Analysis

This research study employed factor analysis to establish variables that could be measuring aspects of similar underlying dimensions and to identify clusters of related variables, thereby reducing them to a smaller understandable framework (Norusis, 2000; Ahadzie et al.,2008:681). Factor analysis is a statistical technique that can be used to analyseinterrelationships (correlations) among many variables (e.g. test scores, test items, questionnaire responses) and to explain these variables in terms of their common underlying dimensions (factors). It is also described as a data reduction technique as it takes a large set of variables and seeks to summarise the data using a smaller set of factors/components

(Pallant,2007). Factor analysis can be utilised for either confirmatory or exploratory purposes. The study adopted the exploratory factor analysis (EFA) as it is a widely used and applied statistical technique in the social sciences. As stated by Osborne and Costello (2009:2), EFA is preferable because it aims to show any latent variables that can make the manifest variables to co-vary. The shared variance of a variable is partitioned from its unique and error variance during factor extraction in order to reveal the underlying factor structure, thereby revealing only shared variance in the result. The EFA was used in this research study to confirm the reliability and validity of the biomimicry principles, approaches and materials that can promote sustainable construction practices and likewise the barriers, benefits and ways of promoting the adoption in the South African construction industry. The EFA was undertaken using version 21.0 of the SPSS software.

**5.8 Reliability**

Reliability refers to the degree of consistence or accuracy with which an instrument measures the attribute it is designed to measure (Polit & Hungler, 1993:296). If a study and its result are reliable, it means that the same results would be obtained if the same study were to be replicated. The reliability of a scale indicates how free it is from random error. Two frequency used indicators of a scale reliability are test-retest reliability and internal consistency. However, will pay attention to internal consistency, Internal consistency is the degree to which items that make up the scale are all measuring the same underlying attribute (i.e the extent to which the items hang out together) (Pallat, 2013). Internal consistence is measured in different ways and the most common used is the Cronbach's coefficient alpha. This statistic provides an indication of the average correlation among all of the items that make up the scale. Value range from 0 to 1 with higher values indicating greater reliability (Pallat, 2013).

While different levels of reliability are required, depending on the nature and purpose of the scale, Pallat (2013), recommends a minimum level of 0.7 Cronbach alpha values are depends on a number of items in the scale. When there are a number of items in the scale (fewer than 10), Cronbach alpha values can be quite small. In this situation it may be better to calculate and report the mean inter-item correlation for items (Pallat, 2013). Cronbach Alpha Co-efficient is a measurement which represent the consistency with which a research instrument measures a given performance or behaviour.

### 5.9 Descriptive statistics

Marshall and Rossman (1999) define descriptive statistics as, “condensing large volumes of data into a few summary measures. The descriptive statistics used in the present study included percentage distribution and mean scores. Percentages are defined as the number of times a certain answer appears in the data. The mean calculates an average across a number of observations and the standard deviation is the square root of the variance around the mean, in other words, how the mean represents the data” (Mellville & Goddard, 1999).

### 5.10 Inferential Statistics

“Inferential statistics is the area of statistics which extends the information extracted from the sample to the actual environment in which the problem arises” (Mellville & Goddard, 1999).

### 5.11 Pretesting

“Pretesting refers to the testing of the questionnaire on a small sample of respondents in order to identify and eliminate potential problems” (Malhotra, 1993). In this study, pre-testing was used as a research instrument in the survey’s development stage through a pilot study. For the purpose of the pilot study, data was collected from about 10-20 respondents. This was subsequently analysed using Cronbach Alpha Test software.

### 5.12 Content validity

This is a non-statistical type of validity that involves “the systematic examination of the test content to determine whether it covers a representative sample of the behaviour domain to be measured” (Babbie & Mouton, 2001). A group of experts was utilized in reviewing the articles and making comments on whether the articles cover a representative sample of the population.



### 5.13 Internal validity

Internal validity refers to, “the confidence that is placed in the cause and effect relationship”. In other terms, it addresses the following question: “to what extent does the research design permit us to say that the independent variable causes a change in the dependent variable” (Babbie & Mouton, 2001).

### 5.14 Ethical Considerations

Since the study made use of interviews, issues of ethical considerations were central and hence there was need for strict adherence to ethical principles. Ethical considerations were of prime importance in the conduct of this study and it fully recognized the ethical protocols.

Questionnaires and interviews were formatted and structured in a manner which protected human dignity, integrity, rights and confidentiality and the need to avoid any activity which stigmatized, demeaned, harmed or disintegrated the community under investigation.

Participants consent was sought for interviews after highlighting to them what involvement in the study entailed, the benefits of the study, and the confidentiality of the participant identity. All data acquired in the course of this enquiry project was considered confidential material and was not openly divulged in a manner that would identify any individual or organization without their consent.

The researcher became familiar with the ethical guidelines prescribed by the research body of the university. All the participants were interviewed voluntarily, and their names were kept confidential. The answers were kept out of the registry, since the respondents were not asked to enter their name or provide any identification. The researcher informed the interviewees about how the information collected by the investigation would be used.

### 5.15 Summary

This chapter examined the research methodology of the study. The scope of the survey, the sampling method and the organization of the survey were widely discussed. In addition, the chapter examined the data collection method used, in particular, the basis for choosing self-administered questionnaires. In addition, the chapter focused on data processing.

### 5.16 Conclusion

In this chapter, the research methodology used for the study was described, including the population, sample, data collection instruments as well as strategies used to ensure ethical standards and also why questionnaires survey was adopted for the research. The next chapter presents data analysis and discussion.

## CHAPTER SIX
## PRESENTATION OF FINDINGS AND ANALYSIS

### 6.1 INTRODUCTION

This chapter presents the findings collected from the research questionnaires survey.The questionnaires were aimed at residents of apartments and houses in the Province of Western cape in South Africa. The examination of this data and translations of its outcomes were procured from the organized survey filled in as the essential means of quantitative gathering of data.

The analysis of the data and interpretation of the results were acquired from the questionnaire study as the basis of this quantitative data collection. The questionnaire consisted of three sections, with each section having multiple questions. However; not all questions were answered, and other respondents were not consistent with their responses. Seventy-nine questionnaires were completed out of ninety that were dispensed, indicating an eighty-nine % response rate. The following exploratory factor analysis was conducted namely: The Extraction method, which is principal axis factoring and the Rotation method which includes the first order; varimax rotation as well as second order which is direct oblimin rotation.

### 6.2 Section A: BIOGRAPHICAL DATA ANALYSIS

This section represents the background information of respective respondents with regard to their demographics such as: gender, household occupants, ages of household occupants, level of education, uses of water, types of bathing etc. It is elaborated graphically below precisely what has actually been analyzed.

#### 6.2.1 Respondents demographic per gender group

Biographical gender frequencies of respondent's shows that 38% are males while females accounted for 62% as figure 6.1 below indicates.

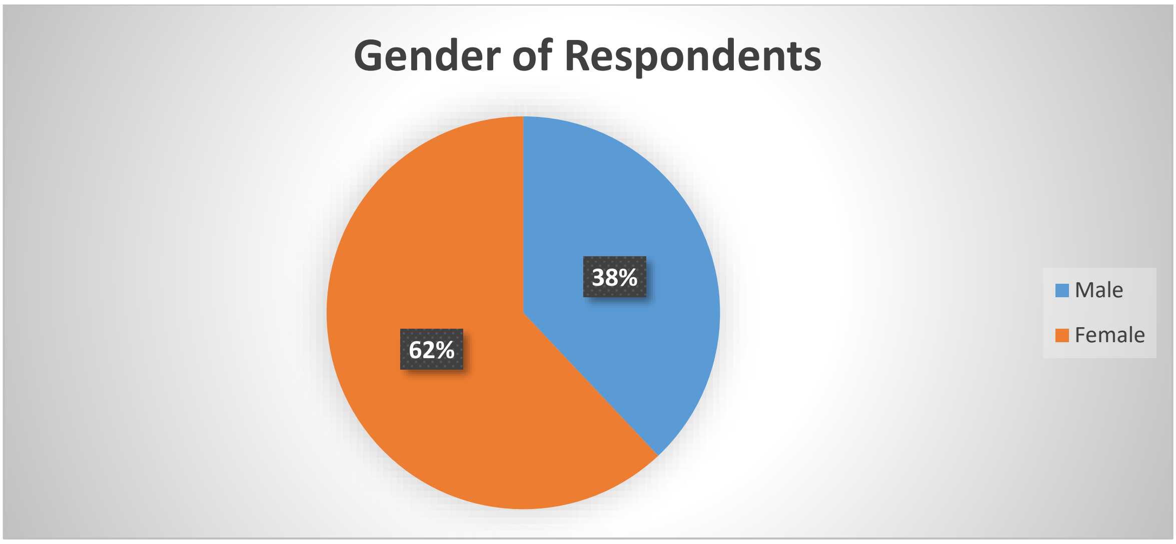


Figure 6.1 Respondent demographic per gender

### 6.2.2 Respondents demographic per age group

The sample distribution according to group of age is shown in Figure 6.2. It revealed that 12.7 % of respondents were between 0-5 years of age, 11.4 % from 6-10, 16.5 % were from 15-20, 21.5 % were from 20-25, 16.4 % were from 25-30,13.9 % were from 30-35,6.3 % were from 35-40 and lastly above 40 years of age was about 1.3 %.

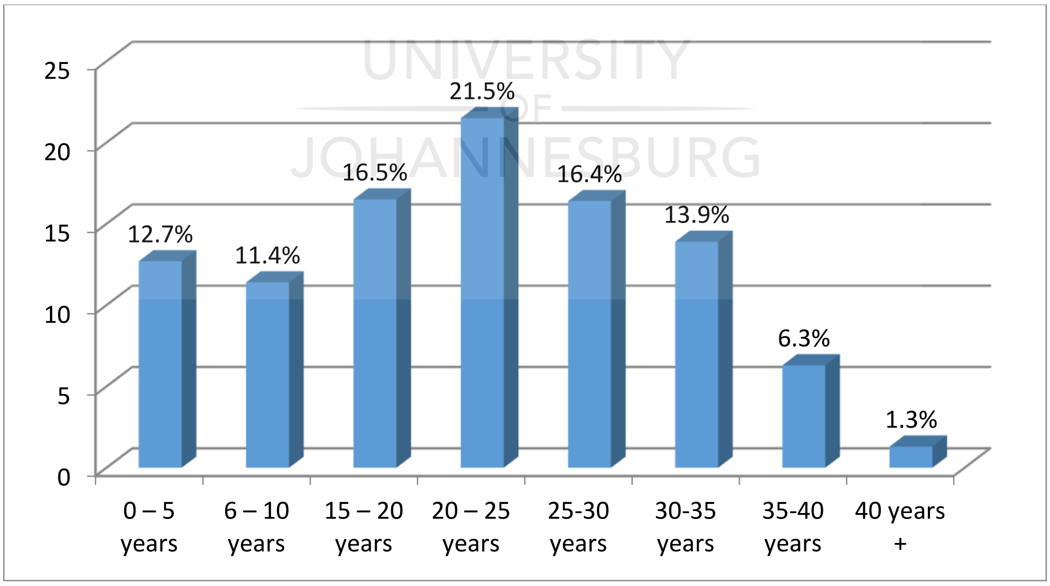


Figure 6.2: Respondent demographic per age group

### 6.2.3 Respondents demographic per educational distribution sample

The distribution sample of respondent's education are follows in figure 6.3. Those in primary education equates to 50.0%, High school 20.5%, University 14.1%, Technical training school 10.3%, No formal education a mere 5.1%.

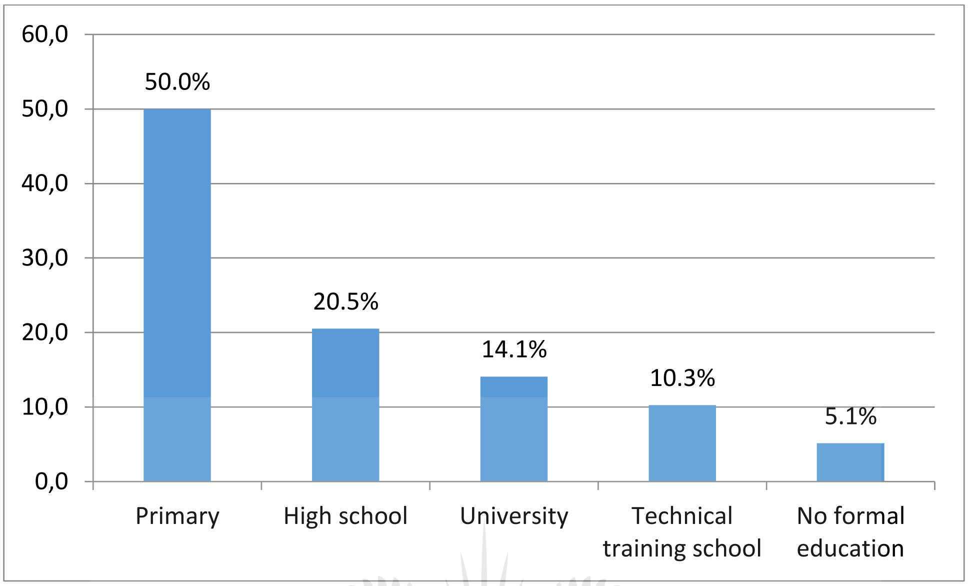


Figure 6.3 Respondent demographic as per education

### 6.2.4 Respondents demographic per sample according to type of residence

The sample distribution according to type of house the respondents reside is recorded in figure 6.4 below. This shows that; those that live in a formal house is 51.9%, informal house 13.9%, flat/apartment 34.2%.



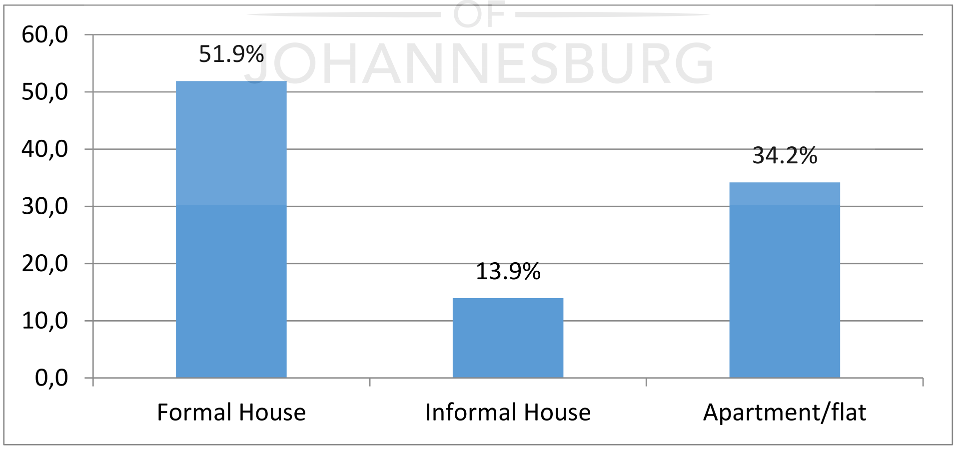


Figure 6.4 Respondent's residence type

### 6.3 Section B: HOUSEHOLD OCCUPANTS AND WATER USAGE

This section is aimed at presenting and discussing the outcomes associated with household occupants and use of water along with their ages. The mean item score (MIS) of the questions, skewness as well as the exploratory factor analysis (EFA) of the findings are represented. The descriptive outcome shows the ranking of all the factors from the highest to the lowest, with the table also showing the individual means and standard deviations of the elements. Exploratory factor analysis (EFA) is normally used in the early stages of research in order to gather data about the interrelationships among a set of variables (Pallant, 2007). The EFA was undertaken using version 21.0 of the SPSS software. The necessary tests were carried out to determine the adequacy of the sample size in order for the factor analysis to proceed.

As suggested by Pallant (2007), to determine the factorability of the correlation matrix, the correlation matrix should show some correlations of $r = 0.3$ or greater, Bartlett's test of sphericity should be statistically significant at $p < 0.05$, and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy value should be 0.6 or above. To confirm the reliability of the research instrument, the Cronbach's alpha values above 0.7 are considered acceptable but values above 0.8 are most preferable (Pallant, 2007). The recommended range for the inter-item correlation should be between 0.2 – 0.4 (Briggs & Cheek, 1986:115), in cases where the Cronbach's alpha values fall below 0.7. The afore-mentioned values are adopted in this research study.



The data has been subjected to principal component analysis (PCA) with varimax rotation. To determine the number of factors to extract using Kaiser's criterion, the total number of components with an eigenvalue of 1 or more are determined and adopted. The eigenvalue is described as a mathematical property of a matrix deployed both as a criterion of establishing the number of factors to extract and as a measure of variance accounted for by a given dimension (Dainty et al, 2003:212; Ahadzie et al., 2008:681). Also, the graphical scree test is used to exclude factors, with the scree plot indicating the cut-off point at which the eigenvalues leveled off (Dainty et al, 2003:212).

This method takes each section separately. For example, items in section B are testing household occupants use of water as a whole (Please see figure 6.1 below). This includes exploratory factor analysis, then it explores more data and tell us how many themes or factors come out of this based on how many people answered the questions.This method works on correlation.

### 6.3.1 Results from Frequencies & Descriptive Analysis

The descriptive statistics table on water usage per household indicates the information that is clearly depicted by the graph. The results of the MIS of the questions and skewness of the data are presented and discussed below (see table 6.1).

Table 6.1. Water usage per household

| **Water usage per household results** | | | |
|---|---|---|---|
| | **Mean** | **Std. Deviation** | **Rank** |
| How many times per week does your family wash the clothes and beddings | | | |
| Rarely | 8.093 | 1.983 | 1 |
| Once a week | 3.313 | 1.544 | 2 |
| Twice a week | 2.080 | 1.032 | 3 |

Table 6.1 indicates the respondents ranking of water usage questions that can help improve the use of water in Cape Town city. It shows that families rarely wash their clothes and bedding which was ranked first with a mean score of 8.093. and standard deviation of 1.983. Second was once a week with a mean score of 3.313 and standard deviation of 1.544. Most often was twice a week with a mean score of 2.080 and standard deviation of 1.032.

Table 6.2 Shower usage in warm season

| How is the shower used daily if it's there in the warm season | **Mean** | **Std. Deviation** | **Rank** |
|---|---|---|---|
| Twice | 4.21 | 1.087 | 1 |
| 3 Times | 3.30 | 1.162 | 2 |
| 4 Times | 3.29 | 0.981 | 3 |
| 5 Times | 3.22 | 1.133 | 4 |
| 6 Times | 3.14 | 0.999 | 5 |
| 7 Times | 2.72 | 0.872 | 6 |
| More than 7 times | 2.54 | 1.077 | 7 |

Table 6.2 indicates the respondents ranking of shower usage in the warm season. It shows that most families shower twice daily and was ranked first with a mean score of 4.21 with a standard deviation of 1.087, secondly was those that shower three times with a mean score of 3.30 and standard deviation of 1.162. Thirdly are those that shower 4 times a day with a mean score of 3.29 and standard deviation of 0.981. Fourthly was those that shower 5 times a day with a mean score of 3.22 and standard deviation of 1.133. Fifthly and strangely there are families that shower six times a day with a mean score of 3.14 and standard deviation of

0.999. Sixthly are those that shower 7 times a day with a mean score of 2.72 and a standard deviation of 0.872. Least often are those that shower more than 7 times with a mere mean score of 2.54 and standard deviation of 1.077.

Table 6.3 Shower usage in cold season

| How is the shower used daily if it's there in cold season | Mean | Std. Deviation |
|---|---|---|
| Twice | 3.01 | 1.064 |
| 3 Times | 2.73 | 1.062 |
| 4 Times | 2.41 | 1.981 |
| more than 5 times | 2.12 | 0.133 |

Table 6.3 indicates the respondents' ranking of shower usage in cold season. It shows that most families shower twice daily, ranked first with a mean score of 3.01 with a standard deviation of 1.064. Next were those that shower three times with a mean score of 2.73 and a standard deviation of 1.062, thirdly are those that shower 4 times a day with a mean score of 2.41 and standard deviation of 1.981. Least often are those that shower more than 5 times with a mean score of 2.12 and standard deviation of 0.133.

Table 6.4 Leakages

| Does your house have any leaking taps and toilet? | Mean | Std. Deviation | Rank |
|---|---|---|---|
| Dripping? | 5.44 | 1.781 | 1 |
| Running? | 2.893 | 1.188 | 2 |



Table 6.4 indicates the respondents ranking of leakages in the house. It shows that indeed there are some leaks in most households, ranked first with a mean score of 5.44 and a standard deviation of 1.781. Least were those with heavy leaks that run daily with a mean score of 2.893 and standard deviation of 1.188.

#### 6.3.1.1 Factor Analysis

Before performing the principal component analysis (PCA), the suitability of information for factor analysis was assessed. Inspection of the correlation matrix revealed the presence of a mere 10 coefficients of above 0.3 as presented in Table 6.5. As shown in Table 6.6, the KMO measure of sampling adequacy achieved a value of 0.457, which is **NOT** exceeding the recommended minimum value of 0.6. The Bartlett's test of sphericity was also statistically insignificant (less than 0.05), thus not supporting the factorability of the correlation matrix.

This however is not a cause for concern because it simply means strategies cannot be grouped together because correlations between the items were low, and diagnostics from factor analysis is way too low to be presented as a group, as the Correlations and KMO indicate. Factor analysis indicates therefore that strategies will not be used as a group. It's not possible to combine strategies into a smaller group of strategies. This will also apply with reliability analysis because you are not getting internal consistencies between the statements which indicate that the statements need to be treated as a separate strategy. This simply means that it's not possible to combine strategies into a single strategy or smaller strategies.

Data reduction can be defined as the process of representing a number of items as a factor. An attempt to perform data reduction was made whereby items (questions) from different sections of the questionnaire were subject to an exploratory factor analysis (efa) and internal consistency analysis. Sections tested in this way included (a) change in price of cold and hot water, electricity and heating (Q11) (b) change in usage under different scenarios e.g. if water price increased (Q12) (c) policy suggestions for when water is scarce (Q13) (d) water saving habits (Q14), and strategies to save water (Q15). Results from the education for all and internal consistency analysis suggested it would not be possible to generate factors from items. For example, the KMO for the efa for knowledge of water price was 0.457, well below the recommended value of 0.600. The low KMO was elicited because the correlations between items proposed to make it up were low. The measure for internal consistency for knowledge for water price items was low (Cronbach alpha = -). These results indicated it was not possible to combine knowledge of water price items into a factor (or factors). Similar results were obtained for other dimensions.

Table 6.5 Factor Analysis Correlation Matrix Household occupants (Factor 1)

| **Correlation Matrix** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | KFWP6 | KFWP7 | KFWP8 | rKFWP9 | KFWP10 | KFWP11 |
| **Correlation** | KFWP6 | **1.000** | -0.042 | 0.030 | -0.071 | -0.046 | 0.189 |
| | KFWP7 | -0.042 | **1.000** | -0.147 | 0.058 | -0.213 | -0.076 |
| | KFWP8 | 0.030 | -0.147 | **1.000** | 0.072 | 0.106 | -0.027 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | rKFWP9 | -0.071 | 0.058 | 0.072 | **1.000** | -0.387 | -0.092 |
| | KFWP10 | -0.046 | -0.213 | 0.106 | -0.387 | **1.000** | -0.149 |
| | KFWP11 | 0.189 | -0.076 | -0.027 | -0.092 | -0.149 | **1.000** |

Table 6.6 KMO and Bartlett’s test for household occupants

| **KMO and Bartlett's Test** | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | 0.457 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 26.404 |
| | df | 15 |
| | Sig. | 0.034 |

Table 6.6 shows a low KMO and low Cronbach alpha for each dimension. These results are not unexpected, because the dimensions included a wide range of policies, behaviours, activities and proposed strategies. For example, strategies included installing sub meters, protecting the Cape Town river and reducing water flow, three very different options. Since the statistical analysis did not elicit groups of items, it was decided to analyse items separately.

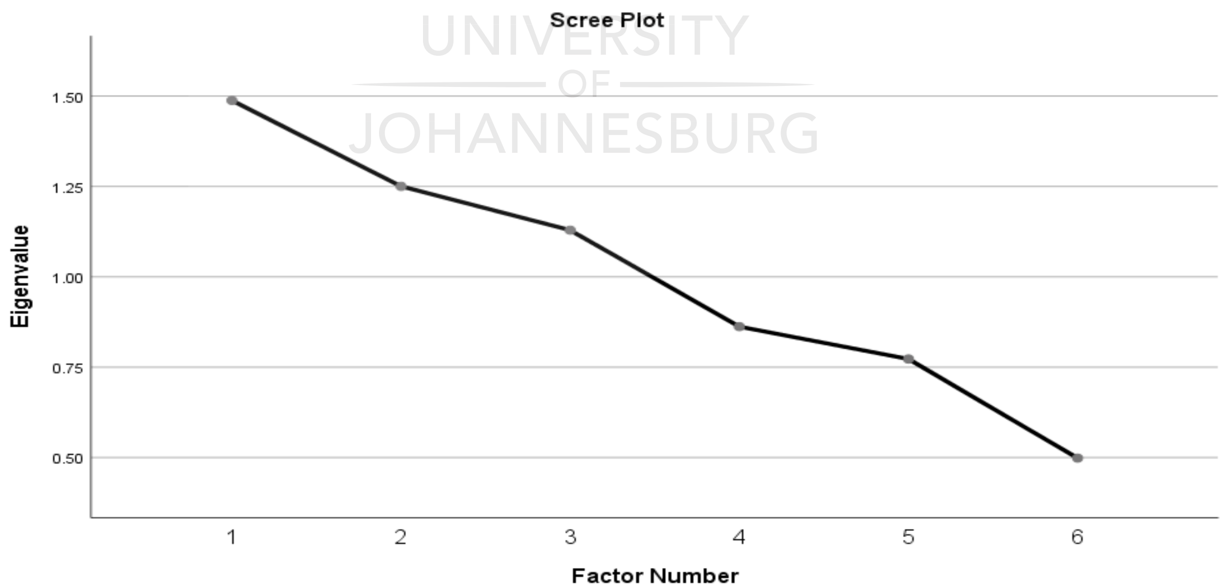


Figure 6.5 Scree plot Household occupants

The scree plot presented in Figure 6.5 also revealed the excluded factors by indicating the cut-off point at which the eigenvalues levelled off. The total variance explained by each of the extracted factors is shown in table 6.7 Thus, the final statistics of the PCA and the extracted factors accounted for approximately 64.44% % of the total cumulative variance.

Table 6.7 Explanation of total variance for factor one Household occupants

| **Total Variance Explained** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Factor | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 1.488 | 24.796 | 24.796 | 1.031 | 17.182 | 17.182 | 0.950 | 15.828 | 15.828 |
| 2 | 1.250 | 20.837 | 45.633 | 0.564 | 9.404 | 26.586 | 0.560 | 9.336 | 25.165 |
| 3 | 1.129 | 18.816 | **64.449** | 0.374 | 6.233 | 32.819 | 0.459 | 7.654 | 32.819 |
| 4 | 0.862 | 14.368 | 78.817 | | | | | | |
| 5 | 0.773 | 12.875 | 91.693 | | | | | | |
| 6 | 0.498 | 8.307 | 100.000 | | | | | | |

Extraction Method: Principal Axis Factoring.

### 6.3.2 Reliability Test Analysis of Household occupants and water usage for factor one

The collected information from the study was tested for reliability, normality, correlation and the compatibility or comparison to enable the researcher to make a prediction about the population. The internal consistency of the data collected on household occupants and water usage was measured by calculating the Cronbach's alpha coefficient. Table 6.8 below presents the reliability analysis.

Table 6.8 Reliability analysis for household occupants and water usage for factor one

| **Reliability Statistics** | | |
|---|---|---|
| Cronbach's Alpha[a] | Cronbach's Alpha Based on Standardized Items[a] | N of Items |
| -0.066 | -0.434 | 6 |
| a. The value is negative due to a negative average covariance among items. This violates reliability model assumptions. | | |

The results are negative because the researcher did not get internal consistencies between the statements from respondents which indicates that the statements need to be treated as a separate strategy. This simply means that it's not possible to combine strategies into a single strategy or smaller strategies to get reliable results.

Before performing the principal component analysis (PCA), the suitability of information for factor analysis was assessed. Inspection of the correlation matrix revealed the presence of a mere 5 coefficients above 0.3 as presented in Table 6.9. As shown in Table 6.10, the KMO measure of sampling adequacy achieved a value of 0.503, which is **NOT** exceeding the recommended minimum value of 0.6. The Bartlett's test of sphericity was also statistically insignificant (less than 0.05), thus not supporting the factorability of the correlation matrix.

This however is not cause for concern, it simply means strategies cannot be grouped together because correlations between the items were low and diagnostics from factor analysis is way too low to be presented as a group as the Correlations and KMO indicate. Factor analysis indicated that strategies will not be used as a group. It's not possible to combine strategies into smaller group of strategies. This also applies with reliability because you not getting internal consistencies between the statements, and that indicates that the statements need to be treated as a separate strategy. This simply means that it's not possible to combine strategies into a single strategy or smaller strategies.



Table 6.9 Factor Analysis Correlation Matrix (Factor 2)

Correlation Matrix

| | | KFWP12 | KFWP13 | KFWP14 | KFWP15 |
|---|---|---|---|---|---|
| Correlation | KFWP12 | **1.000** | 0.179 | -0.171 | 0.906 |
| | KFWP13 | 0.179 | **1.000** | 0.044 | 0.088 |
| | KFWP14 | -0.171 | 0.044 | **1.000** | -0.178 |
| | KFWP15 | 0.906 | 0.088 | -0.178 | **1.000** |

Table 6.10 KMO and Bartlett's Test for factor two

| **KMO and Bartlett's Test** | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | 0.503 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 138.182 |
| | df | 6 |
| | Sig. | 0.000 |

Table 6.10 shows a low KMO and low Cronbach alpha for each dimension. These results are not unexpected, because e.g. dimensions included a wide range of policies, behaviours, activities and proposed strategies. For example, strategies included installing sub meters, protecting the Cape Town river and reducing water flow, three very different options. Since the statistical analysis did not elicit groups of items, it was decided to analyse items separately.

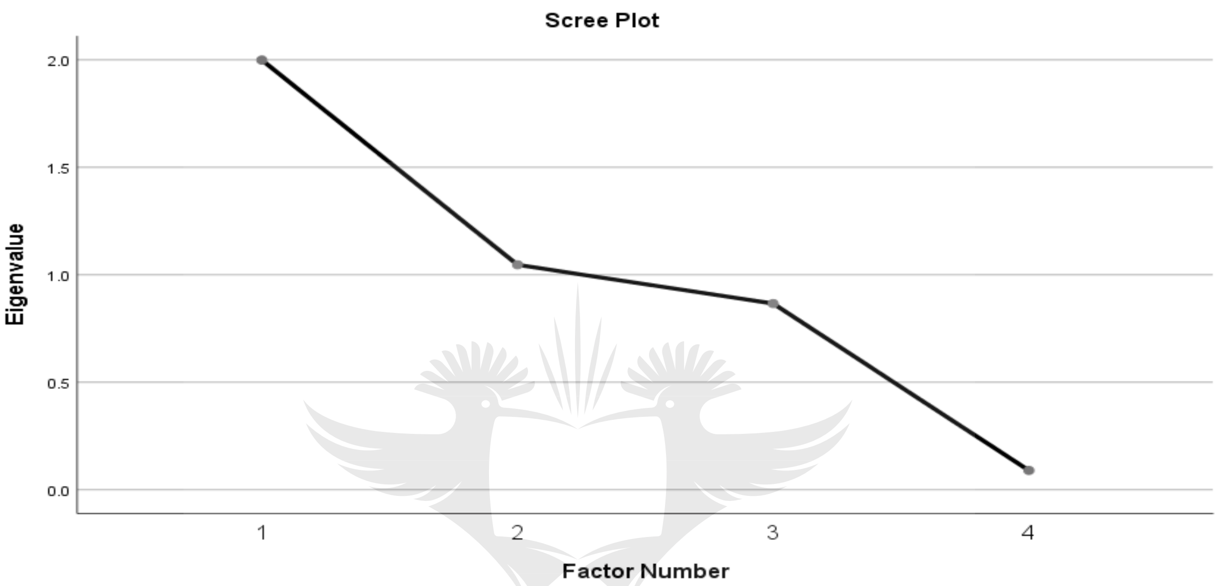


Figure 6.6 Scree plot for factor two

The scree plot presented in Figure 6.6 also revealed the excluded factors by indicating the cut-off point at which the eigenvalues levelled off. The total variance explained by each of the extracted factors is shown in table 6.11 Thus, the final statistics of the PCA and the extracted factors accounted for approximately 76.12% % of the total cumulative variance.

Table 6.11 Explanation of total variance for factor two

| **Total Variance Explained** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
| Factor | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 1.999 | 49.970 | 49.970 | 1.887 | 47.164 | 47.164 | 1.792 | 44.809 | 44.809 |
| 2 | 1.046 | 26.153 | **76.123** | 0.225 | 5.637 | 52.801 | 0.320 | 7.991 | 52.801 |
| 3 | 0.866 | 21.644 | 97.767 | | | | | | |
| 4 | 0.089 | 2.233 | 100.000 | | | | | | |
| Extraction Method: Principal Axis Factoring. | | | | | | | | | |

### 6.3.3 Reliability Test Analysis of Household occupants and water usage for factor two

The collected information from the study was tested for reliability, normality, correlation and the compatibility or comparison to enable the researcher to make a prediction about the population. The internal consistency of the data collected on household occupants and water usage was measured by calculating the Cronbach's alpha coefficient. Table 6.12 below presents the reliability analysis

Table 6.12 Reliability analysis for household occupants and water usage for factor two

| **Statement** | **Reliability Statistics** | | |
|---|---|---|---|
| | Cronbach's Alpha | Cronbach's Alpha Based on Standardized Items | N of Items |
| Scarcity of water | 0.460 | 0.403 | 4 |

From table 6.12, the Cronbach's alpha for household occupants is as follows: scarcity of water is based on a 4- item scale of 0.403. According to Tayokol and Dennick (2011), Cronbach's alpha of 0.7 to 0.9 is **not** an acceptable value. However, this is mainly due to factor analysis indicating that strategies will not be used as a group, as there is no sufficient correlation.



Before performing the principal component analysis (PCA), the suitability of information for factor analysis was assessed. Inspection of the correlation matrix revealed the presence of a mere 7 coefficients above 0.3 as presented in Table 6.13. As shown in Table 6.14, the KMO measure of sampling adequacy achieved a value of 0.424, which is **NOT** exceeding the recommended minimum value of 0.6. The Bartlett's test of sphericity was also statistically insignificant (less than 0.05), thus not supporting the factorability of the correlation matrix.

This however is not a cause for concern. It simply means that strategies cannot be grouped together because correlations between the items were low and diagnostics from factor analysis is way too low to be presented as a group, as the Correlations and KMO indicate. Factor analysis indicates that strategies will not be used as a group because it's not possible to combine strategies into smaller group of strategies. This will also apply to reliability, because you are not getting internal consistencies between the statements. This indicates that the statements need to be treated as a separate strategy. This simply means that it's not possible to combine strategies into single strategy or smaller strategies.

Table 6.13 Factor Analysis Correlation Matrix (Factor 3)

| Correlation Matrix | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | WSHANPP1 | WSHANPP2 | WSHANPP3 | WSHANPP4 | WSHANPP5 | WSHANPP |
| Correlation | WSHANPP1 | **1.000** | -0.003 | -0.055 | -0.053 | -0.230 | -0.153 |
| | WSHANPP2 | -0.003 | **1.000** | -0.013 | -0.074 | 0.010 | 0.000 |
| | WSHANPP3 | -0.055 | -0.013 | **1.000** | 0.231 | -0.140 | -0.040 |
| | WSHANPP4 | -0.053 | -0.074 | 0.231 | **1.000** | -0.122 | 0.291 |
| | WSHANPP5 | -0.230 | 0.010 | -0.140 | -0.122 | **1.000** | -0.245 |
| | WSHANPP6 | -0.153 | 0.000 | -0.040 | 0.291 | -0.245 | **1.000** |
| | WSHANPP7 | -0.046 | 0.112 | -0.033 | -0.088 | 0.143 | 0.051 |

Table 6.14 KMO and Bartlett's Test for factor three

| KMO and Bartlett's Test | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | **0.424** |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 31.212 |
| | df | 21 |
| | Sig. | 0.070 |

Table 6.14 shows a low KMO and low Cronbach alpha for each dimension. These results are not unexpected, because e.g. dimensions included a wide range of policies, behaviours, activities and proposed strategies. For example, strategies included installing sub meters, protecting the Cape Town river and reducing water flow, three very different options. Since the statistical analysis did not elicit groups of items, it was decided to analyse items separately.

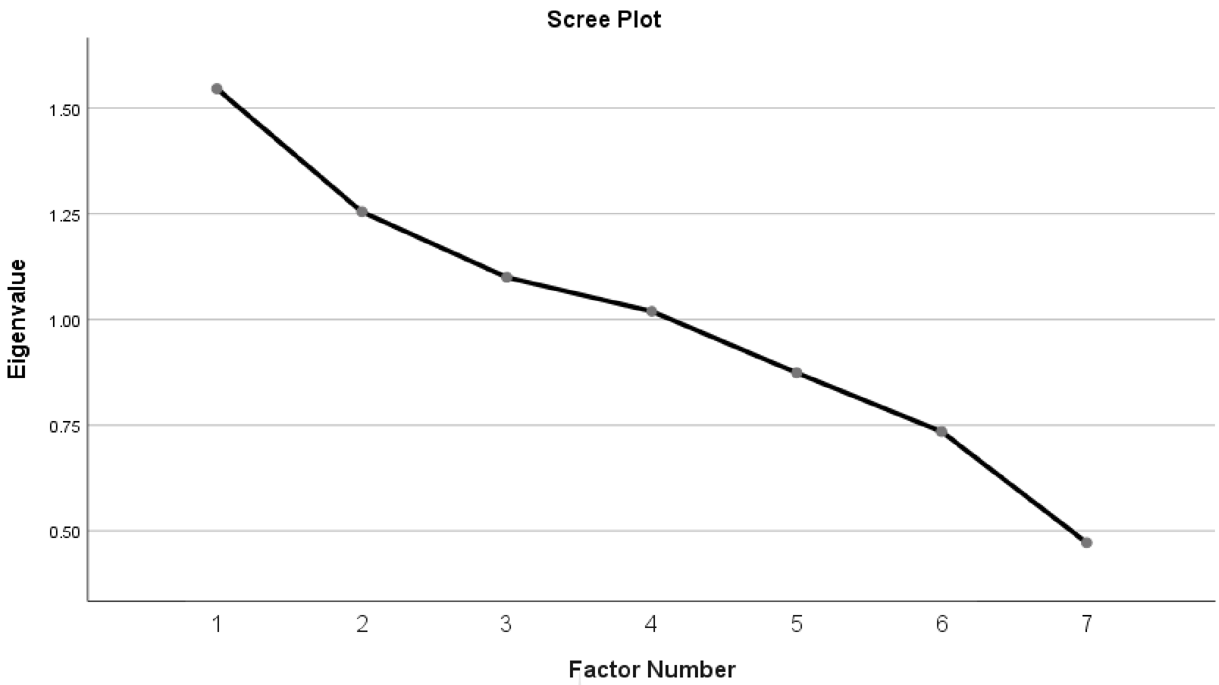


Figure 6.7 Scree plot for factor three

The scree plot presented in Figure 6.7 also revealed the excluded factors by indicating the cut-off point at which the eigenvalues levelled off. The total variance explained by each of the extracted factors is shown in table 6.15 Thus, the final statistics of the PCA and the extracted factors accounted for approximately 70.27% % of the total cumulative variance.



Table 6.15 Explanation of total variance for factor three

| **Total Variance Explained** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Factor | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 1.546 | 22.081 | 22.081 | 1.138 | 16.252 | 16.252 | 1.033 | 14.758 | 14.758 |
| 2 | 1.255 | 17.924 | 40.005 | 0.726 | 10.365 | 26.618 | 0.701 | 10.014 | 24.772 |
| 3 | 1.100 | 15.709 | 55.715 | 0.571 | 8.153 | 34.771 | 0.651 | 9.296 | 34.068 |
| 4 | 1.019 | 14.561 | **70.276** | 0.256 | 3.660 | 38.431 | 0.305 | 4.363 | 38.431 |
| 5 | 0.874 | 12.482 | 82.758 | | | | | | |
| 6 | 0.735 | 10.496 | 93.254 | | | | | | |
| 7 | 0.472 | 6.746 | 100.000 | | | | | | |
| Extraction Method: Principal Axis Factoring. | | | | | | | | | |

**6.3.4 Reliability Test Analysis of Household occupants and water usage for factor three**

The collected information from the study was tested for reliability, normality, correlation and the compatibility or comparison to enable the researcher to make a prediction about the population. The internal consistency of the data collected on household occupants and water usage was measured by calculating the Cronbach's alpha coefficient. Table 6.16 below presents the reliability analysis.

Table 6.16 Reliability analysis for household occupants and water usage for factor three

| **Reliability Statistics** | | |
|---|---|---|
| Cronbach's Alpha | Cronbach's Alpha Based on Standardized Items[a] | N of Items |
| 0.012 | -0.176 | 7 |
| a. The value is negative due to a negative average covariance among items. This violates reliability model assumptions. | | |

The results are negative because the researcher did not get internal consistencies between the statements from respondents which indicates that the statements need to be treated as a separate strategy. This simply means that it's not possible to combine strategies into single strategy or smaller strategies to get reliable results. This however is not a cause for concern.

Before performing the principal component analysis (PCA), the suitability of information for factor analysis was assessed. Inspection of the correlation matrix revealed the presence of a mere 12 coefficients of above 0.3, as presented in Table 6.17. As shown in Table 6.18, the KMO measure of sampling adequacy achieved a value of 0.446, which is **NOT** exceeding the recommended minimum value of 0.6. The Bartlett's test of sphericity was also statistically insignificant (less than 0.05), thus not supporting the factorability of the correlation matrix.

This however is not a cause for concern. It simply means that strategies cannot be grouped together, because correlations between the items were low and diagnostics from factor analysis is way too low to be presented as a group as Correlations and KMO indicate. Factor analysis indicates that strategies will not be used as a group and it's not possible to combine strategies into smaller group of strategies. This also applies for reliability, because you are not getting internal consistencies between the statements which indicates that the statements need to be treated as a separate strategy. This simply means that it's not possible to combine strategies into single strategies or smaller strategies.

Table 6.17 Factor Analysis Correlation Matrix (Factor 4)

| Correlation Matrix | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | WSHANPP9 | WSHANPP10 | WSHANPP11 | WSHANPP12 | WSHANPP13 | WSHANPP14 | WSHANPP15 | WSHANPP16 | WSHANPP17 | WSHANPP18 | WSHANPP19 | WSHANPP20 |
| Correlation | WSHANPP9 | **1.000** | -0.118 | -0.268 | -0.117 | 0.131 | -0.005 | -0.062 | -0.050 | -0.064 | 0.010 | -0.072 | 0.119 |
| | WSHANPP10 | -0.118 | **1.000** | -0.019 | -0.186 | -0.024 | -0.252 | -0.027 | 0.125 | -0.115 | 0.118 | 0.028 | -0.135 |
| | WSHANPP11 | -0.268 | -0.019 | **1.000** | -0.123 | -0.193 | 0.002 | -0.018 | 0.158 | -0.086 | -0.043 | 0.005 | 0.123 |
| | WSHANPP12 | -0.117 | -0.186 | -0.123 | **1.000** | 0.084 | 0.089 | -0.060 | -0.134 | -0.019 | 0.025 | -0.019 | -0.040 |
| | WSHANPP13 | 0.131 | -0.024 | -0.193 | 0.084 | **1.000** | -0.229 | -0.026 | 0.033 | -0.186 | 0.170 | -0.057 | -0.090 |
| | WSHANPP14 | -0.005 | -0.252 | 0.002 | 0.089 | -0.229 | **1.000** | -0.093 | -0.128 | 0.058 | -0.086 | -0.053 | 0.059 |
| | WSHANPP15 | -0.062 | -0.027 | -0.018 | -0.060 | -0.026 | -0.093 | **1.000** | -0.129 | -0.059 | -0.058 | -0.168 | -0.188 |
| | WSHANPP16 | -0.050 | 0.125 | 0.158 | -0.134 | 0.033 | -0.128 | -0.129 | **1.000** | -0.072 | -0.034 | -0.122 | 0.060 |
| | WSHANPP17 | -0.064 | -0.115 | -0.086 | -0.019 | -0.186 | 0.058 | -0.059 | -0.072 | **1.000** | 0.023 | 0.004 | -0.114 |
| | WSHANPP18 | 0.010 | 0.118 | -0.043 | 0.025 | 0.170 | -0.086 | -0.058 | -0.034 | 0.023 | **1.000** | -0.025 | -0.069 |
| | WSHANPP19 | -0.072 | 0.028 | 0.005 | -0.019 | -0.057 | -0.053 | -0.168 | -0.122 | 0.004 | -0.025 | **1.000** | 0.418 |
| | WSHANPP20 | 0.119 | -0.135 | 0.123 | -0.040 | -0.090 | 0.059 | -0.188 | 0.060 | -0.114 | -0.069 | 0.418 | **1.000** |

Table 6.18 KMO and Bartlett's Test for factor four

| **KMO and Bartlett's Test** | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | **0.446** |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 75.770 |
| | df | 66 |
| | Sig. | 0.192 |



Table 6.18 shows a low KMO and low Cronbach alpha for each dimension. These results are not unexpected because the dimensions included a wide range of policies, behaviours, activities and proposed strategies. For example, strategies included installing sub meters, protecting the Cape Town river and reducing water flow, three very different options. Since the statistical analysis did not elicit groups of items, it was decided to analyse items separately.

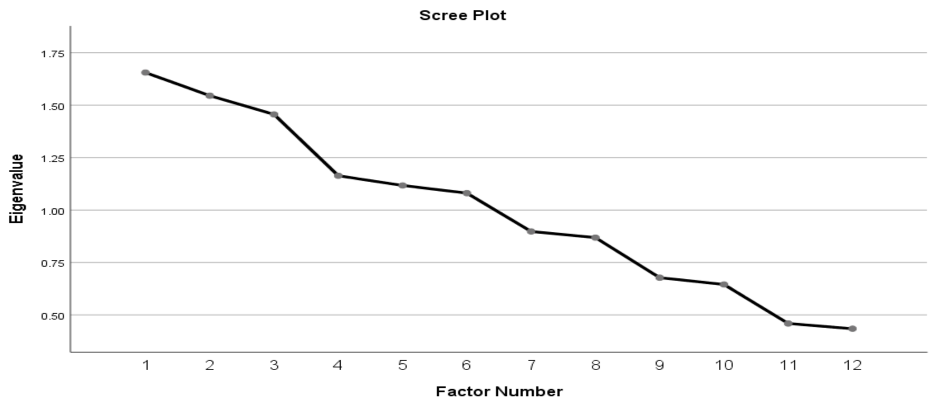


Figure 6.8 scree plot for factor four

The scree plot presented in Figure 6.8 also revealed the excluded factors by indicating the cut-off point at which the eigenvalues levelled off. The total variance explained by each of the extracted factors is shown in table 6.19. Thus, the final statistics of the PCA and the extracted factors accounted for approximately 74.30% % of the total cumulative variance.

Table 6.19 Explanation of total variance for factor four

| **Total Variance Explained** | | | | | | |
|---|---|---|---|---|---|---|
| Factor | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | |
| | Total | %of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 1.656 | 13.797 | 13.797 | 1.195 | 9.959 | 9.959 |
| 2 | 1.545 | 12.878 | 26.675 | 1.034 | 8.615 | 18.574 |
| 3 | 1.456 | 12.135 | 38.810 | 0.899 | 7.495 | 26.069 |
| 4 | 1.163 | 9.696 | 48.506 | 0.636 | 5.297 | 31.366 |
| 5 | 1.117 | 9.311 | 57.817 | 0.564 | 4.703 | 36.069 |
| 6 | 1.080 | 9.004 | 66.821 | 0.489 | 4.079 | 40.148 |
| 7 | 0.898 | 7.482 | **74.302** | | | |
| 8 | 0.868 | 7.237 | 81.540 | | | |
| 9 | 0.677 | 5.645 | 87.185 | | | |
| 10 | 0.645 | 5.375 | 92.560 | | | |
| 11 | 0.459 | 3.824 | 96.384 | | | |
| 12 | 0.434 | 3.616 | 100.000 | | | |
| Extraction Method: Principal Axis Factoring. | | | | | | |



### 6.3.5 Reliability Test Analysis of Household occupants and water usage for factor three

The collected information from the study was tested for reliability, normality, correlation and the compatibility or comparison to enable the researcher to make a prediction about the population. The internal consistency of the data collected on household occupants and water usage was measured by calculating the Cronbach's alpha coefficient. Table 6.20 below presents the reliability analysis.

Table 6.20 Reliability analysis for household occupants and water usage for factor fourT

| **Reliability Statistics** | | |
|---|---|---|
| Cronbach's Alpha[a] | Cronbach's Alpha Based on Standardized Items[a] | N of Items |
| -0.869 | -0.724 | 12 |
| a. The value is negative due to a negative average covariance among items. This violates reliability model assumptions. | | |

The results are negative because the researcher did not get internal consistencies between the statements from respondents, and that indicates that the statements needs to be treated as a separate strategy. This simply means that it's not possible to combine strategies into single strategy or smaller strategies to get reliable results. This however is not a cause for concern, as respondent's behavior is still recorded in descriptive analysis.



### 6.4 Normality test

The supposition should be tested that the data gathered follows a normal distribution (Razali & Wah, 2011). However, a normality test was **not** conducted on all four factors relating to household respondents with regards to water, because there was a lack of consistency between the statements from respondents.

For example, the Kolmogorov-Smirnov test results states that each of the p-values presented should be higher than 0.05. According to Ghasemi and Zahediasi (2012), if the p-value is higher than 0.05 then it is an indication of normal distribution, which was not the current case.

The Shapiro-Wilk test results also state that all the values presented should fall between 0 and 1. The values of a normal distribution on a Shapiro-Wilk test fall between 0 and 1 (Razali & Wah, 2011). Each of the p-values presented should be higher than 0.05. According to

Ghasemi and Zahediasi (2012), if the p-value is higher than 0.05 then it is an indication of normal distribution which was not supported in this case as some values were negative.

### 6.4.1 Comparison test of between male and Female water usage

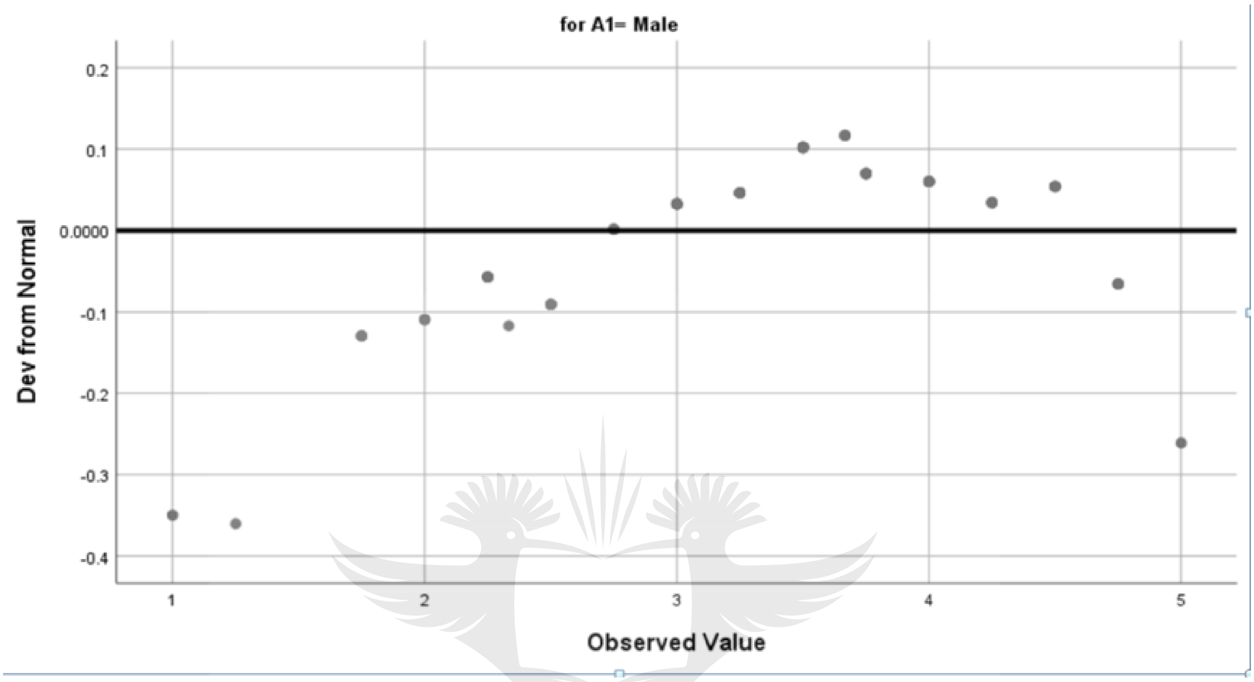


Figure 6.9 water usage comparison for males

Figure 6.9 demonstrates the exact pattern of male water usage in different seasons. It depicts the inconsistency of responses as was earlier highlighted in Factor analyses. This graph explains exactly why it is not a neutral response, based on the illustration of the gender histogram.

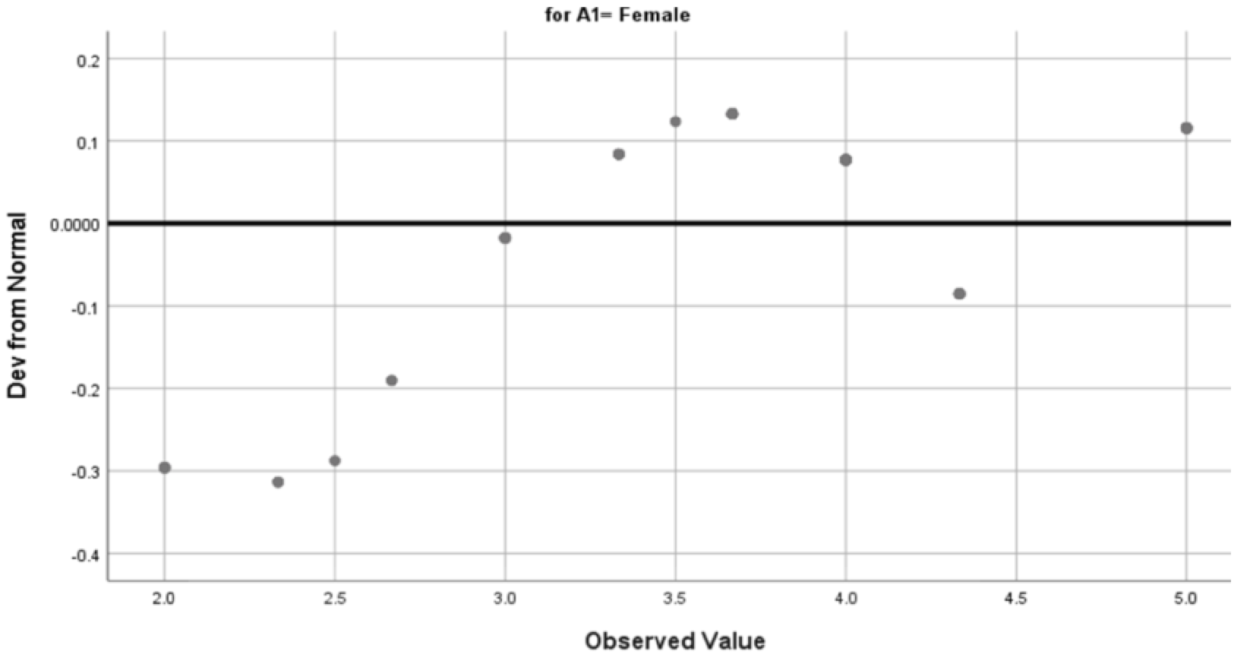


Figure 6.10 water usage comparison female

Figure 6.10 demonstrates the exact pattern of female water usage in different seasons, it depicts the inconsistency of responses as earlier highlighted in Factor analyses. This graph shows the pattern of water usage by female respondents.

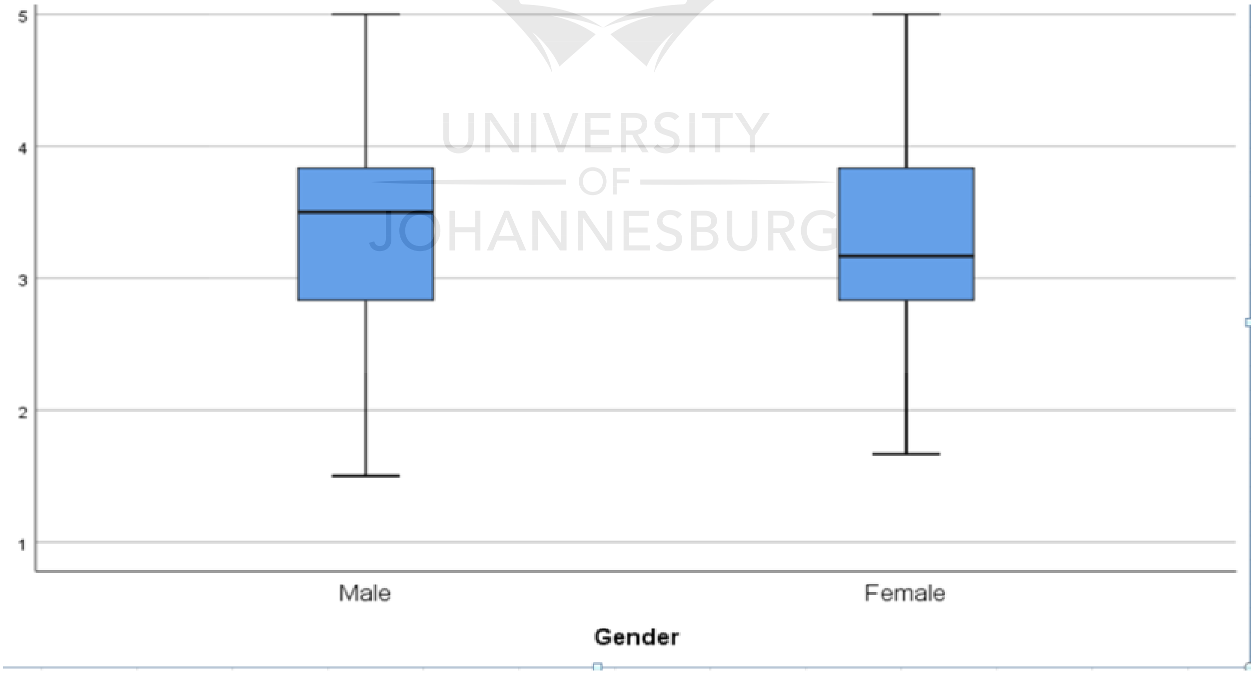


Figure 6.11 Observed Values between male and female respondents per water usage

Figure 6.11 shows that males bathed 3.164 times daily, which is about the difference of 0.58, and the significance is 0.000. Females bathed 3.001 times daily which is a difference of 0.29 which equates to the significance of 0.000. That's how low the margin for genders are.

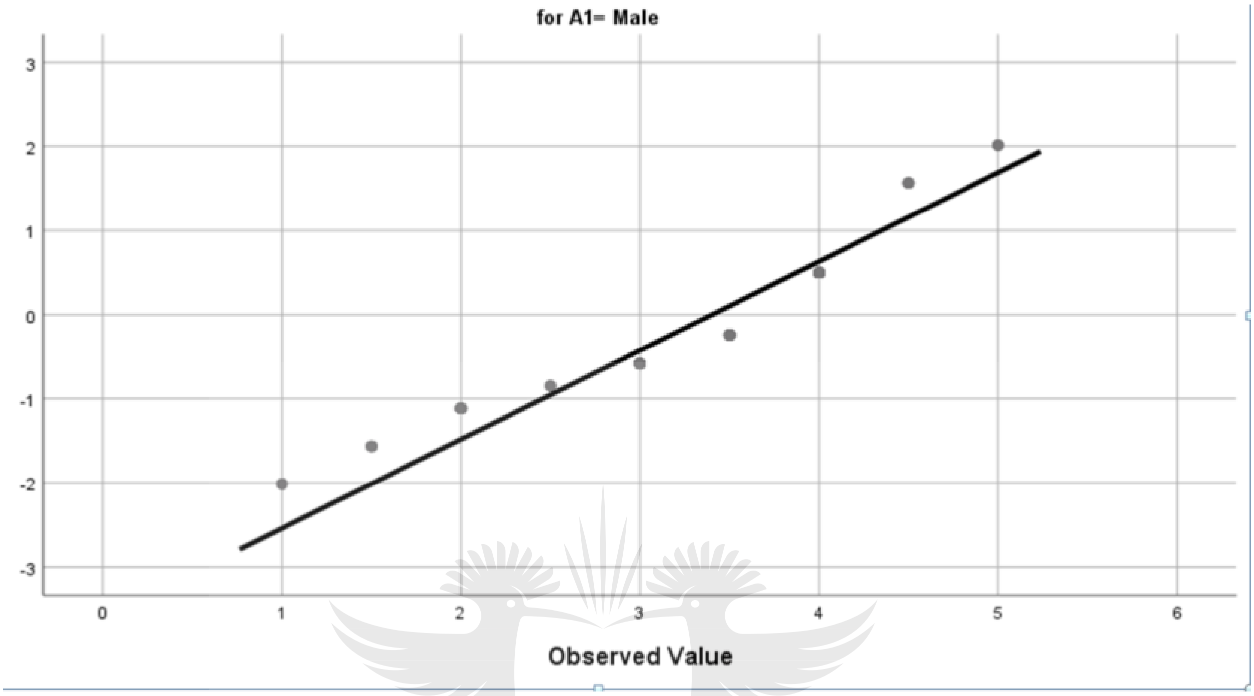


Figure 6.12 Observed normality test for male

Figure 6.12 demonstrates the exact abnormalities that demonstrate inconsistency with regard to water usage for male respondents. Some have shown negative responses while others responded positively when answering the questionnaire. An example for this is the first question which says, "do you have a shower at home?" A respondent can answer "No", but later say "I shower three times a day". This causes major confusion; hence a normality test was not carried out.

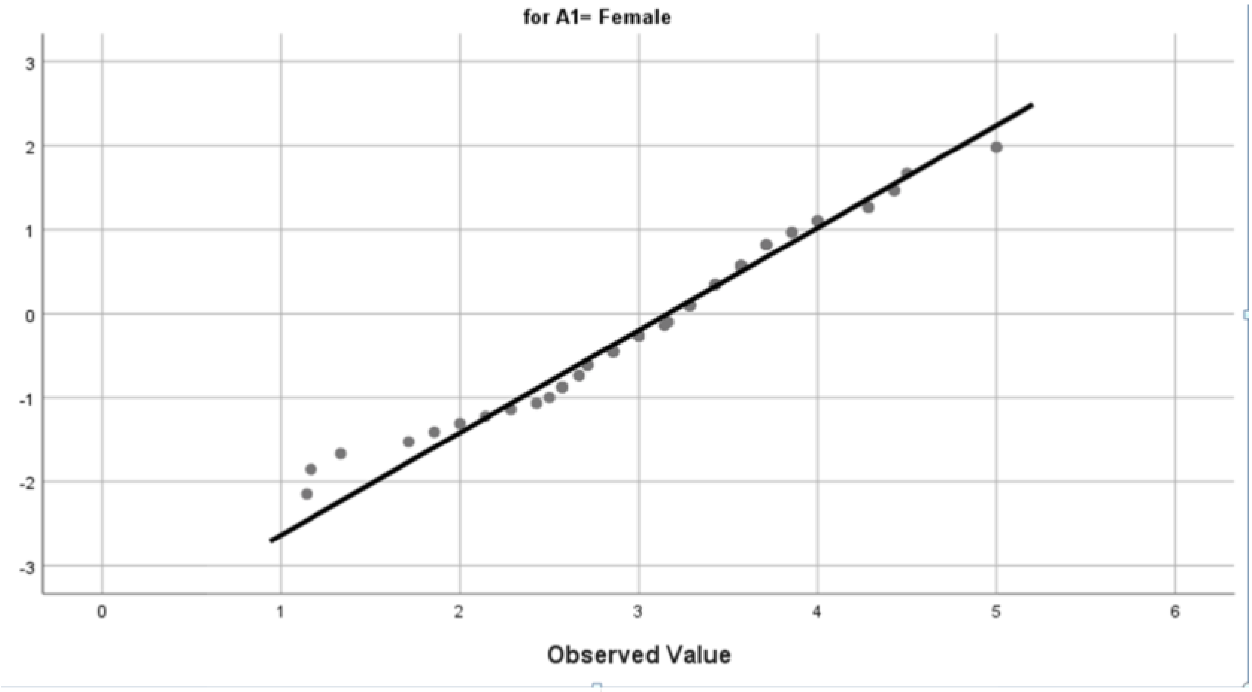


Figure 6.13 Observed normality test for females

Figure 6.13 demonstrates the exact abnormalities that demonstrate inconsistency with regard to water usage per female respondents. Some have shown negative responses, while others responded positively when answering the questionnaire. An example for this is the first question which says; "do you have a shower at home?" Respondents can answer "No", but later say "I shower three times a day". This causes major confusion; hence a normality test was not carried out.



### 6.4.2 Detrended Analysis

Linear correlation was used to identify existence of a straight-line relationship between water usage and water challenges. A scatter plot, regression analysis and multiple regression was conducted. This, as indicated by Pallant (2007), is perfect for conducting an investigation for correlation analysis. Figure 6.15 below depicts the regression analysis testing the linear relationship between water usage and water challenges. By observing the values in Figures 6.15 and 6.16, the information was not grouped along a straight line due to inconsistencies from respondents, which is an assumption of an indirect relationship, which is a presumption of linear correlation. This regression analysis  would make a prediction from the population not to be clear. This data analysis takes into consideration for both male and female respondents as per figure 6.14 and figure 6.15 respectively.

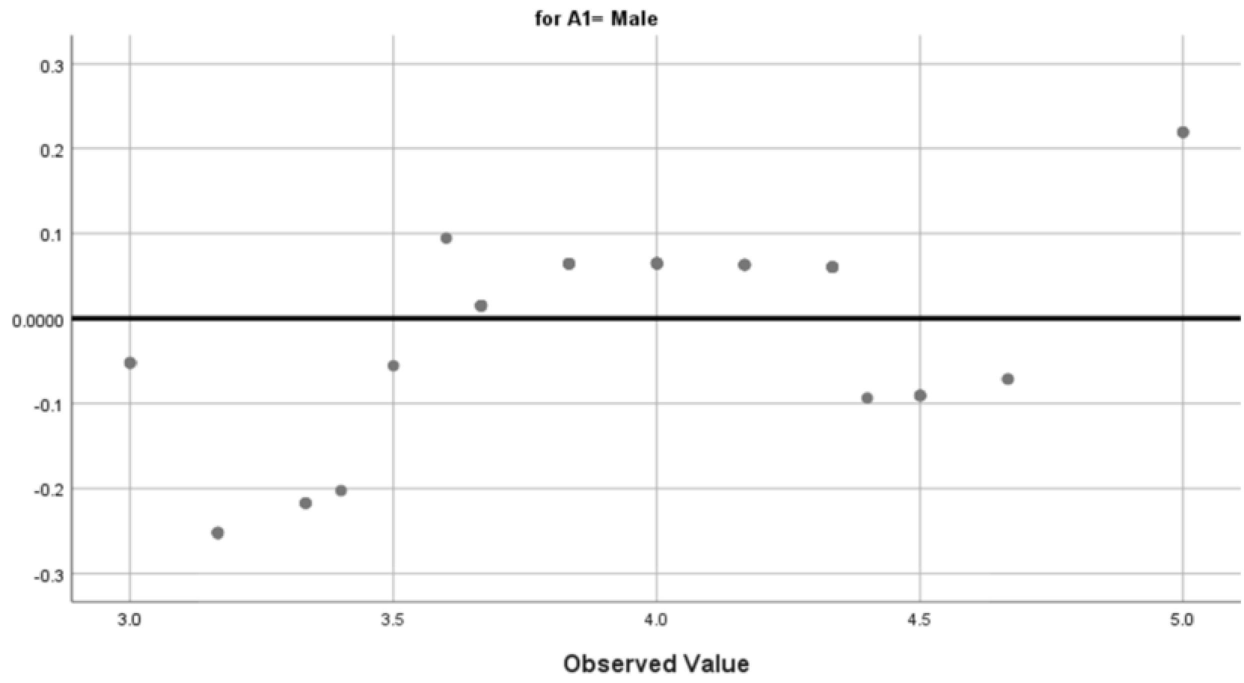


Figure 6.14 Detrended normal plot for water usage male respondents

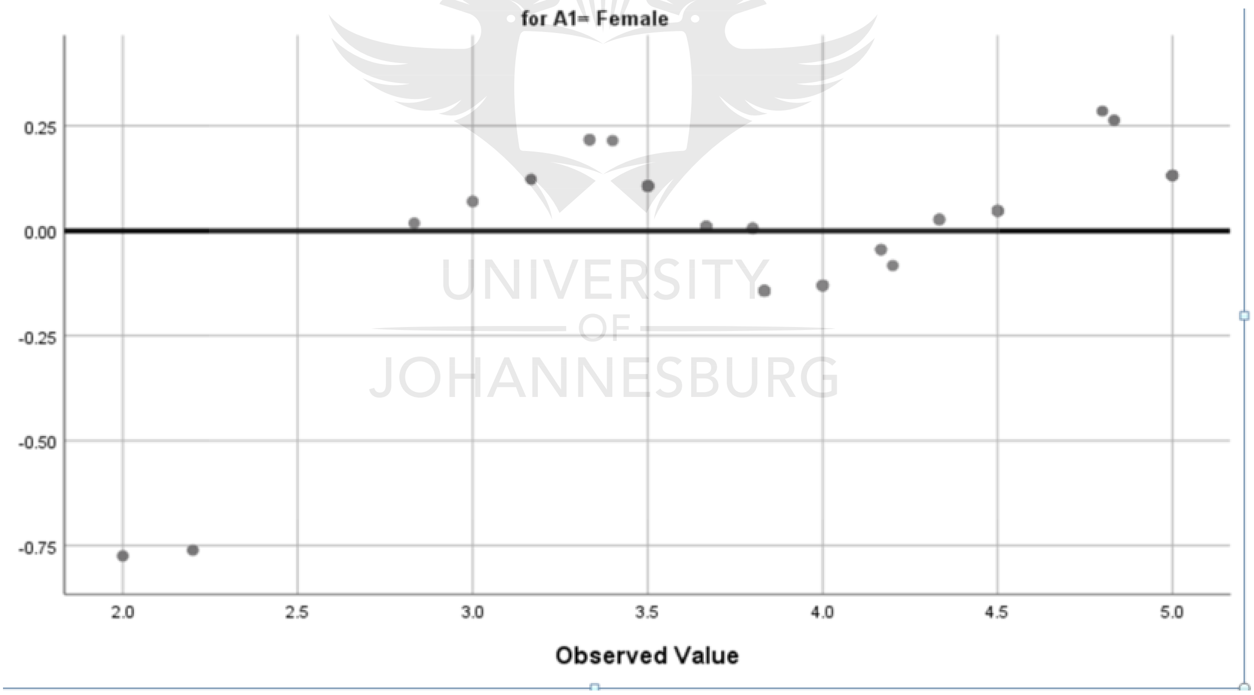




Figure 6.15 Detrended normal plot for water usage female respondents

### 6.5 Conclusion

The data obtained from the structured questionnaire sent out and completed by the clients were analysed in this chapter. Respondents included government, professionals that stay in formal houses, flats, apartments, consultancies of the department of water affairs, who are responsible for the water utilization, monitoring and supervising of public about water usage. The following chapter will focus on analysis and discussion of the findings from the research in relation to the research objectives that were formulated in chapter one. The purpose for this is to establish if the research objectives were met.

## CHAPTER SEVEN

## CONCLUSIONS AND RECOMMENDATIONS

### 7.1 Introduction

The main focus of this chapter is the discussion of conclusions and recommendations.This study research goal which is measuring factors affecting sustainable water supply in the Province of Western Cape. They are introduced and discussed thoroughly with regards to the objectives of the research. The customer, as literature states which is household occupants in this case, is a vital point of the entire decisions and actions of municipalities. Water is a scarce resource which is severely affected by climate changes; hence the most efficient management of water resources has become a priority, especially in the developing countries like South Africa. That is the motivation for effective and efficient management of water resources becoming a priority for the current demanding environment in the Province of Western, precisely in the City of Cape Town.

#### 7.1.1 Research Objective One

Objective One was to determine water usage practices in the city of Cape Town, South Africa. To achieve this objective, this study carried out a critical appraisal of previous studies conducted on the sustainable water supply within different countries. Current literature demonstrated that various studies have been conducted on the significance of water usage over the past two decades. There are however few studies that focused on South Africa, especially in the province of Western Cape in general. In light of this, the present study seeks to fill this gap by emphasizing the need to conceptualize the importance of water and how it can be reserved. Hence the need exists for measuring factors affecting sustainable water supply in the Province of Western Cape

The descriptive results demonstrated the ranking of all the factors from the highest to the lowest and also showed the individual means and standard deviations of the factors. Reserving water in any household or any area for that matter is of critical importance due to its scarcity, and failure to develop such model may result in drought for the entire City of Cape Town. As per literature review stated, we can certainly conclude that water is a need that we cannot live without. It plays a vital part in any household or industry and failure to take serious measures regarding this scarce resource may end in disaster for the entire province.

### 7.1.2 Research objective Two

Objective two was to determine the extent to which consumers have knowledge regarding water pricing policy. Based on exploratory factor analysis, it was demonstrated that respondents **ranking of Water usage per household results can be beneficial in Cape town.** It shows that families rarely wash their clothes and bedding. This was ranked first with a mean score of 8.093. and a standard deviation of 1.983. Second was once a week with a mean score of 3.313 and a standard deviation of 1.544. Third was trained twice a week with a mean score of 2.080 and standard deviation of 1.032.

Furthermore, data showed respondents ranking of shower usage in the warm season for most families and which could help improve the use of water in Cape Town city. It showed that most families shower twice daily, ranked first with a mean score of 4.21 with a standard deviation of 1.087. Secondly was those that shower three times with a mean score of 3.30 and standard deviation of 1.162. Thirdly are those that shower 4 times a day with a mean score of 3.29 and standard deviation of 0.981, fourthly was those that shower 5 times a day with a mean score of 3.22 and standard deviation of 1.133. Fifthly and strangely there are families that shower six times a day with a mean score of 3.14 and standard deviation of 0.999. The sixth factor was those who shower 7 times a day with a mean score of 2.72 and standard deviation of 0.872, and lastly those that shower more than 7 times with a mere mean score of 2.54 and standard deviation of 1.077.

Lastly it also demonstrated how households shower in the cold season. It indicates the respondents ranking of shower usage in the cold season per household. This information can help improve the use of water in Cape Town city. It shows that most families shower twice daily and was ranked first with a mean score of 3.01 with a standard deviation of 1.064. Secondly was those that shower three times with a mean score of 2.73 and standard deviation of 1.062 and thirdly are those that shower 4 times a day with a mean score of 2.41 and standard deviation of 1.981. Lastly were those that shower more than 5 times with a mean score of 2.12 and standard deviation of 0.133. In concluding this objective, we can safely say that an effective sustainable water supply strategy is vital to any household, business or Country.

### 7.1.3 Research objective Three

Objective 3 examined the relationship between water saving habits, the demand for water and attitudes towards different water management policies. Exploratory Factor Analysis indicates the respondents ranking of leakages in the households which information can help improve the use of water in Cape Town city. It shows that indeed there are some leaks in most households and was ranked first with a mean score of 5.44 with a standard deviation of 1.781, secondly was those heavy leaks that run daily with a mean score of 2.893 and standard deviation of 1.188. We can safely conclude that consumers should be made aware of strict policies which should be followed accordingly in order to save water. Penalties must apply in each household should such carelessness be discovered.

To further demonstrate the conclusions stated above, Wegelin and Jacobs (2012: 415) indicated that, "the implementation of municipal water conservation and the management of water demand has been inadequate for many years, although South Africa is one of the driest countries in the world, which could be attributed to a lack of planning and not to the realization of the importance and potential benefits of water restrictions." This study established that the local authorities in Cape Town, South Africa have not favored the development of a water demand management strategy and seem not to have the capacity and experience to develop such a strategy.



The local authorities should recognise the critical significance of education and behaviour transformation for sustainable water saving. They should engage in massive education and awareness promotion on water saving as part of their roles, even when the primary focus is on water service delivery. Raising awareness on these issues will be aimed at changing some aspects of the status quo that is making water demand management sustainable.

Given the recurrent droughts that have occurred in almost all the provinces of South Africa, it is appropriate to emphasize the use "of all possible policies to change water consumption patterns, given the current presumption of consuming too much. To do this, water managers have to know the shape and structure of their demand curves. Armed with this crucial knowledge, they are at a better position to design policies that take into consideration the various objectives of diverse policies".

## 7.2 Conclusions of the Research Study

The objective of this research study was to develop a water demand management model for the South African water utility in the city of Cape-town. This has been accomplished by recognizing models and techniques by using questionnaires to see what needs to be introduced and what challenges need to be rectified. Therefore, the following conclusions were drawn from the research study.

- Without an effective sustainable water supply, the municipalities will not be able to put strict policies in place to restrict usage of water which will in turn result in drought.
- In Africa, there is still a lack of general water management models and in order to take advantage of global knowledge from scarce resourced commodities such as the ones in USA etc, African-based municipalities need to embrace the digital revolution. The digitalization of the water management system in Africa is long overdue. The future of this sector therefore lies in its ability to modernize its internal infrastructure as well as its ability to strengthen the skill sets of its champions.

## 7.3 Recommendations

- It is recommended that a sustainable water supply strategy (SWSS) be introduced. This is a human behavioural tool based application that can used to manage, control and manipulate water usage processes and procedures in a way that delivers greater efficiencies with regard to water usage in the province of Western Cape, particularly in the city of Cape Town. South Africa as a whole can benefit a lot especially by looking at how this system is utilized globally.

- It is also recommended to install water management devices for excessive water users at home. Although the municipality has installed more than 25,000 water management devices at residential homes that have continued excessive water usage, the idea needs to be strengthened and a massive implementation has to be undertaken. These devices cut the supply of water to homes once they have used water to the tune of more than 350 litres water per day.

### 7.3.1 Further recommendations

**Throttling of suburbs water supply;** this strategy is said to have been pioneered by various city councils including the City of Cape Town. It involves extreme water pressure reduction, or "throttling", the water network. This means that water pressure is radically reduced in the water pipe network, resulting in an intermittent supply of water to high-lying areas.

**Day Zero deadline;** this strategy was introduced long ago but was not popularized to full effect. The Day Zero campaign was introduced after the city experienced consecutive years of low rainfall. On the "Day Zero" taps would be completely turned off and residents would then have to queue for water. Every week the city will be sending out some updates to its citizens on when they should expect this day, while also highlighting tips on water saving and emergency Day Zero plans.

**City-wide media campaign;** a comprehensive city wide media campaign is very crucial to drive consumption of water down. Slogans for water saving must be pasted in radio adverts, pamphlets, billboards and public bathrooms to drive home the water-saving message.

**Banning filling up of swimming pools;** several public swimming pools must be closed, and households must not be allowed to use municipal water for the topping up of their pools. Those residents who want to fill up their swimming pools must choose to truck in water from other places in South Africa.

**Rallying Local businesses to save water;** meetings should be regularly conducted with large corporations encouraging saving water. Restaurants must be encouraged to sell bottled water, which is imported from other parts of the country, while businesses must introduce hand sanitizers for employees and turn off their taps. Aircons, which use water, must intermittently be switched off and hotels must plug all baths.

**Deploying Water ambassadors;** residents must be encouraged to form water saving committees even on social media platforms like Twitter and Facebook, where they shared ideas on saving water. Ideas which include gray water harvesting, waterless toilets and ways to reduce household washing should be shared in these committees. Key social media figures should be appointed as water ambassadors.

## 7.4 Recommendations for Future research

Some participants with intimate knowledge on the water resource models that can assist Cape town to avoid drought failed to complete the questionnaire, and the focus was also in the Western province only. Further study can be made in a larger research area with more respondents in order to gain a deeper understanding of this scarce resource as it is vital to the entire country.

## 7.5 CONCLUSION

Information/ data were collected from respondents through structured questionnaires to establish the factors affecting the water crisis on the South African households. The information helped to determine water usage practices in the city of Cape Town, South Africa. It determined the extent of consumers knowledge regarding water pricing policy and examined the relationship between water saving habits, the demand for water and attitudes towards different water management policies. The findings from the research analysis and results were able to address the research questions.

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## APPENDIX 1: INTRODUCTORY LETTER

UNIVERSITY OF JOHANNESBURG



**Developing a water demand management model for the South African water utility: a case study of the city of Cape-town.**

Dear Sir/Madam,

I, **Carisa Guimar Camuto** am undertaking a research project that aims at developing a water demand management model for the South African water utility, with the general aim to come up with water demand management measures that must be taken at the government policy level to contribute in the provision of a sustainable water supply for South Africa. I will first give a brief description of the term 'sustainable development'.

| |
|---|
| **“Water demand management involves the adoption of policies or investment by a water utility to achieve efficient water use by all members of the community”.** |

I, therefore, kindly request that you complete the following short questionnaire as comprehensively as possible. “The survey consists of 11 questions and should take no longer than 15 minutes to complete. Please read each question carefully and tick a relevant box to indicate your answer”. The information collected in this project is strictly confidential and the identity of participants will be protected. Hence, **DO NOT** write your surname and name on this form.

I thank you so much in advance for your time and cooperation in this matter. Should you require more information on the project do not hesitate to contact me telephonically at 0610182486 or e-mail me at carisa.guimar@yahoo.com .

**APPENDIX 2: QUESTIONNAIRE**



**A. General information**

“We would like to know a little about your household information. This will be kept strictly confidential and is used to ensure that we have collected information from a wide variety of households”.

**“Please answer the following questions by crossing (X) the relevant block or writing down your answer in the space provided”.**

**“EXAMPLE of how to complete this questionnaire”:**

Please indicate your gender.

*If you are female:*

| | | |
|---|---|---|
| G00 | Male | 1 |
| G00 | Female | 2 |

**1. Please indicate your gender.**

| | | |
|---|---|---|
| GI1 | Male | 1 |
| GI2 | Female | 2 |

**2. How many people live in your house?**

| | |
|---|---|
| GI3 | |

**3. How many of those people are? (write in number in space provided)**

| | | |
|---|---|---|
| GI4 | 0-14 years old | 1 |
| GI5 | 15-59 years old | 2 |
| GI6 | 60 + years old | 3 |

**4. What is the highest level of education in your household? (Tick appropriate box.)**

| | | |
|---|---|---|
| GI7 | Primary | 1 |
| GI8 | High school | 2 |
| GI9 | University | 3 |
| GI10 | Technical training school | 1 |
| GI11 | No formal education | 2 |
| GI12 | Others (please specify) | 3 |

**APPENDIX A-1: QUESTIONNAIRE FOR RESIDENTIAL USERS FOR APARTMENT AND HOUSES AREAS**

**A. ATTRIBUTES OF PROPERTIES**

**1. Type of dwelling do you live in (tick where applicable)**

| | | |
|---|---|---|
| AOP1 | Formal House | 1 |
| AOP2 | Informal House | 2 |
| AOP3 | Apartment/flat | 3 |
| AOP4 | Other (please specify) | 4 |

**2. Does your house/apartment have any plumbing?**

| | No | Yes |
|---|---|---|
| AOP5 | 1 | 2 |

**B. WATER USAGE**

**3. "Do you use water for any of the following? (if yes, write down the monthly using number)".**

| | | No | Yes | |
|---|---|---|---|---|
| WU1 | To wash carpets | 1 | 2 | |
| WU2 | To wash the car | 1 | 2 | |
| WU3 | To irrigate the garden | 1 | 2 | |
| WU4 | Do you irrigate even when it has rained? | 1 | 2 | |

**4. How many times per week does your family wash the clothes and beddings?**

| | Rarely | Once a week | Twice a week | 3 times a week | 4 times a week | 5 times a week | Daily |
|---|---|---|---|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| WU5 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**5. Does your house/apartment have any shower (tick relevant box)**

| | No | Yes |
|---|---|---|
| WU6 | 1 | 2 |

**6. How many times approximately does each person shower per week?**

| | | **Once** | **Twice** | **3 times** | **4 times** | **5 times** | **6 times** | **7 times** | **More than 7 times** |
|---|---|---|---|---|---|---|---|---|---|
| WU7 | In warm season | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| WU8 | In cold season | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |



**7. Does your house/apartment have a bathtub?**

| | No | Yes |
|---|---|---|
| WU9 | 1 | 2 |

**8. How many times per week does each person use the bathtub?**

| | | Once | twice | 3 times | 4 times | 5 times | 6 times | 7 times | more |
|---|---|---|---|---|---|---|---|---|---|
| WU10 | In warm season | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| WU11 | In cold season | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

**9. Does your house have any leaking taps and toilet?**

| | No | Yes |
|---|---|---|
| WU12 | 1 | 2 |

**10. If yes, how many are?**

| | | | | |
|---|---|---|---|---|
| WU13 | Dripping? | 1 | Running? | 2 |

**C. Knowledge for water price**

**11. How much did you pay for each of the following this year relative to last year?**

| | | **Comparison with previous year** | | | |
|---|---|---|---|---|---|
| | | **Less than last year** | **About the same as last year** | **More than last year** | **Don't know** |
| KFWP1 | Cold Water | 1 | 2 | 3 | 4 |
| KFWP2 | Hot water | 1 | 2 | 3 | 4 |
| KFWP3 | Electricity | 1 | 2 | 3 | 4 |
| KFWP4 | Heating | 1 | 2 | 3 | 4 |
| KFWP5 | Other | 1 | 2 | 3 | 4 |

12. **Please tell us whether you think your household would use more water or less water if the price of water increased? (Tick appropriate box.)**

| **We would probably use** |
|---|

| **less water** | **more water** |
|---|---|

| | | **Less than half of what we use now** | **Probably use little less** | **No change** | **Probably use a little more** | **More than Twice as much as we use now** |
|---|---|---|---|---|---|---|
| KFWP6 | If water price increased twice the current price | 1 | 2 | 3 | 4 | 5 |
| KFWP7 | If water price increased by 50% | 1 | 2 | 3 | 4 | 5 |
| KFWP8 | If water price decreased by 10% | 1 | 2 | 3 | 4 | 5 |
| KFWP9 | If household income increased by 100% | 1 | 2 | 3 | 4 | 5 |
| KFWP10 | If household income decreased by 50% | 1 | 2 | 3 | 4 | 5 |
| KFWP11 | If your household | 1 | 2 | 3 | 4 | 5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | member increased by one adult | | | | | |

13. **The "following are some possible water pricing policy changes. Please show how you feel about each suggestion".**

| | | Strongly disagree | Disagree | Undecided | Agree | Strongly agree |
|---|---|---|---|---|---|---|
| KFWP12 | "When water is scarce business should pay more for water". | 1 | 2 | 3 | 4 | 5 |
| KFWP13 | "When water is scarce, residents should pay a zoning price rather than current price" | 1 | 2 | 3 | 4 | 5 |
| KFWP14 | "When water is scarce business should pay more according to seasonal effects". | 1 | 2 | 3 | 4 | 5 |
| KFWP15 | "Water price should be correlated with annual income of households and business". | 1 | 2 | 3 | 4 | 5 |
| KFWP16 | Other | 1 | 2 | 3 | 4 | 5 |



## D. WATER SAVING HABITS AND NON-PRICE POLICIES

14. **How often do you and your family members practice any of the following water saving techniques?**

| We do |
|---|

| | | Never | Rarely | Sometimes | Often | Always |
|---|---|---|---|---|---|---|
| **WSHANPP1** | Encouraging children to turn taps off | 1 | 2 | 3 | 4 | 5 |
| **WSHANPP2** | Use sink filled with water for dishes. | 1 | 2 | 3 | 4 | 5 |
| **WSHANPP3** | Turning tap off while soaping. | 1 | 2 | 3 | 4 | 5 |
| **WSHANPP4** | Check taps are turned off. | 1 | 2 | 3 | 4 | 5 |
| **WSHANPP5** | Fix dripping or leaking taps | 1 | 2 | 3 | 4 | 5 |
| **WSHANPP6** | Reduce water level of washing machine | 1 | 2 | 3 | 4 | 5 |
| **WSHANPP7** | Have short showers | 1 | 2 | 3 | 4 | 5 |
| **WSHANPP8** | Other (please specify) | 1 | 2 | 3 | 4 | 5 |

15. **Below are some possible strategies to save water. Please rate the importance of each strategy.**

| | | Unimportant | Of little importance | Moderately important | important | Very important |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| **WSHANPP9** | Provide Efficient and safe water delivery system. | 1 | 2 | 3 | 4 | 5 |
| **WSHANPP10** | Install sub water meters in apartments. | 1 | 2 | 3 | 4 | 5 |
| **WSHANPP11** | Fix leaking taps and toilets of apartments. | 1 | 2 | 3 | 4 | 5 |
| **WSHANPP12** | Install low flow toilets to apartments or households. | 1 | 2 | 3 | 4 | 5 |
| **WSHANPP13** | Provide water efficient technologies to the business users. | 1 | 2 | 3 | 4 | 5 |
| **WSHANPP14** | “Improve water conservation knowledge, encourage households and business to reduce their consumption”. | 1 | 2 | 3 | 4 | 5 |
| **WSHANPP15** | Provide Free water audit business | 1 | 2 | 3 | 4 | 5 |
| **WSHANPP16** | Protect the Cape Town River | 1 | 2 | 3 | 4 | 5 |
| **WSHANPP17** | Connect informal areas to sewerage systems. | 1 | 2 | 3 | 4 | 5 |
| **WSHANPP18** | Construct water reuse plants. | 1 | 2 | 3 | 4 | 5 |
| **WSHANPP19** | Reduce water flow | 1 | 2 | 3 | 4 | 5 |
| **WSHANPP20** | Make water assessable at specific times. | 1 | 2 | 3 | 4 | 5 |
| **WSHANPP21** | Other (please specify) | 1 | 2 | 3 | 4 | 5 |

**Thank you for your time.**