ASSESSING THE IMPACT OF A MOBILE APPLICATION IN PROMOTING RESPONSIBLE HOUSEHOLD WATER USE: A CAPE TOWN CASE STUDY

U Rivett, M McLaren, H Arito, T Pashapa, R Solomon & C Jacobs

WATER
RESEARCH
COMMISSION

TT 753/18

ASSESSING THE IMPACT OF A MOBILE APPLICATION IN PROMOTING RESPONSIBLE HOUSEHOLD WATER USE: A CAPE TOWN CASE STUDY

Report to the

Water Research Commission

by

U Rivett, M McLaren, H Arito, T Pashapa, R Solomon & C Jacobs

iCOMMS, University of Cape Town, Department of Information Systems

WRC Project No.TT 753/18

May 2018

Obtainable from:

Water Research Commission
Private Bag X03
Gezina

0031

orders@wrc.org.za or download from www.wrc.org.za

This report emanates from a project entitled**:** *Assessing the impact of a mobile application in promoting responsible household water use: A Cape Town case study* (WRC project No K5/2485).

DISCLAIMER

This report has been reviewed by the Water Research Commission (WRC) and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the WRC, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

ISBN: 978-1-4312-0977-4

Printed in the Republic of South Africa

EXECUTIVE SUMMARY

Background

South Africa is experiencing a water crisis. Recent research anticipates that water demand in the South African municipal sector will peak by 2035. In large municipalities, domestic water demand contributes approximately 26% to the total water demand. At the same time, mobile phones (and other forms of information and communication technology) have become ubiquitous in households around the world and have been identified in many contexts as being useful tools for providing citizens with contextual information to help steer behavioural change. This study assessed the effect of water-related information provided by a mobile phone application on water conservation participation at domestic or household level through a case study in the City of Cape Town.

Aims

The aims of the project were:

- To identify the successes and failures of residential water conservation and water demand management initiatives in the City of Cape Town through a literature review.
- To conduct household surveys to identify current mobile phone usage, willingness to pay for information, and commitment to partake in research across a representative sample of social classes of Cape Town households.
- To gather household information on water consumption, charges and municipal engagements through questionnaires and interviews.
- To implement the use of a mobile application (called DropDrop) in households for three months and observe its use.
- To evaluate the water consumption and charges in households and engagement with the municipality based on the findings of the field study.
- To examine how to upgrade DropDrop to be more useful by determining the functionalities that are heavily relied on and the recommended functionalities.

Methodology

The study entailed implementing a mobile phone application called DropDrop for residents of the City of Cape Town to assess if water use information supplied through a mobile phone affects water usage in households. Two sets of research were undertaken. An initial investigative survey was done to assess citizens' access and attitudes toward mobile phones and applications. The second part of the research – the main study – entailed selecting participants who either used the mobile application or formed part of a control group. Both groups were monitored over three months to assess changes in water use and attitude before and after implementing DropDrop.

For the main study, two groups of participants were selected by purposive sampling, namely, the treatment group and the control group. Participants in the treatment group were allowed to use the water-related information provided by the application while managing their water usage. Participants in the control group did not use the DropDrop application. Baseline and follow-up questionnaires were issued to participants in the treatment group before and after the study period. Monthly consumption data for participants in both treatment and control groups was collected to compare and determine consumption trends before and during the study period. A cross-tabulation analysis was used to interpret and compare the results.

Results

The study found that water-related information generally increased water-related knowledge and conservation awareness of the sample population on leak detection, consumption monitoring and conservation measures. It was noted that during the study period, the cumulative monthly water consumption of the participants in the treatment group was consistently lower than the cumulative consumption of the participants in the control group. At the same time, the gap between the cumulative consumption of the treatment group and that of the control group widened. This was attributed to the intensified water conservation practice by participants in the treatment group due to accessing the water-related information provided by the DropDrop mobile application.

The usability of the DropDrop mobile application in providing water-related information was generally satisfactory. Lastly, this study illustrated that opportunities for more extensive and consistent conservation participation at homes could be realised if water conservation information was presented through media (such as mobile phones), which are easily accessed by consumers.

ACKNOWLEDGEMENTS

The project team wishes to thank the following people for their contributions to the project.

Reference Group	Affiliation
Faye Balfour	
Shaun Pather	University of the Western Cape
Raymond Siebrits	Green Cape, Western Cape
Martine Visser	Department of Economics, University of Cape Town
Others	
City of Cape Town, Department of Water Demand Management	
General Public	All participants who willingly gave of their names to assist us in the study

Page left blank intentionally

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

AMR	Automated Meter Reading
app	Application
DWS	Department of Water and Sanitation
GIS	Geographic Information System
IBR	Incentive Base Regulation
ICT	Information and Communication Technology
IVR	
IWLRP	Integrated Water Leaks Repair Project
IWRP	Integrated Water Resource Planning
NCWSC	Nairobi City Water and Sewerage Company
RUBS	Ratio Utility Billing System
SDA	Small Doable Action
SWM	Smart Water Metering
TOC	Technical Operations Centre
Wasreb	Water Services Regulatory Board
WC/WDM	Water Conservation and Water Demand Management
WDM	Water Demand Management

1 INTRODUCTION

1.1 Background

South Africa's water resources have reduced over the last decade due to increasing demands from the agricultural, industrial and domestic/urban use sectors, and changes in rainfall patterns. Hedden and Cilliers (2014) state that low and unpredictable water supply coupled with a high and growing demand and the poor use of existing water resources are adding to the burden of South Africa's water resource management. The traditional approach to dealing with this has been supply-side management, namely, increasing production by building new dams. However, there has been a growing awareness that a shift to demand-side management, namely, reducing user demands, is necessary (Allon & Sofoulis, 2006; Corbella & Pujol, 2009; Parker & Wilby, 2013; Postel, 1992; White, 1998).

Demand-side management entails implementing conservation measures and efficiency in water usage in all sectors, which include household consumption. While there are many ways in which demand-side management is addressed – for instance, leak detection programmes and tariff adjustments – one of the core objectives of the Water Conservation and Water Demand Management (WC/WDM) Strategy is to create a culture of WC/WDM for all consumers and users. This can be achieved by educating consumers on ways and means of usage reduction and recycling (United Nations, n.d.) – an emerging approach to encouraging water demand management (WDM) participation at household level.

Concerning consumer education, International Water Resource Management acknowledges that practical management instruments include informed stakeholder participation and encouraged self-regulation among others. The means by which citizens are equipped with this awareness and the tools of self-regulation, and how to do so in the most efficient and effective way in order to create long-term behaviour change, are vital components within the demand-side management strategy of any water-scarce region. Mckenzie and Wegelin (2008) acknowledge that WDM is essential and in many cases the most cost-effective solution to address water shortfalls. Yet, it is often regarded as unpopular by water resource planners due to the challenges associated with shifting consumer behaviour.

These challenges include: (1) excessive demands; (2) non-payment; (3) plumbing leakages; (4) vandalism/theft and illegal connections; (5) inadequate community buy-in; and (6) inadequate education (DWS, 2013b). The consumer-oriented challenges experienced in the South African municipalities, as highlighted by the Department of Water and Sanitation (DWS), can be mitigated through effective implementation of WC/WDM strategies.

1.2 Problem Statement

Herbertson and Tate (2001) state that the two major factors affecting the future of water demand in the southern African region are seen to be human consumption and irrigation. The human consumption factor is associated with the rising per capita consumption, which is in turn associated with improved socioeconomic conditions, and population growth (Herbertson & Tate, 2001). In this regard, domestic water conservation is increasingly important (Allen, 2010) and there is an urgent need for water users to participate in water conservation to adjust their water demands in order to contribute to mitigating the water shortfalls in South Africa. It has been noted that providing citizens with information about their water consumption and the resulting knowledge could support and enable water users to manage or adjust their water demands and ideally conserve water.

Van Zyl (2011) remarks that some of the ways that water meter data can be used, which rely on technology to interpret and display the data, include:

- Consumers can be made aware of their consumption, how it varies with time and how it compares with other consumers in the same class; this can be done using graphs and tables printed on municipal water bills.

- Consumption data can be analysed in different user categories to determine the distribution of consumptions in each category, and how consumption varies with stand size and stand value; the highest consumers in each category may be identified and targeted for WDM initiatives.
- Consumers can be made aware of on-site losses and encouraged to have these repaired.

Mobile phones present a unique opportunity to address some of the shortcomings in information by providing a modern interface that allows households to engage with their water consumption. Further to this, Hellström and Jacobson (2014) note that the water sector is facing a number of governance challenges where mobile services can make a difference, especially when it comes to increasing transparency, accountability and participation. They mention that mobile applications (apps) can:

- Increase transparency through awareness-raising campaigns on water issues among citizens, simplify billing and metering through mobile payment.
- Improve accountability and participation by facilitating data collection and monitoring the status of water sources and strengthening consumer voice through online platforms.

While international research into the efficacy of mobile apps to change water consumption behaviour has shown promising results, there is a shortage of research in the unique South African context. For mobile tools to be adopted by South African governance structures and be utilised as part of their WDM toolkits, this gap in understanding must be addressed to identify both the willingness of citizens to engage with a mobile app to manage their household water use, and the nett result on water consumption.

1.3 Project Aims

The study is motivated by the need to understand how information and communication technology (ICT) – mobile phone apps in particular – can be used for household water conservation in the South African context. Part of the study is to understand the extent to which households are willing to use mobile technologies to manage water consumption. Therefore, at the beginning of the study, the research team identified the following aims:

- To identify the successes and failures of residential WC/WDM initiatives in the City of Cape Town through literature review.
- To conduct household surveys to identify current mobile phone usage, willingness to pay for information, and commitment to partake in research across a representative sample of social classes of Cape Town households.
- To gather household information on water consumption, charges and municipal engagements through questionnaires and interviews.
- To implement the use of a mobile app (called DropDrop) in households for six months and observe its use.
- To evaluate the water consumption and charges in households and engagement within the municipality based on the findings of the field study.
- To examine how to upgrade DropDrop to be more useful by determining the functionalities that are heavily relied on and the recommended functionalities.

1.4 Project Limitations

The study is only limited to the City of Cape Town and, as such, care should be taken when attempting to generalise the results to other urban contexts within the country. The research outlined in this report was a pilot project that entailed a restricted sample size to facilitate the depth required to understand individuals' experiences of the app. An additional round of use and monitoring on a wider scale is recommended to be able to further validate the findings of this study.

1.5 General Research Approach

The study is a case study of household water conservation in the City of Cape Town, focusing on assessing the impact of a water management mobile software app called DropDrop. In addition, the study assesses the willingness of people to manage water conservation by using mobile phone apps. The study also includes a literature review of the successes of past and existing WC/WDM apps.

This study used both quantitative and qualitative data analysis techniques to assess the effect of water-related information on water conservation at a household level. These effects are assessed by:

- Measuring and evaluating participants' water consumption during the study period.
- Evaluating and comparing the frequency of accessing water-related information with conservation practice.
- Evaluating the range of conservation practices and knowledge gained from a water conservation mobile app by population size of participants.

Primarily, the study approach is such that it provides rational explanation that attempts to deduce relationships between knowledge gained due to the water-related information and the resulting conservation practices and consumption trend.

For the primary field study, longitudinal data was collected by issuing questionnaires at the beginning and at the end of the three-month study period, that is, from the beginning of August 2014 to the end of October 2014. Data collected from the questionnaires were analysed in order to draw correlations among variables and also relate the variables with the water consumption data.

2 WATER CONSERVATION AND WATER DEMAND MANAGEMENT IN SOUTH AFRICA

2.1 Introduction

This chapter expounds on household water use in South Africa; the state of water conservation and demand at a national level in South African municipalities; and household water requirements and management. Water metering and billing, and incentives for WC/WDM interventions are also reviewed. Lastly, technologies that have been adopted, both locally and internationally, to manage water use/ services at household level are explained.

This review aligns with a set of drivers perceived to influence domestic water demand, as outlined by Butler and Memon (2006). The drivers highlighted include:

- Behavioural drivers (type and pattern of personal washing, garden watering): These change the pattern of the frequency of appliance use and the extent of ownership.
- Water policy drivers (metering and water regulations, pricing): These help to regulate the volume of water used in the household and restrict the ownership of high consumption appliances.
- Technology drivers (water efficient appliances, water management information systems): Owing to extensive research and regulatory requirements, innovative technologies render savings in water consumption.

2.2 The South African Context of Water Supply and Demand

This section of the report explains the national South African context of water supply and demand, both in terms of municipal planning, common national challenges and household water use patterns.

2.2.1 Water supply and demand management in South African municipalities

Many parts of South Africa are approaching the point at which accessible freshwater resources are fully utilised (DWS, 2013a). According to the water usage forecast by Hedden and Cilliers (2014), the largest increase in water demand by 2035 will come from the municipal sector. Municipal water demand is predicted to increase from 5.5 km^3 in 2014 to 7.2 km^3 in 2035. Therefore, additional and far-reaching demand management interventions should be implemented in this sector to close the widening water demand–supply gap. The rise in municipal water demand is mainly attributed to rising income levels and increasing rural-urban migration, especially to the provinces of Gauteng and the Western Cape (Go et al., 2013). In the 2011 census, it was found that 20.71 million people (or 40% of the population) lived in large metropolitan areas (Stats SA, 2014). Industrial water demand is expected to increase as a result of rising electricity demand, which is linked to rural-urban migration and economic growth.

Currently, the total water demand is estimated at 15.6 km^3 per annum whereas the total supply is 14.6 km^3 (Figure 2) (Hedden & Cilliers, 2014). It is estimated that the gap between demand and supply will increase to 3.2 km^3 by 2035, consequently increasing water stresses and competition among sectors. Hedden and Cilliers (2014) also state that increasing supply will not be sufficient to meet the growing demand (Figure 2), and strongly recommend interventions such as decreasing the volume of water lost through physical leakage or commercial losses. Similarly, households should also participate in reducing the overall water demand by decreasing water losses by fixing leakages and tracking consumption to ensure proper use of potable water.

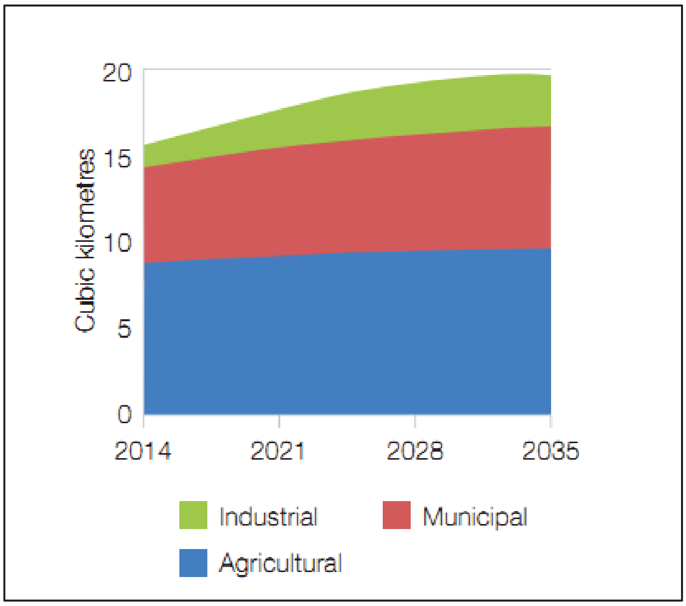


Figure 1: South African water demand forecast by sector (Hedden & Cilliers, 2014)

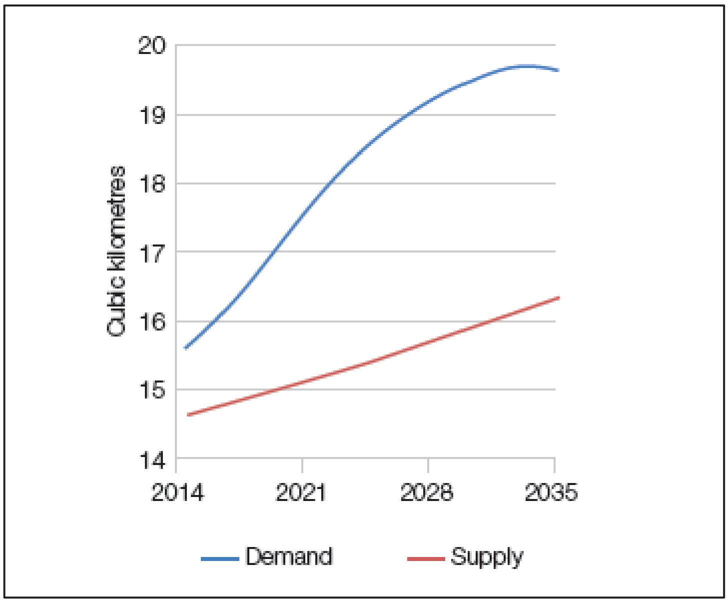


Figure 2: Increasing gap between water demand and supply (Hedden & Cilliers, 2014)

The demand-supply gap has necessitated the formulation of policies and reconciliation strategies by the DWS, which aims at closing the gap through interventions that include water use efficiency, water conservation and exploiting alternative water sources such as boreholes. Box 1 illustrates water crises in the South African municipalities and measures taken to mitigate the crises.

Box 1: Increase in demand for potable water in South African municipalities

Case Study: Water shortage as experienced by municipalities[1, 2]

Madibeng Local Municipality, located in the North West province of South Africa, experienced water shortages, especially in Jericho. The municipality devised short-term solutions that included deploying water tankers to deliver potable water to the community. In addition, the DWS renovated non-operational boreholes to augment the water supply. Four elevated storage tanks were also scheduled to be constructed.

In KwaZulu-Natal, several municipalities started water rationing in a bid to conserve water resources in the province. It was reported that the province was suffering water shortages and that mandatory water conservation measures would have to be implemented. The most affected municipalities included eThekwini, iLembe, uThungulu and Mtubatuba. In eThekwini Municipality, the water restriction is expected to reduce to 50% to sustain the supply from Hazelmere Dam, whose water level is receding rapidly (Frankson, 2015a). However, plans are underway to construct the new Shemula Water Treatment Plant to address the water shortage. The plans also seek to educate the surrounding community about the importance of water (Frankson, 2015c).

Water supply within the Polokwane Municipality in Limpopo has been under strain and has been exceeded by water demand. In this regard, the municipality declared that it would tighten controls and punish any water wastage. This was partly due to the municipality continuing to experience water shortages despite being supplied with water from Lepelle Northern Water (Frankson, 2014a). The shortage was mainly attributed to increased population growth as well as households using more water for their gardens (Frankson, 2014b).

2.2.2 Challenges in sustaining basic water services

The Municipal Systems Act (South Africa, 2000) authorises municipalities to maintain sustainable service delivery in a manner that will adequately support the populace. Although the national government funds municipalities by paying equitable share and other transfers, many municipalities still struggle to cover the costs of the utilities they are mandated to provide. CSIR (2010) attributes the challenge of cost recovery to a combination of the following reasons: (1) there are not enough customers who can pay; (2) customers who should pay, do not pay; and (3) customers who are eligible for the free basic service use more than the allocation, but are unable to pay for the additional amount. The inability to recover costs affects the municipality's quality and reliability of service delivery since municipalities tend to forgo adequate financing of service delivery by having to fund free basic water.

Other challenges, as cited by the DWS (2013b) are: (1) available water resources are limited; (2) municipal water consumption per capita is too high; and (3) a lack of WDM and poor water use efficiency affect the delivery of services.

Besides providing revenue for the municipality, water pricing should also reflect the true value of water. Water pricing is a strong incentive to reduce water consumption. Postel (1992) observe that water use reduces by 3–7% if the water price increases by a mere 10%. In this regard, the free basic water allocation policy creates a false impression of the actual value of water among consumers in South Africa.

Implementation of WC/WDM by customers at their homes can help limit their usage below the free basic amount or the amount they can afford. Informed customers can determine the amount of water they will

[1] http://allafrica.com/stories/201506180413.html

[2] http://www.news24.com/SouthAfrica/News/Water-rationing-kicks-off-in-some-KZN-municipalities-20150621

use and therefore avoid excessive consumption and unaffordable water bills. Ultimately, equipping water users with timely and adequate information on WC/WDM can facilitate water savings, which allow for an adequate supply of municipal water and sustainable delivery of water services due to knowledgeable customers and manageable competition for funds.

2.2.3 Household water use in South Africa

Water use in South Africa is dominated by irrigation in the agricultural sector, which accounts for around 60%; followed by municipal use (including water for both domestic and industrial use) accounting for 30%; and mining, large industries and power generation accounting for 7.5% (Figure 3). Commercial forestry plantations account for a little less than 3% of the overall demand (DWS, 2013b).

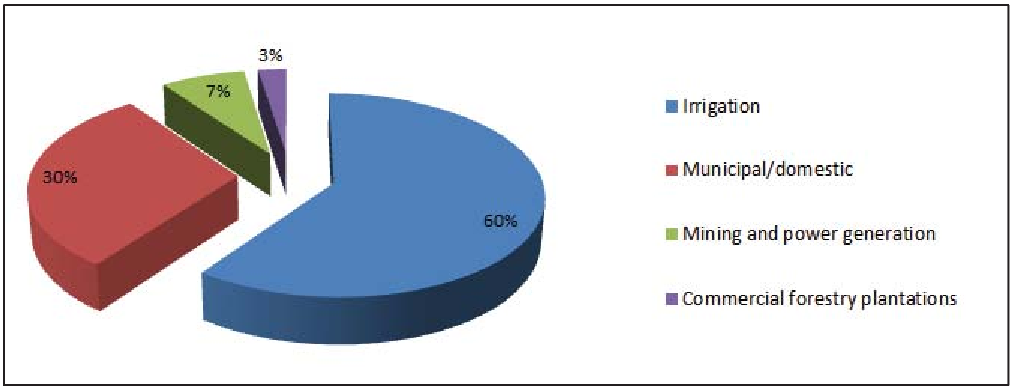


Figure 3: Water use per sector in South Africa (DWS, 2013b)

The main driver of municipal water demand is the size of a country's urban population – around 33.2 million for South Africa (Hedden & Cilliers, 2014). In metropolitan and large municipalities, domestic water use accounts for 27% (24% urban and 3% rural) and industrial use accounts for 3%. For instance, the domestic water demand in the City of Cape Town Metropolitan Municipality is significantly more than the industrial and commercial water demand (Figure 4).

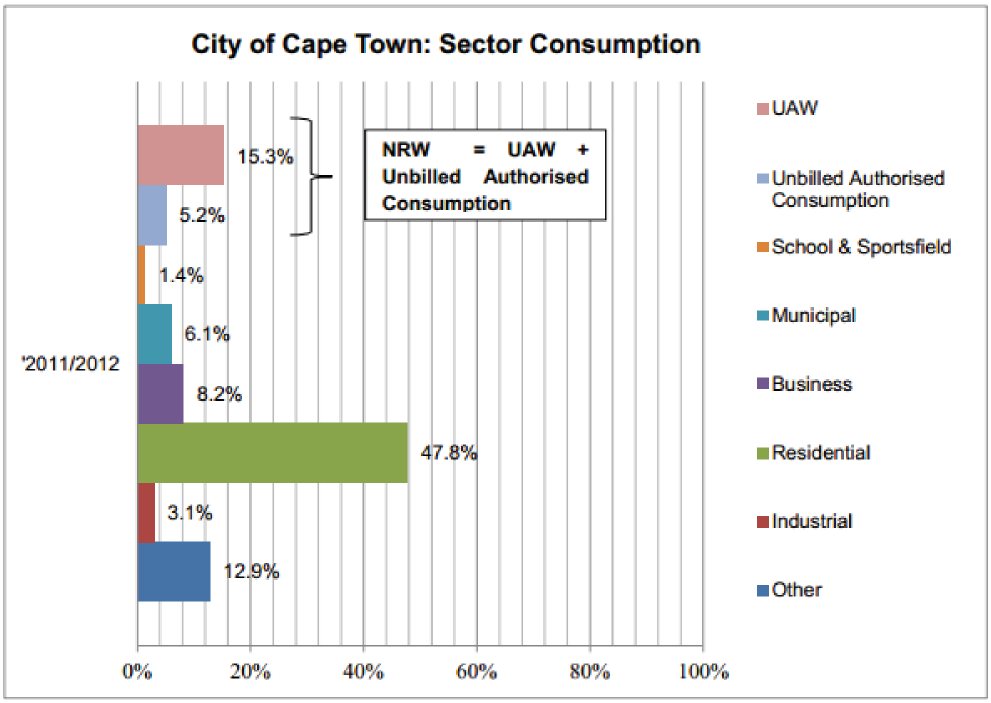


Figure 4: Domestic and urban use sector – City of Cape Town (City of Cape Town, 2013)

UAW: unaccounted-for water; NRW: non-revenue water

Although the criteria outlined by Mckenzie et al. (2012) describe water consumption in South Africa as average and as an indicator of adequate level of service, it should be noted that South African water resources are more limited than water resources in most countries it is compared with. Therefore, management strategies should be formulated to facilitate reduction in the overall consumption to match the available water resources. Likewise, the current level of consumption of 235 ℓ per capita per day (235 $\ell/c \cdot d^{-1}$) can be reduced to match the world average of 173 $\ell/c \cdot d^{-1}$ by promoting water efficiency, water conservation and efficient management of water use among the water users.

The trend in Figure 5 presents an opportunity to save potable water by focusing on implementing WC/WDM at the domestic or household level. The next section of this report provides information on the different means and efficacy of WDM interventions.

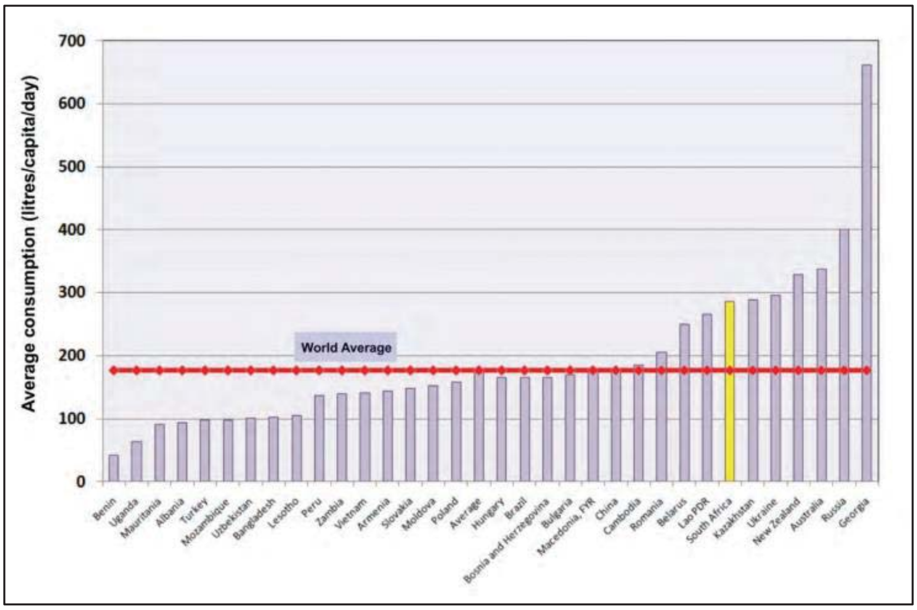


Figure 5: International litres per capita per day (Mckenzie et al., 2012)

2.3 Water Conservation and Water Demand Management

2.3.1 The broad elements and strategy of WC/WDM

WC/WDM for urban water supply entails various measures to reduce the demand for water, including but not limited to cost-reflective pricing; universal customer metering; reticulation leakage detection and repair; zone and customer pressure reduction; use of reclaimed water; and temporary or permanent water use restrictions (White, 1998). Instilling behavioural change (i.e. custodial management of water among consumers) in municipal water consumption to citizens is of high importance in this context. The recommended behaviour of citizens should include regular identification of leaks, consumption monitoring and economical use of water. Hedden and Cilliers (2014) expound that the emerging global notion of stewardship is fundamental to realising the required change in behaviour or attitude. This stewardship is based on a mentality of sustainable custodianship rather than on water consumption, which can be achieved through rigorous education and awareness campaigns.

Social awareness promotes co-management of services by citizens and can be considered a key pillar in WC/WDM. Cornwall and Gaventa (2001) observe that there is a growing emphasis on co-management of services at the local level, which has created new spaces for citizen involvement, as the 'owners', and to some extent as the 'makers and shapers' rather than simply the 'users and choosers' of services. Awareness campaigns can be conducted via media and various technologies to highlight efficient water use principles that will ensure relevant information is shared, the public is educated, and that the profile of WC/WDM is enhanced to achieve buy-in, involvement and accountability from citizens (DWS, 2013a). Katchmark et al. (2011) expound that educators should convey an understanding to the public of why water conservation is important and why the combined efforts of thousands of households can significantly contribute to reducing water demand. Still et al. (2008) categorise WC/WDM strategy into four elements that require equal attention:

- Structural – includes fitting on-site pressure-reduction devices, using recycling systems, and using water efficient devices.
- Operational – entails reducing supply pressures, and detecting and repairing leaks.
- Economic – comprises pricing changes and penalties to ensure that marginal water use is given its real marginal value; implemented by authorities.
- Socio-political – requires advertising in all forms of the media, as well as revising laws and regulations.

From a South African perspective, an essential component for WC/WDM is a programme of communication, education, awareness creation and promotion, and the development of supportive networks (DWS, 2013a) (Figure 6). Ultimately, this component aims at instilling a WC/WDM culture among water users and other stakeholders in the water sector (Box 2). It further classifies social awareness and education as a WDM intervention at consumer or household level. In addition to reducing consumption, WC/WDM programmes focus on the social, economic and environmental advantages that can be gained by citizens (DWS, 2004a). As stated in the National Water Reconciliation Strategy, some of the benefits include:

- Water users are empowered to understand the value of water as a scarce resource, and to adopt a responsible attitude to its use.
- Water is made available for allocation to other uses; either within the particular sector or for competing uses, and for the reserve.
- The necessity for capital investments in new infrastructure can be postponed, which means that increases in the cost of water to end users can be delayed.

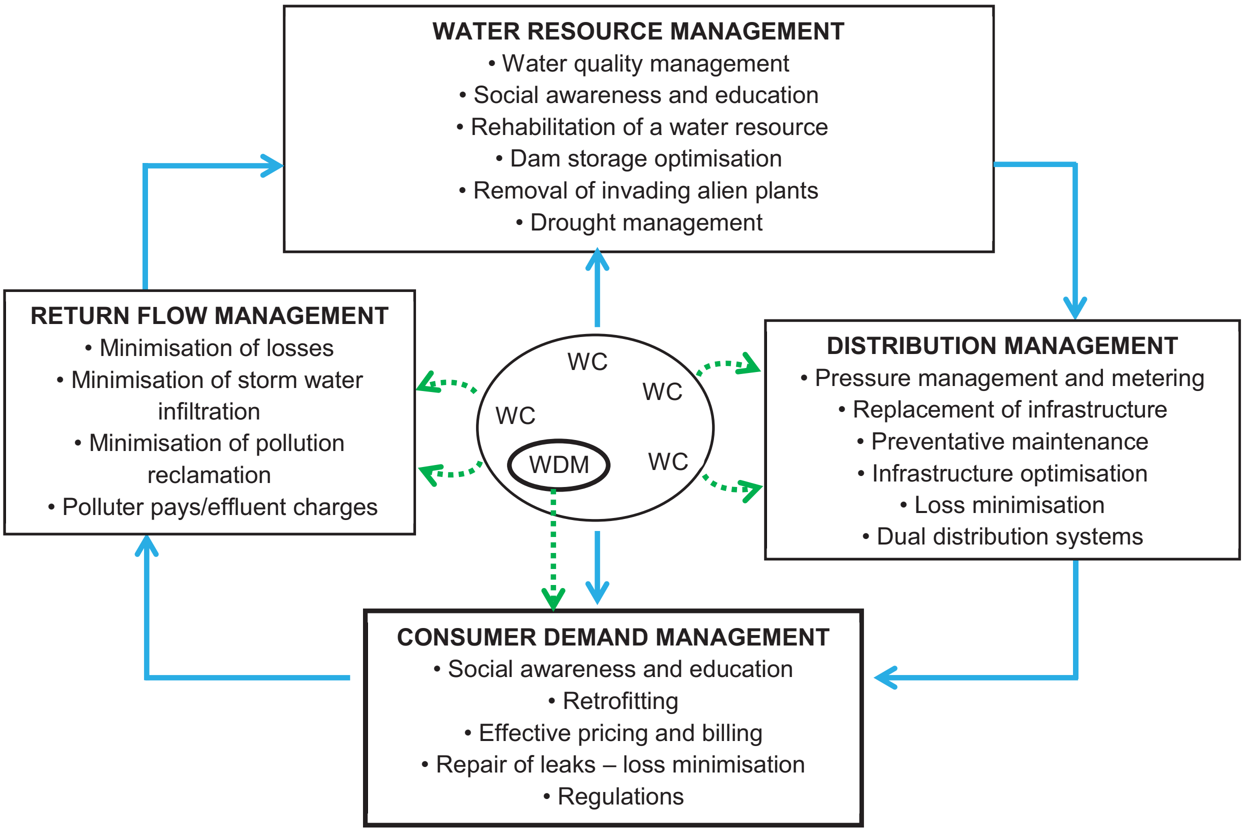


Figure 6: Elements of WC/WDM (DWS, 2013a)

Box 2: Securing attitudinal and behavioural changes toward the value of water

DWS Strategy: Instilling sense of appreciation of the value of water among South Africans

The DWS intends to continue sustaining water awareness campaigns, especially targeting younger children of primary school age. The department's philosophy is that meaningful change in people's attitudes toward water must be inculcated from a young age to reap the benefits of these positive attitudes in the future. However, it was noted that a massive national awareness campaign, underpinned by the principle of 'every drop counts', and with the aim of instilling a sense of appreciation of the value of water among all South Africans would enhance water conservation and water use efficiency (DWS, 2009). Active learning procedures for educators and facilitators in South African Schools and communities are documented by the DWS (2001) under the banner of 2020 VfW (Value for Water) Project.

The War on Water Leaks campaign, kickstarted by President Jacob Zuma in August 2015 in Port Elizabeth, investigates water leaks and educates citizens on how to save water (Frankson, 2015b). The campaign entails training 15 000 young people to fix leaking taps in their communities (Frankson, 2015b). The programme is expected to be rolled out throughout South Africa.

2.3.2 A focus on WDM interventions

WDM interventions are aimed at encouraging water institutions and water users to increase the efficiency of their water use and reduce their demand for water. They are based on the premises that, first, many water users can maintain their quality of life and achieve the desired outcomes or products from their water use while using less water, and, second, that significant reductions in water use can be achieved by minimising wastage and increasing the efficiency of water use by changes in behaviour and adopting water-saving technologies (DWS, 2004a).

Incorporating WDM practices both in the long and short term is a necessary component to extend the useful life of the regional water supply. Long-term WDM is practised through more efficient water use, water conservation, and reductions in water loss (Katchmark et al., 2011). Productive long-term management of water demand enables the available amount of water to be ample. Katchmark et al. (2011) describe this practice as a programme that provides additional water supply by lowering overall water demand. Successful implementation of long-term demand management can prevent or defer the need for an augmentation scheme or new water supply source for many years, and consequently minimise utility costs. Nkondo et al. (2012) emphasise that WC/WDM targets must be met in a number of priority water supply systems to reduce demand and thus 'stretch' the available water resources up to the date when the new augmentation projects are implemented.

Short-term WDM is usually implemented during periods of scarce water supply. Short-term management measures include the practices involved in long-term water conservation programmes along with mandatory water use restrictions, penalties, and rationing (Katchmark et al., 2011). These measures are usually successful in conserving water due to consumers having first-hand experience of the crisis and thus realising the importance of conserving water. Herbertson and Tate (2001) recommend that understanding of the mechanisms that make water usage drop during emergency situations but rise again when the emergency is over, could be employed usefully to manage demand under normal resource conditions.

2.3.2.1 *Efficient water use, water conservation and water saving*

The DWS defines wasted water as water used without any direct benefit being derived. In addition, inefficient use of water is described as water use that exceeds the accepted benchmark for the particular purpose, or water used where the derived benefit is sub-optimal (DWS, 2013a). For instance, water dripping from leaking household fixtures goes to waste. Efficient watering of the lawn implies practices such as sprinkling enough water on the grass area only or washing vehicles in a grassy area. The right to use water comes with responsibilities to preserve and protect (Postel, 1992). Sustainable efficiency may be realised by optimising the use of water through active participation by users with a sense of social responsibility. Water would be used efficiently if consumers consumed water with a value judgement about the existing water condition reality in South Africa.

Water saving, preceded by efficient water use, refers to a reduction in water demand. However, Jacobs et al. (2007) observed that the term 'water saving' could be misinterpreted because the data extracted from the water meter is analysed instead of 'actual water use.' From the municipal perspective, saving may be perceived to be achieved when the records of corresponding consumer meter readings are reduced, and the consumer is presented with a lower monthly water bill. Jacobs et al. (2007) describe this as 'reduction in metered demand' since it may not represent the actual water use – some customers may bypass the municipal water meter with an illegal connection. Although this method of quantifying water savings is relatively accurate, it is evident that it does not address water use adequately. In the event of abstracting water from alternative water sources such as boreholes, Jacobs et al. (2007) argue that water is not saved as the efficiency of use does not improve in such cases. Water conservation entails any beneficial reduction in water losses, consumption or waste (DWS, 2004b). Formulation of water conservation policies are aimed toward water users and can involve both the technical or engineering practices and behavioural practices. Examples of recommended water conservation practices for the residential users are described briefly in Table 1. Kashian et al. (2012) note that installation of water efficient appliances applies more to homeowners than renters because installing water efficient appliances is a capital investment with an initial relatively high installation cost. As time progresses, the water and money saved from the reduction in water usage eventually compensates for the initial investment (Kashian, et al. 2012). Their literature review shows that renters, because they rent for a short time on average, find no financial incentive to install water efficient appliances given that they are unlikely to realise the return on their investment. On the other hand, homeowners are more apt to make the initial investment since they will realise future savings from doing so (Kashian et al., 2012).

Table 1: Recommended water conservation practices for residential users (UNEP, n.d.)

Engineering practices		Behavioural practices	
Plumbing changes	Replacing existing plumbing fixtures with equipment that uses less water can result in substantial water savings.	Changing water use habits	Includes such measures as meter reading, leak detection and using water efficiently.
Low-flush toilets	Low-flush toilets use 6 ℓ per flush or less, and therefore reduce the volume of waste water produced also.	Pricing	Provides fiscal incentive to conserve water – increasing block rates on water discourages high consumption.

Engineering practices		Behavioural practices	
Toilet tank volume dis-placement devices	Between one and three plastic containers filled with pebbles can be placed in a toilet tank to reduce amount of water used per flush and save more than 4 ℓ.	Public information and education	Public awareness and education programmes may be targeted at specific user groups or age groups – e.g., housekeepers to encourage domestic water conservation, or schoolchildren to provide information on the implications of water conservation for future consumption, the environment and other uses.
Low-flow showerheads	By replacing the standard 18 ℓ/min showerheads with 10 ℓ/min showerheads, a family of four can save approximately 80 000 ℓ/year.	Lawn irrigation scheduling	Supplying water when most needed by the irrigated plants and applying the water in a manner best-suited to the plants being irrigated can reduce the amount of water required to irrigate the lawn\garden.
Faucet aerators	Aerators can reduce the volume of water use at a faucet by as much as 60% while still maintaining a strong flow. More efficient faucets can use only 7.5 ℓ/min, in contrast to standard faucets, which use 12 ℓ/min to 20 ℓ/min.	Drought manage-ment practices	Many communities are currently experiencing a need to have drought management plans in place to ensure the greatest possible availability of fresh water during periods of below average rainfall.
Pressure reduction devices	Homeowners can reduce the water pressure in a home by installing pressure-reducing valves to reduce the likelihood of leaking water pipes.		
Grey water reuse on landscaping	Grey water can be used by homeowners for home gardening, lawn maintenance, landscaping, and other uses that do not require potable water.		
Drought-tolerant plants	Water conservation in landscaping can be accomplished by using native plants, which have evolved water-tolerant characteristics ideally suited for the local climatic conditions.		
Xeriscaped landscapes	Xeriscaping – practised in arid and semi-arid lands – is useful for minimising irrigation, which promotes water conservation.		

2.3.2.2 *Benefits and challenges in implementing WC/WDM at household level*

The benefits of implementing WDM strategies are associated with monetary savings. Some of the best practices of WDM are remarkable. In Namibia, for example, there was very low overall growth in water consumption from 1990 to 1997 despite a 35% population increase (Herbertson & Tate, 2001). In South Africa, WDM interventions have reduced the projected demand, which was soaring. A typical case is the City of Cape Town as discussed in the previous chapter. Herbertson and Tate (2001) observe that many countries are showing their commitment to demand management by developing new policies. However, implementing such policies requires perseverance, commitment and education from key stakeholders across governmental sectors and the public. A separate challenge for South Africa is the perception that water management is not regarded as being socially responsible. In many parts of the country, water is considered a gift from a spiritual creator; it is not understood why water should be paid for as it is not perceived as something the government or the country owns. This belief structure often leads to water wastage and inefficient use (Wegelin & Jacobs, 2012).

2.3.2.3 *Small doable action approach to promote WC/WDM*

In order to facilitate water conservation participation at homes and realise its benefits, Washplus (2015) recommends the small doable action (SDA) approach. Although this approach is aimed at resource-constrained settings, its effectiveness can be simulated in the water, sanitation and hygiene sector by investigating feasible and effective behavioural improvements. According to Washplus (2015), once the progression of SDAs has been identified, community agents or facilitators ought to negotiate with householders to promote advancement along the continuum toward the ideal practice. The steps for negotiating SDAs as outlined by Washplus (2015) include:

- Assessing current practices.
- Validating current good practice.
- Identifying and negotiating new improved behaviours (SDAs).
- Eliciting commitment.
- Following up and conducting additional problem solving to promote sustained practice if necessary.

Devices that provide respective water-related information can be used during the implementation of WC/WDM to elicit commitment from householders in order to promote sustained practice. This approach is motivated by assumptions that (Washplus, 2015):

- Households are not engaging in ideal practices because they are unaware.
- Awareness-raising campaigns and education catalyse ideal practices with a bit of motivation.

2.3.3 Water use profile in single residential households

In South Africa, potable water is supplied to consumers through a water service provider. Municipalities are the so-called water services authorities who are responsible for providing water services to its residents. Such water services include not only water provision, but also ensuring that the appropriate quality levels of water and management of infrastructure. Some water services authorities delegate the task of providing residential water services to other water services authorities or private companies. For instance, in some areas of Stellenbosch Local Municipality, water services are provided by the adjacent City of Cape Town Metropolitan Municipality (Stellenbosch Municipality, 2013). From the municipal water main, water enters the residents' properties through a water meter, as illustrated in Figure 7. The water service provider has the responsibility of managing the water reticulation system outside the property boundary. The responsibility includes detecting and mending leaking pipes. However, within the property boundary, the property owner takes responsibility for both water reticulation system management and water use management.

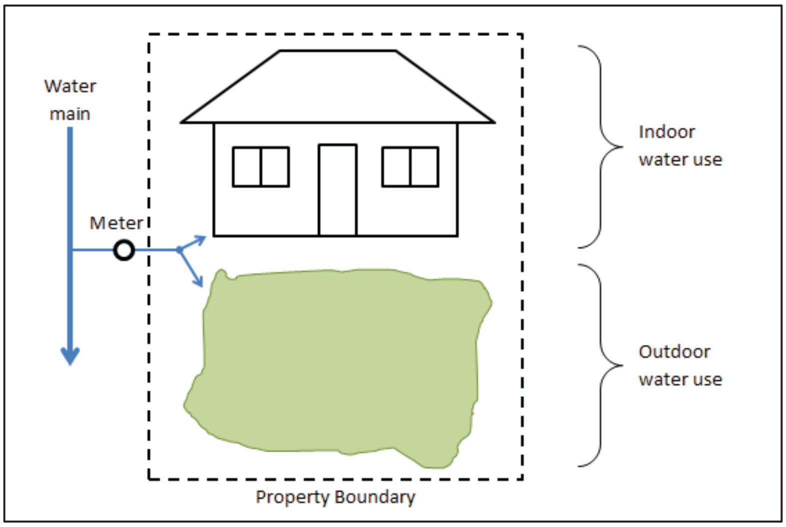


Figure 7: Water supply into residential properties

In single residential houses, water demand can be categorised into indoor demand and outdoor demand. For indoor consumption, Jacobs (2008) states that baths, showers, toilets and washing machines combined contribute about 80% to the total indoor water use. However, garden water demand accounts for a greater portion of outdoor water use. Although the actual share of garden water demand is hard to predict, a study reported garden irrigation in South Africa to be 73%. The end uses identified as being significant in their contribution to water demand have the potential of contributing most to water savings – the garden, toilet, bath, shower, washing machine and leaks (Jacobs, 2008).

2.3.3.1 Household properties and per capita consumption

Per capita consumption refers to the amount of water used by an individual. It is the mean consumption of people in a social unit, such as a household, and is calculated on a daily basis. Domestic water use responds to weather, technologic, economic, demographic and cultural factors; thus, demand profiles vary between regions (Parker & Wilby, 2013). Studies indicate that important determinants of water consumption are number of water fixtures and household size (Parker & Wilby, 2013). Considering household size, Butler and Memon (2006) note that there is a general agreement that per capita consumption decreases with increased occupancy (Table 2), although an increase in the size of household increases the total domestic water consumption. According to Stats SA (2014), the number of households in South Africa increased from 10.8 million in 2002 to 15.1 million in 2013. This trend implies a growth of over 3% in the number of households in South Africa. It also indicates a reduction in the number of people per household, which in turn implies an increase in per capita consumption.

Table 2: Household size and water consumption – UK survey (POST, 2000)

Household size	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Consumption (ℓ/c·d^{-1})	211	154	130	122	103	103	108	54

Household size mutually correlates with economic status. For instance, high-income residential is characterised by both a small household size as well as detached or freestanding houses. These households exhibit higher per capita consumption than low-income residential. On the other hand, lower per capita consumption in low-income residential can be attributed to larger household size, communal amenities (such as communal taps or standpipes, and communal swimming pools), smaller homestead areas and lack of, or fewer appliances (such as washing machines) that consume water. However, Van Drunen and Stoker (n.d.) point out that household size may not influence exterior water use, where a house with only one resident may have as much lawn to water as a household with four people.

With regard to household type and consumption, Butler and Memon (2006) attribute low demands in flats to the relatively low per capita garden watering requirements. Kashian et al. (2012) explain that a detached home is on average larger than a bungalow, a flat or a mixed home and therefore demands more water. The age of consumers was also found to influence consumption because single-occupant households with retired residents uses 70% more water than working age people because working people spend less time at home (Butler & Memon, 2006).

Other significant factors that influence water consumption are explained below:

- ***Price of water*** is arguably the most common factor influencing demand. Water is generally accepted to be price-inelastic, especially for indoor water demand. In contrast, garden water demand is highly responsive to price (Jacobs et al., 2006). This is explained by the increase in price elasticity during the summer months when people become more conscious of water usage. However, Kashian et al. (2012) point out that most people do not realise the marginal price paid for water; thus, they are not as likely to be affected by a price increase. By reviewing studies on developed areas, they justify why an individual's water bill is a small portion of their total expenditures, so unless it is exorbitantly high, not much attention is paid to it.
- ***Income*** is usually determined from the property value or stand size and is commonly used to explain demand in the literature (Jacobs et al., 2006). High property value implies high income and consequently high demand. For instance, Van Zyl (2011) elaborates that the peak demand of domestic users without outdoor consumption rarely goes above 1500 ℓ/h, but can be significantly higher for users with large stands.
- ***Stand size*** is arguably the variable the most widely used by civil engineers in South Africa to estimate residential water demand, based on stand size and stand value as functions. Previous research indicates that the stand size elasticity of demand varies significantly, but that the value is always positive (Jacobs et al., 2004; Van Zyl & Husselmann, 2006).
- The only two ***weather*** variables that influence demand are temperature and rainfall. All published values for the rainfall elasticity of demand are negative; for temperature all values are positive. As can be expected, this implies that higher rainfall reduces demand and higher temperature increases residential water demand, which is a direct result of garden water demand in both cases (Jacobs et al., 2006).
- The ***age of the home*** also greatly affects water consumption since newer homes often come with the most efficient water appliances available. Thus, it is no surprise that older homes with inefficient water appliances use more water than newer homes. This difference in water consumption is further aggrandised if the home develops leaks in piping as it ages (Kashian et al., 2012).
- ***Water pressure*** has a significant impact on demand: a reduced supply system pressure reduces water demand (Jacobs et al., 2006).

2.3.3.2 Basic water requirements

Adequate water supply is essential for quality life, health and human dignity. Although adequate supply may be argued to depend on factors such as health, age and lifestyle, Gleick (1996) argues that 50 $\ell/c{\cdot}d^{-1}$ is sufficient to meet the four basic human needs, namely, drinking water for survival, water for human hygiene, water for sanitation services, and modest household needs for preparing food. This basic water requirement amount is further apportioned as illustrated in Table 3.

Table 3: Recommended BWRs for human needs (Gleick, 1996)

Purpose	Recommended min. (ℓ/c·d^{-1})	Range (ℓ/c·d^{-1})
Drinking water[3]	5	2 to 5
Sanitation services	20	0 to over 75
Bathing	15	5 to 70[4]
Cooking and kitchen	10	10 to 50[8]
Total recommended basic water requirement	50	

According to the WHO (1997), access to 50 ℓ/c·d^{-1} is considered an intermediate service level, and consumption and hygiene are assured. However, the average consumption per person per day in Africa is estimated to be 20 ℓ. The WHO (1997) categorises the ability to access 20 ℓ/c·d^{-1} as basic, and asserts that the level of health risk is high because hygiene may be compromised. There have been reports of unequal distribution of water utility in developing countries. The inequality is characterised by overuse of scarce water among the wealthy, and at the expense of drinking water in poor areas of the city (Stephens, 1996). In South Africa, the DWS has the core objective of equitable and sustainable management of water for the benefit of all citizens (South Africa, 1998). If implemented effectively, the objective will not only result in equitable distribution of water utility, but also reduce water demand in South Africa.

The South African government has a long-term plan that strives to ensure that all households receive between 50 ℓ/c·d^{-1} and 60 ℓ/c·d^{-1} (DWS, 2013b). This is in accordance with Gleick's basic water requirement recommendation of 50 ℓ/c·d^{-1}. However, with the widening demand–supply gap, the plan may not be realised since much attention will be focused on mitigating the increasing water demand rather than doubling the free basic water amount (from 25 ℓ/c·d^{-1} to over 50 ℓ/c·d^{-1}). Promoting WC/WDM among citizens (especially those whose consumption is above average) will lower the overall water demand, therefore enabling any water augmentation project to focus on increasing the amount of free basic water per household as envisioned by the DWS.

2.3.4 Metering household demand

Metering is an incentive to engage consumers in WC/WDM by improving their knowledge about personal water consumption. It facilitates measurement of consumption quantity to determine the cost of consumption, thus creating stiff incentives for consumers to use water more efficiently. Postel (1992) states that metering can reduce water use by between 10% and 15%. Generally, the very presence of water meters and monitoring policies tend to discourage waste (Katchmark et al., 2011). The DWS (2013b) states that without effective metering and billing, consumption in urban and rural areas could rise by over 7.3 km^3/annum, resulting in an increase in total water usage of close to 20 km^3/annum. In this respect, the National Water Resource Strategy highlights the implementation of an effective water metering and monitoring system as a specific action and target to manage the rising water demand. Service connection metering ought to inform customers about how much water they are using in order to track water use accurately. It should be noted that even knowledgeable water users take time to interpret or analyse their water bills (Still et al., 2008). For less knowledgeable consumers, the bills are often incomprehensible and as such untrustworthy. However, with advancements in ICT, it is possible

[3] This is a true minimum to sustain life in moderate climatic conditions and with average activity levels (Gleick, 1996).

[4] The upper values here represent societal preferences for moderately industrialised countries. The lowest values reflect minimum uses in developing countries (Gleick, 1996).

to display timely and easily comprehensible water-related information, such as a graph displaying how water consumption has varied over previous weeks. With such easily comprehensible information, consumers can be alerted more easily to leaks or wastage on their properties (Still et al., 2008).

2.3.4.1 Standard metering strategies

There are various types of water meter, and their installations at properties depend on customers' requirements and considerations. The various types of metering strategy are:

- **Conventional metering**: This strategy entails installing water meters on all consumer connections and sending monthly water bills based on the actual or projected water consumption. When water meters are not read every month, the consumption for intermediate months is estimated based on factors such as historical consumption and seasonal patterns. Errors in the meter reading process can cause excessive bills to the consumer. A large but hidden leak occurring on the consumer's property can also be responsible for a very large bill (Van Zyl, 2011).
- **Prepaid metering**: Prepaid meters are water meters with built-in processing units and a mechanism that can automatically close a valve to cut a consumer's water supply. Consumers purchase water in advance, and the amount purchased is transferred through a token or electronic signal to the meter. Once the available credit on the meter has been exhausted, the prepaid meter automatically cuts the water supply. In some cases, the supply is stopped completely, while in other cases a small flow is maintained through the meter (Van Zyl, 2011).
- **Other metering strategies**: Include installation of flow restrictors that incorporate trickle feed systems that reduce the flow to a trickle collected by the user in a container such as a roof tank. Also, electronic flow limiters require direct connection to the flow meter to enable an operator to set a predetermined water flow rate such as the amount of water dispensable per day.

It should be noted that the metering strategies mentioned differ from automated meter reading (AMR) in that the amount of consumption is manually read from the meter. On the other hand, AMR automatically transmits consumption data to a receiver. The main contrast between AMR and standard water metering is shown in Table 4. South African municipalities have installed standard (or conventional) water meters in most houses and properties. Generally, most meters in municipalities are domestic meters supplying single households (Van Zyl, 2011). Water supplied to flats is also metered but the meter specifications may be different than those in single households, as shown in Table 5. Meter sizes for flats are generally larger than meter sizes for single households. This is because housing units in flats share one master meter; thus, the meter size should be big enough to allow more water into the flat and flow from the taps in houses at a rate not less than 10 ℓ/minute (as stipulated in the Water Services Act). In this regard, it is important that the selected meter should be able to handle the flow rates and operational conditions expected at a given installation (Van Zyl, 2011).

Table 4: Contrast between standard water metering and AMR

	Standard water metering	AMR
1.	Low purchase and installation cost	High purchase and installation cost
2.	Periodical data available e.g. monthly consumption	Real-time consumption data available since it allows frequent transmission of data
3.	Minimal information available i.e. overall consumption	Personalised data with more information such as consumption trend
4.	Unable to display information on leakage	Leak detection capability

Table 5: Meter specifications for various apps (Van Zyl, 2011)

Meter		App (domestic classification)
Size (mm)	Flow range (ℓ/min)	
15	1–55	Single-family homes
20	2–110	Large residences, homes with irrigation systems or swimming pools, flats with up to six units
25	3–185	Residences with pools and irrigation systems, small to medium apartment buildings (6–17 units)
38	5–375	Apartment buildings (18–40 units), old age homes (up to 50 units)
50	7–600	Medium apartment buildings (41–120 units), duplex complexes (41–80 units)
75–100	40–1 900	Housing complex or apartment building (over 150 units)
75–100	2–1 600	Housing complex or apartment building (120–350 units)

2.3.4.2 Water rates in single dwelling residential and multi-unit properties

Although water tariffs are similar for various types of housing, the water and sanitation bill paid by households for a certain amount of water used varies (see Box 3). Technically, only households dwelling in single residential may not have any water bill if their consumption have not exceeded the monthly free basic water allocation (i.e. 6 kl). On the other hand, multi-residential unit properties can only be supplied with an allowance of 6 kl per unit per month at zero cost by submitting a signed affidavit stating the number of completed and occupied units (City of Cape Town, 2015a).

Nonetheless, many tenants dwelling in flats in South Africa pay a flat rate charges for water services, and not for their actual water consumption. In such a case, there might be inequitable payment for water services rendered to households dwelling in flats. For instance, households who use much less than the free basic water amount will still pay water and sanitation charges; they will share costs with households who surpassed the free basic water limit. This method of payment for water utility may discourage efficient water use in flats as consumers may be prompted to use more water since they pay water bills anyway.

Box 3: Metering water consumption at multi-unit properties

Promoting water conservation to flat dwellers by metering consumption[5, 6]

Most water providers bill apartments and commercial properties through one or several master meters. Charges for water are allocated and included in occupants' monthly rent. Occupants do not receive water bills from the water provider directly. This practice provides little or no financial incentive to use water efficiently or to report leaks. The effects may be exacerbated during water shortages, when requests by the water provider to curtail usage are not directly conveyed to the occupants or can be easily dismissed.

[5] http://www.allianceforwaterefficiency.org/uploadedFiles/Resource_Center/Library/non_residential/EBMUD/EBMUD_WaterSmart_Guide_Metering_of_Individual_Units.pdf

[6] http://www.americanwater.com/pdf/DevelopersSubmeteringGuide.pdf

Why sub-metering?

Residents prefer sub-metering to having the water expense hidden in their rent or using an allocation system such as the Ratio Utility Billing System (RUBS). Billing residents for their actual utility usage puts them in a position to control their expenses. The typical 20% to 40% decrease in water usage, documented by multiple studies, at multi-unit properties reduces the need for additional water treatment plants and helps reduce the need to implement mandatory water restrictions during drought conditions.

What is the future of RUBS?

RUBS is the process of allocating water usage to each resident based on a formula that can include factors such as the number of occupants in an apartment, the apartment square footage, and the number of water-using devices. Since there is no water meter installed in each apartment, common problems are resident resistance and complaints. When water bills are not based on actual usage, a resident who travels frequently pays the same bill as one who may use double the amount of water. It has been noted that RUBS does not encourage as much water conservation as sub-metering, especially over the long term.

Actual metering still ideal to promote WC/WDM

Because these practices neither promote conservation nor provide for awareness of water use and responsibility, water providers may wish to implement a programme to meter individual units in new multi-units and commercial properties to capture the water-saving benefits. In order to further promote WC/WDM by householders, there is need to formulate local regulations that would require water billing in new apartments and mixed-use buildings to be based upon actual metering and not allocation. The average water savings for flat occupants is estimated at 15% and average energy savings at 21%.

2.3.4.3 Significance of water bill in raising awareness

The water bill gives an itemised statement of money owed by water users to utility providers. It is commonly used in conventional metering strategy (discussed above). Besides informing the consumer about the utility cost, the document is intended to provide information on consumption with the objective of encouraging the consumers to track their daily consumption and consequently make water use decisions. Katchmark et al. (2011) emphasise that water bills should offer customers features beyond basic payment information that help them to maximise their water conservation efforts. An observation made by Whitcomb (2005) while evaluating the water rates of single-family homes in Florida, USA, asserts that water/utility bills with limited or no information on customer’s historical use, water price and rate structure among other details do not impact water use.

Katchmark et al. (2011) deduced that including this information in the water/utility bill correlates with more informed customers, which in turn, correlates with greater quantitative introspection regarding water use. See Box 4 for a case study example from Australia.

Box 4: Impact of conservation strategies in Melbourne, Australia

Case Study: Impact of conservation campaigns

Blom et al. (2010) conducted a study by investigating conservation campaigns and studies to determine their effectiveness. The areas examined entailed: (1) the results of a comprehensive review of conservation campaigns; and (2) the factors that increased the conservational impact of a campaign.

According to the findings, it was noted that changing behaviour in people is a multi-step process. Secondly, motivation, simplicity and trigger are needed to cause behaviour change. Thirdly, information must be presented in a compelling way. The findings also showed that: (1) continuous feedback is more effective than monthly feedback; (2) feedback on usage comparisons and cost impacts are more effective than environmental impact; (3) setting high goals result in more conservation than setting low goals; and (4) the greatest conservation arises from a combination of strategies.

In one of the study sites water usage was recorded to drop by 9.1% from 164 ℓ to 149 ℓ. This was attributed to a combination of goal setting, information, rewards (rebates) and feedback through weekly usage averages.

Residential water audits can help customers to improve their water usage habits and avoid high water bills by demonstrating water usage trends (Katchmark et al., 2011). This can be achieved by including a special insert – that has the customer's water audit – in a customer bill, especially when consumption spikes. In addition, Van Zyl (2011) elaborates that consumers can be made aware of their consumption, how it varies with time, and how it compares to other consumers in the same class. He asserts that this can be done using graphs and tables printed on the municipal water bills.

In South Africa, communication via water bills may be affected by the existence of diverse languages. Despite this diversity, the Department of Water Affairs (2003) states that wherever practical, communication should be in the home language of the consumer. In this regard, many South African municipalities use native languages for both written and oral communication. The setback of including relevant official languages is that the water bill becomes very long. Too much information on the water bill has a similar effect as too little information. It should also be noted that different social classes exhibit different expectations. For example, Sarah Slabbert Associates (2010) cite that higher socioeconomic groups want detailed information (it cultivates trust) whereas lower socioeconomic groups find detailed information overwhelming (it inhibits trust). Such differences can only be addressed by a customer-oriented approach to designing water bill documents (Sarah Slabbert Associates, 2010).

Alternatively, innovations capable of both providing concise consumption information and promoting consumption awareness through processing input meter readings and displaying simple and easily understood graphics (which illustrate consumption) might be very effective in facilitating water use efficiency by householders. Being informed about consumption, including warnings of possible leaks or excessive consumption encourages consumers to manage their water consumption.

2.4 The Role of ICTs in Managing Water Demand

2.4.1 Introduction

Over the last decade, ICTs have resulted in notable developments in Africa in various sectors, such as education, finance, health and agriculture (The World Bank, 2012b). ICTs have had a profound impact on the water sector, which the water profession has not yet acknowledged fully and embraced (Nguyen-Khoa et al., 2012). Unfortunately, it is still under-researched and there is significantly less literature on ICTs in the water sector, particularly in South Africa (Champanis et al., 2013).

This section of the report provides information on ICT in relation to WDM by introducing ICTs in general and the public perception of them. The research then delves into a particularly valuable and ubiquitous form of ICT – the mobile phone – by exploring mobile phone use in South Africa and in the water sector, and by providing examples thereof to illustrate some ways in which mobile phones can be used successfully to manage water demand.

2.4.2 What constitutes ICT?

Information can be propagated through various media, referred to as ICTs. Established ICTs include radio and television, while new ICTs refer mainly to mobile phones and the internet (Schouten, 2013). In the water sanitation and hygiene sector, ICT comprises the mobile network, the mobile tools used for data collection, transfer and analysis, and the technology (hardware, software and services) that expedites the data flow (Schouten, 2013). Schaub-Jones (2012) mentions that the technologies potentially used in the water sector are vast, ranging from relatively simple mobile phone-based systems over geographic information system (GIS) to remote sensing from satellites as well as smart grids, which automatically regulate water pipe networks. The focus in this study is on the technologies that can facilitate WC/WDM by householders.

The introduction of ICTs in the water sector has influenced water management productively. For instance, the development indicators include instant payment of water bills, which not only eliminates transportation costs but also saves time that would be spent while traveling to the utility offices to make payments. Examples of mobile-based ICT systems that have resulted in developments in the WDM sector include MajiVoice (Kenya), Banki ya Maji (Kenya) and smart water meters among other systems. These ICTs have been successful in enabling water users to participate in the management of water and also facilitate adequate service delivery.

2.4.3 Public acceptance of ICTs in the water sector

Public acceptance of ICTs, especially in the water sector, partly determines the effectiveness of the respective ICTs to facilitate the purpose for which they were designed for. Regardless of the status of technologies, their potential will not be realised unless customers wish to acquire them (POST, 2000). For the technology to be adopted, there should be adequate demand. In addition, the technology should be suitable to the setting in which it will be implemented. This implies that prospective users must be involved in the design process of the technology. Table 6 states and describes the elements that are critical in the successful design of mobile phone solutions.

Table 6: Considerations for user participation and experience (Hutchings et al., 2012)

Understand the socio-cultural context	While it is not always easy to anticipate challenges based in a specific socio-cultural context, documented successes and challenges of others can help future projects to prepare for issues such as: differences in mobile phone access and usage individually and as part of a household; rigid attitudes and expectations about government action; preferred mode of communication; and prohibitive fears and concerns.
Build the user base through well-planned outreach to achieve uptake	Outreach is important for user uptake of the system, both during project development and implementation.
Ensure the system is easy to use	The success of a system and level of user participation depends heavily on technical accessibility of the data collection step (which was the user's first, and sometimes only, interface with the system), and relevant output formats in data dissemination and analytics.
Fulfil a key need – monetary incentives are not necessary	Compensation is not needed when the user receives a direct benefit from submitting data, such as improvements to service provision.

Besides the design of technology, barriers to successful ICT adoption as listed by Champanis et al. (2013) are:

- Misuse of the technology – the users might use the technology (e.g. distributed mobile phones) for activities that they were not intended for.
- Bureaucracies in project procurement.
- Failure to understand project incentives.
- Project coordinators or managers might perceive that more data results in more work and added responsibility in an already constrained environment.
- Projects becoming politicised and judged based on inappropriate criteria (overlooking technical and social success).
- Financial concerns including the initial outlay for a project; most projects are also susceptible to termination when funding stops.
- The tendency to maintain status quo, especially by users and avoiding risks, especially by managers.
- Inadequate technical skills, or low literacy.
- Infrastructure shortages such as poor electrical and network connectivity.

Incentives and enablers to successful ICT adoption as stated by (Champanis et al., 2013) include:

- The potential gain of knowledge or understanding and technical skills is a valuable incentive.
- Getting away from paper-based or traditional systems to new age techniques of running activities.
- A consistent record of information that can be used for accountability and transparency purposes.
- Leveraging the perception that IT systems enable better and more efficient collection and management of data.

2.4.4 Opportunities in mobile phone technology in water services

Hellström and Jacobson (2014) note that the water sector is facing a number of governance challenges where mobile services can make a difference, especially when it comes to increasing transparency, accountability and participation. Mobile apps can (Hellström and Jacobson; 2014):

- Increase transparency through awareness-raising campaigns on water issues among citizens, simplify billing and metering through mobile payment.
- Improve accountability and participation by facilitating data collection and monitoring the status of water sources and strengthening consumer voice through online platforms.

ICTs present an opportunity to obtain information in real time for time-critical decision-making (Champanis et al., 2013). This is critical for the water sector as it offers new opportunities to address South Africa's enduring WDM challenges, especially education and awareness. Mobile technology is increasingly helping resolve governance challenges by solving limitations of education in two areas: access and personalisation (McKinsey & Company, 2012).

The emerging mobile solutions improve access to information in two ways:

- **Universally available tools:** Use of universally available technology enables propagation of information to a large number of target populations. For instance, it can be effective in accelerating public engagement in the municipal service delivery processes such as reporting complaints and implementing water conservation. A report by The World Bank (2012a) denotes that more people have access to a mobile phone than clean water in some of the African countries. In Africa, the southern Africa region accounts for the highest mobile penetration.

South Africa and Botswana have between 126 and 175 mobile cellular subscriptions per 100 people (The World Bank, 2012c). The subscriptions are expected to increase with time. Although smartphone penetration in South Africa has been increasing at a rapid pace of about 20% a year, many people still use feature phones (Lana, 2014) (Figure 8). Regarding the WDM sector, the ubiquity of mobile phones in South Africa can be harnessed to make every water user participate in water conservation and water use efficiency.

- **Real-time access and independence:** Access to timely and relevant information by citizens improves interaction, and builds trust, confidence and participation in initiatives such as water conservation and governance at grassroots.

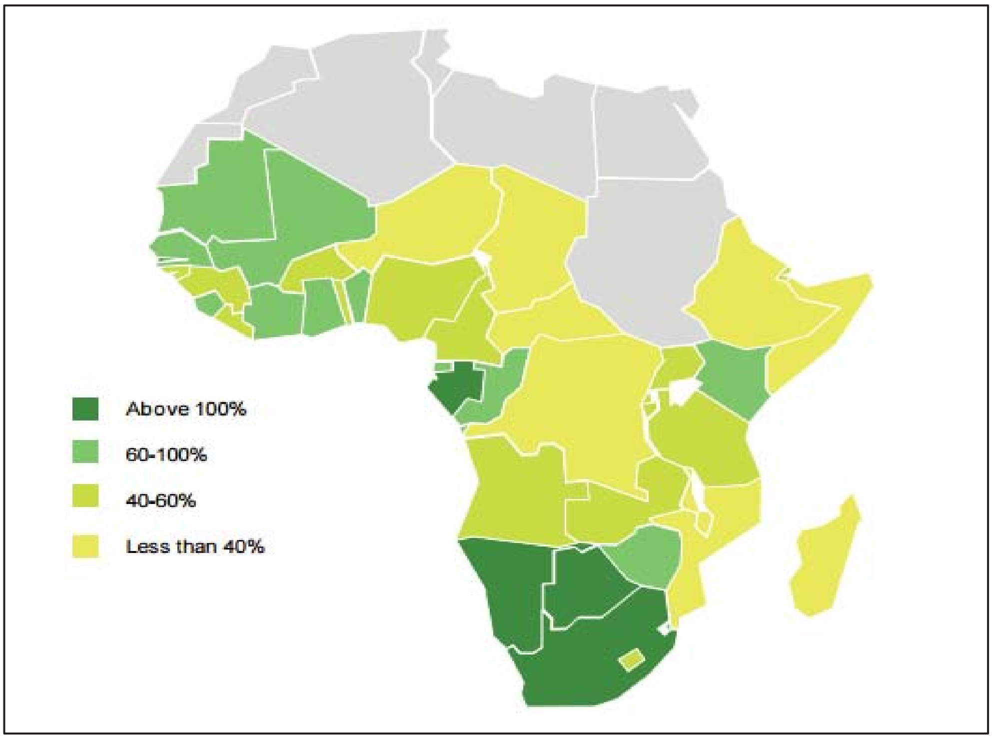


Figure 8: Mobile penetration in sub-Saharan Africa (Deloitte & GSMA, 2012)

Although some progress has been made to educate consumers and create water conservation awareness, more effort is still required to ensure that the consumers are equipped with easily accessible information, using appropriate technologies, so as to influence their decisions and habits.

2.4.5 Mobile phone utilisation in South Africa

Mobile phones offer new opportunities for citizens to access information that would enable them to participate in implementing practical policies such as the WC/WDM strategies. In South Africa, statistics show that mobile phones are mainly used for making and receiving calls, especially in the rural areas (Gillwald et al., 2012). Apart from making and receiving calls, other uses are shown in Table 7. Table 7 implies that less than a quarter of the South African population download apps from the internet (for example, from iStore or Google App Store). These downloads could be mainly games, which are used by more than 43% of the population. Also, apps such as Facebook, Google Maps and banking apps account for 22% downloads. The low rate of downloading apps could be attributed to the fact that only few people own smartphones. It can also be attributed to managing costs of data packages. However, the use of the internet via mobile devices is expected to increase as access to low-cost, internet-enabled devices increases (Gillwald et al., 2012).

Table 7: How mobile phones are used in South Africa (Gillwald et al., 2012)

Use	National	Urban	Rural
Making and receiving calls	99.2%	98.9%	99.6%
Playing games	43.7%	43.4%	44.2%
Taking photos and/or video clips	54.9%	64.0%	39.2%
Browsing the internet	27.6%	34.3%	16.1%
Facebook/Twitter/Mxit/other social networking	25.4%	30.4%	16.6%
Downloading apps	21.9%	26.2%	14.5%
SMS to radio or TV programmes	8.9%	9.7%	7.6%

Although South Africa has a low rate of downloading apps, educational apps that promote water conservation may be downloaded at a higher rate since the incentive to lower their water bill could provoke the user's interest in the app. Most importantly, the population must be sensitised on the objective of the activity and their consent sought. On general internet usage (using either a mobile phone or computer), Gillwald et al. (2012) found that the internet is mainly used for social networking and communication purposes, and less for information-gathering, with 52% of individuals stating that they access social networking or video-sharing websites daily (Table 8).

Based on these statistics, dissemination of information to the public via the internet would not be an effective method of imparting knowledge or awareness to citizens. This is because the larger population (about 90%) would not access the information. Alternative techniques of effectively educating the public using the internet may comprise incentives that would for example enable social networking or sharing videos. Mobile technology can be harnessed in the water sector to foster transparency, accountability and participation (Hellström & Jacobson, 2014). Although it is clear that mobile technology presents new ways for water users to participate in the management and provision of water services, for this to happen, users need to be made aware of the opportunities (Hellström & Jacobson, 2014).

Table 8: Purposes for which the internet is used on a daily basis in South Africa (Gillwald et al., 2012)

Purpose	National	Urban	Rural
Getting information about goods or services	10.2%	10.5%	9.0%
Getting information related to health or health services	4.2%	5.1%	1.3%
Getting information from government organisations	4.9%	4.3%	7.1%
Accessing educational or learning activities (formal)	9.8%	9.6%	10.6%
Reading or downloading online newspapers or magazines, electronic books	10.7%	9.7%	13.8%
Getting information for school or university related work or researching a topic	8.8%	8.9%	8.3%
Looking for free education content, such as free courses	5.4%	4.9%	7.3%
Using social networking or video-sharing websites (e.g. Facebook, Twitter YouTube, Mxit)	51.7%	51.5%	52.4%

2.4.6 Examples of ICTs in the WDM sector

Despite a relatively slow start, the use of new technologies has been embraced in the water sector, changing the way water is governed (Hellström & Jacobson, 2014). Some of the main benefits that have been facilitated by the use of ICTs in the water sector include timely reading of the water meter, quicker response to queries and transparency in utility operations. These benefits have been observed to contribute to both customer satisfaction and better management of water demand. Examples of ICTs in the WDM sector are explained in the sub-sections that follow.

2.4.6.1 Smart water metering

Smart water metering (SWM) refers to a system that measures water passing through a meter and communicates that information in an automated manner for monitoring and billing purposes. Smart meters offer a range of intelligent functions that include communicating to some form of user interface, which is viewed by a range of users who include private homeowners, property developers and water utilities (WISA, 2015). The ability to provide accurate data and consumption levels at specific times enables the rate of water used to be managed and tracked better. This may result in an automatic incentive to begin managing the use of water, whether motivated by the need to reduce overheads or due to environmental concerns (WISA, 2015). Smart meters differ from conventional meters as they measure consumption in greater detail and transmit that information back to the service provider without the need for manual readings (Figure 9). The technology includes meter data management software and services that enable utilities to remotely read meters and integrate data with back-end systems.

Figure 9: Smart meters (internet source)

SWM systems include AMR and advanced metering infrastructure systems. AMR refers to a system that allows automated collection of meter readings, usually by radio transmission. advanced metering infrastructure describes an end-to-end system that involves two-way communication between the back-end system and a water meter. Over the last decade, the smart water meter that has been most widely used around the world is the AMR. However, the industry has been shifting toward advanced metering infrastructure and smart grid solutions. Regardless of their different setups, all smart metering systems consist of three main elements, that is: measurement, communication, and a software app.

For water service utilities, the SWM approach can improve revenue collection from water bills and hence boost financial performance. Combining SWM technology and mobile banking can create a secure, transparent and low-cost flow of funds and information between consumer, water service provider and delivery system. By driving down water payment transaction costs, revenue collection increases and administrative costs are reduced (Hope, et al., 2011).

SWM has been widely adopted in many industrialised regions such as Europe and North America (see Box 5 for case study examples). The wide adoption is attributed to its ability to offer more accurate measurement data and a more reliable way for citizens to stay up to date with their water usage (WISA, 2015). Smart meters for water measurement have been implemented by the City of Johannesburg and Ekurhuleni municipalities. A significant growth in SWM technology is expected over the next several years. Based on a global literature review and proof-of-concept fieldwork in Kenya and Zambia, Hope et al. (2011) note that the confluence of mobile network coverage expansion, widespread mobile phone ownership, innovative mobile banking apps and SWM technologies offer new, effective, low-cost and inclusive pathways to water security and poverty reduction (Figure 10).

Figure 10: The SWM system (Hope et al., 2011)

Box 5: SWM in the District of Columbia, USA and Cape Town, South Africa

Case study: Benefits of the SWM system

The fixed-network AMR system implemented by District of Columbia Water and Sewer Authority in 2002 provides a good example of the possible dividends an SWM intervention can yield. Reported benefits included reductions in non-revenue water (from 36% to 22%), 7% increase in revenue (through debt reduction), reduction in meter reading costs (from $4.15 per meter to < $1), reduction in costs relating to complaint investigation (50% lower), and customer call centre services (36% lower), 20 less field vehicles required, and 106 000 ℓ of fuel saved every year (Hope et al., 2011).

In South Africa, issues that hinder large-scale adoption of smart water meters include lack of customer knowledge and experience with smart meters, and a lack of South African standards for smart metering. In a bid to remove barriers and motivate successful adoption of smart meters, the British High Commission funded three municipal smart grid project studies. The proposed interventions included generating tariff design guidelines for consumer engagement regarding smart meter roll-out, roadmaps for municipalities on putting processes in place to create an enabling environment for embedded generation, and identifying funding sources for smart grid processes (WISA, 2015).

SWM offers a range of benefits when compared with conventional water metering. These include theft and leak detection; greater billing accuracy; increased read frequency, resulting in improved debt collection; timely information coupled with analysis can help customers to better control the use of water consumption; and ability to remotely monitor resource use.

Although the benefits of smart water meter adoption for water conservation are widely understood, the mechanisms are still viewed with scepticism and mistrust among many members of the South African public mainly because of unfamiliarity (WISA, 2015). Other shortcomings that need to be addressed include:

- Access to and cost of capital investment is a hindrance to a wider adoption of the technology.
- Security threats to both physical assets and data. Hacking of remote devices is a major risk facing the industry. Cyber security is a real threat to the smart metering industry around the world.
- The lack of regulatory strategies and policies is another major challenge when it comes to deploying smart metering.
- In the developing world where SWM systems are still new, there is lack of necessary skill to be employed for a successful uptake.

Lessons learnt

- There is the need to build capacity in handling this technology in developing countries where uptake is new. This would make it easier for local manpower to handle technical challenges that arise (Hope et al., 2011).
- Smart water meters must be built for longevity with the ability to perform reliably in the field for many years – often a decade or even longer. Since water meters are often deployed outdoors, they must be extremely durable with the ability to operate in harsh environmental conditions (Sierra Wireless Inc., n.d.).
- There is a need to standardise SWM products and systems for better deployment efficiencies and effectiveness. It will be helpful in regulating the market and maintaining interoperability of devices while also providing a better understanding of how to develop policies and regulations (Hope et al., 2011).
- No utility will implement remote meter reading capabilities unless it is confident that data transmitted between the device and the cloud is protected (Sierra Wireless Inc., n.d.).

2.4.6.2 Water management device

A water management device is a low-cost, intelligent, electronic control valve capable of controlling the flow of water to a domestic consumer at full pressure (Pollark, 2009). The water management device can be linked to a pulse output water meter to enable leak detection (night flows). The device can also be incorporated in the AMR system to remotely capture data and control the meter. Figure 11 shows a water management device set-up. A water management device differs from a prepaid meter as it guarantees residents the free basic water allocation regardless of the limit of the amount of water set. It should be noted that a prepaid meter only allows the amount of water purchased to flow through the meter to the property. Therefore, water users with prepaid meters may not benefit from the free basic water allocation.

The water management device can be configured to:

- Dispense a fixed daily quantity of water (from 10 ℓ/day to 50 000 ℓ/day), thereby providing the ability to limit a consumer to a finite (or prenegotiated) level of supply. This is especially useful in the case of low-income consumers who may be unable to pay for water but are, nonetheless, entitled to be provided with at least the basic amount of water.
- Be linked to a fixed (flat rate) tariff to provide consumers the option to voluntarily limit consumption according to their budget. As with the free basic water allocation, this facilitates budgeting not only by the individual consumer, but also by social services agencies, government departments and non-governmental organisations.
- Provide meter readings by the radio signal to a drive- or walk-by collector – AMR or advanced metering infrastructure.
- Default to a trickle flow, if required once the full pressure allowance has been consumed. Trickle flow will be approximately 1 ℓ/hour.

Figure 11: The set-up of a water meter and a water management device (Pollark, 2009)

A water management device helps to prevent or minimise wastage of potable water by end users, and hence reduce consumption and water bills. In order to keep their consumption below the budgeted consumption, consumers will opt for responsible water usage, which entails detecting and fixing leaks, fixing dripping faucets, recycling, and exploring alternative sources among other conservation practices (see Box 6 for a case study example).

Box 6: Water management devices in the City of Cape Town, South Africa

Case Study: Devices help save water and money

The City of Cape Town Municipality introduced water management devices in 2007 for people who wanted to save water and money and control the amount of water they used. Currently, 84 000 water management devices have been installed in Cape Town, including the mayor's house. These water management devices saved the City of Cape Town Municipality 156 million ℓ of water every month, worth R510 000 (Pollark, 2009).

2.4.6.3 MajiVoice

MajiVoice is an initiative implemented in Kenya by the Water Services Regulatory Board (Wasreb) in collaboration with The World Bank. It is a platform for communication between citizens and water service providers in the Nairobi and Nakuru counties in Kenya (Wasreb, n.d.). Wasreb observed that utility response times and compliance in dealing with complaints, especially those from the poor in informal settlements, were weak and unreliable (Mooraa et al., 2012; Schouten, 2013). In response, they designed a national complaint handling system dubbed MajiVoice that would use ICT such as mobile phones to strengthen links between utility providers and customers, and enable oversight by the regional board and regulator (Hellström & Jacobson, 2014). MajiVoice is used for:

- Submitting water-related complaints, such as leaks, using a mobile phone or an online platform in addition to reporting these concerns through calls and visits to a local office.
- Providing customers with online responses to complaints including updates on the status of their complaints. The updates are sent in the form of text messages or SMS and may include photos of any repaired leaks in the customer's premises.
- Tracking reported complaints and facilitating quicker payment services. MajiVoice escalates complaints when they have not been addressed within 48 hours. If an issue is not resolved within the set period, it is automatically escalated to a senior official for action, and finally, if still not resolved, it is brought to the attention of the relevant water service board and regulatory agency. In addition to submitting complaints, citizens can also use the system to access and pay their water bills using electronic payment services on the mobile phone.
- For the service providers, MajiVoice has an inbuilt monitoring mechanism that tracks how complaints are being resolved, the time taken, and the performance of persons responsible for resolving complaints. The staff can attend to complaints easily using an online site, which provides customers' background information, history of complaints and also highlights ongoing issues for managers. Each complaint is assigned to a responsible customer care agent, who is bound by a customer service charter and can be observed by other staff and managers to ensure responsiveness. The system also allows service providers to broadcast information, such as service interruption alerts, to its customers by SMS.

The number of reported leakages doubled when MajiVoice was introduced. It was reported that there was a 50% increase in citizen feedback as a result of system implementation (Schouten, 2013). The system uses affordable, accessible and user-friendly technologies, such as the basic feature phones, which enables all consumers to be its potential user. Consumers can provide feedback on service delivery issues including matters of access, tariffs, service provider performance, responsiveness, quality of service, and resolution of complaints among other concerns. Also, the intervention has provided a convenient alternative to other tedious and often time-consuming processes of lodging complaints with service providers.

Water service providers have also witnessed improvement in many areas of their work. MajiVoice has helped with the introduction of systematic and structured procedures for resolving complaints in a consistent and objective manner. The increased responsiveness to complaints led to greater consumer satisfaction. The ability of MajiVoice platform to track logged complaints until they are cleared from the system enables quicker and efficient resolution and follow-up of consumer concerns. Also, the georeferencing tool enables better understanding of typical concerns affecting different localities (Schouten, 2013).

The main challenges of the MajiVoice system include:

- Poor response time to customer complaints.
- Linking MajiVoice and other outreach channels (e.g. social media).
- Establishing legal operational frameworks.

2.4.6.4 Jisomee Mita

Jisomee Mita is a mobile-based ICT that empowers customers who are supplied with metered water to read their water meter at their home or property (Figure 12). Jisomee Mita is a Swahili term meaning 'read your meter'. The technology was launched by the Nairobi City Water and Sewerage Company (NCWSC) in May 2014 and implemented in June 2014 in a low-income residential area, called Kayole Soweto. Jisomee Mita project was implemented alongside the Maji Mashinani (Swahili for 'water at the grassroots') initiative, a World Bank-funded flagship project aimed at installing new piped water networks and connecting water meters in 2200 plots to serve 90 000 Kayole Soweto residents by February 2013 (NCWSC, 2012; The World Bank, 2012a). The mobile-based system allows the customers to use a basic mobile phone to (NCWSC, 2014):

- Submit meter readings by SMS.
- Access multiple billing within one cycle (i.e. a month).
- Pay for water as they use it.
- Query account balance.
- Pay loan.
- Add/remove another phone from the account.

Figure 12: Message from NCWSC reminding a client to read the meter (Business Daily, 2014)

With the digital platform, customers, property owners or landlords, who pay for water services on behalf of their tenants, can send meter readings to NCWSC using their mobile phones. Upon sending the readings, they may receive outstanding water bills and make payments through mobile money services i.e. through MPesa and ZAP. The customers only pay for the water they consumed (see Box 7 for a case study example).

Box 7: Implementation of Jisomee Mita platform in Kayole Soweto, Kenya

Case Study: Self report metering with micropayment[7]

Jisomee Mita system was designed to empower customers to read water meters on their own. Over the period of implementation of Jisomee Mita System, about USD18 000 was collected. In addition, there was increased confidence in the billing system by the customers, who were empowered to read their own meters. The paperless system generally minimised operation and transaction costs associated with meter reading, billing and bill payments.

During the implementation of the ICT system, it was noted that: (1) system change needs demonstration of tangible benefits to the customers and should not cost them higher than the existing services; and (2) SMS is a technology with near universal acceptance in Kenya. Similarly, use of web technologies for the app within NCWSC enabled lowering of training costs.

[7] http://programme.worldwaterweek.org/sites/default/files/9_presentation_on_self_meter_reading_solution_final_version.pdf

Jisomee Mita has benefits for both the water service provider (i.e. the NCWSC) and water consumers. These benefits include:

- **Savings:** The technology enables the NCWSC to save expenses incurred while sending paper bills to clients – these include the cost of purchasing paper, in addition to the cost of producing the printouts. The method also eliminates the expense on fuel costs needed by the NCWSC employees who moved round homes on motorbikes to read water meters. If the customer makes payment through the mobile money services, then expenses such as transportation cost are forgone, which enables customers to save money. Moreover, the SMS number through which the customers send their meter readings is toll free.
- **Instant billing and payment:** The customers receive their water bills on their phones. Payment through mobile money services is quicker and less costly, which enables the customers to enjoy a continuous supply of water by paying on time (Ooko, 2014).
- **Accurate bill:** With the Jisomee Mita technology, customers have the surety that they are only paying for the units of water consumed (Ooko, 2014). This technique fosters integrity and trust in the billing system since the officials will not use estimates to generate bills for customers whose water meters were inaccessible (due to barriers such as locked gates at customers' premises) to the employees who go to homes on motorbikes reading meters so as to relay the information back to the office (Ooko, 2014).
- **Increased revenue collection:** The project has helped improve revenue collection from the residents (Habel, 2014). This is because residents use the system with ease since the arrangement allows them to pay bills at any time of the day. Since the implementation of Jisomee Mita, NCWSC's monthly revenue collections due to water consumption in Kayole Soweto region reportedly doubled (Wolfson, 2014).
- **Better service delivery:** Through instant bill inquiry and prompt payment of the water bill via the convenient method (mobile money services), customers are assured of continued supply of water. Such engagement between the customers and the water service provider fosters accountability and improves customers' trust in the billing system.

The main challenge in the implementation of the project is that the beneficiaries, who are generally poor, are compelled to take on a small loan in order to get water supply. Nevertheless, the willingness of local residents to participating in the initiative is reportedly growing (Wolfson, 2014). Jisomee Mita has proved to be effective in Kayole Soweto slums in Nairobi and the NCWSC intends to roll out the mobile phone payment system to its water consumers by January 2015 to enhance the effectiveness of service delivery and increase revenue collection. The project is also set to be scaled up to other cities in Kenya such as Mombasa, Kisumu and Eldoret, following its success in Nairobi (Habel, 2014).

2.4.6.5 Other ICTs in WDM sector

Other ICTs in the WDM sector include the following:

The Dropcountr app[8,9]:

Dropcountr is a mobile app for both iOS and Android mobile devices (Figure 13). This app was developed following a plea from the governor of California for Californians to reduce water consumption by 20%. The app was intended to prompt more efficient use of water because residents could not estimate their water use. For instance, an average Californian estimated that they used half the amount of water than they actually used. The water bill from the water utility did not allow easy assessment as

---

[8] http://dropcountr.com/

[9] http://www.triplepundit.com/2014/08/dropcountr-launches-app-manage-water-usage/

to whether the units consumed were reasonable or excessive, despite that it showed a three-month history of water usage data in terms of units.

The Dropcountr app was developed to provide real-time data on water usage to homeowners, incorporating features such as push notifications when water use is about to cross over into a higher rate tier, and alerting homeowners when a potential leak is detected. In addition, people would be able to compare their water use with others in similar homes in the neighbourhood. Besides helping water utilities and their customers to save water, money and time, the platform enables utilities to deliver customised drought and water budget messages instantly, and users are notified of damaging leaks immediately.

The system relies on data from the water utility, which in turn, is processed by the app and displayed in the form of easily understood graphics on the screen for users. It also allows customers to prompt their utility to ask it to share real-time data. Dropcountr is expected to enable utilities to establish a better line of communication with their customers.

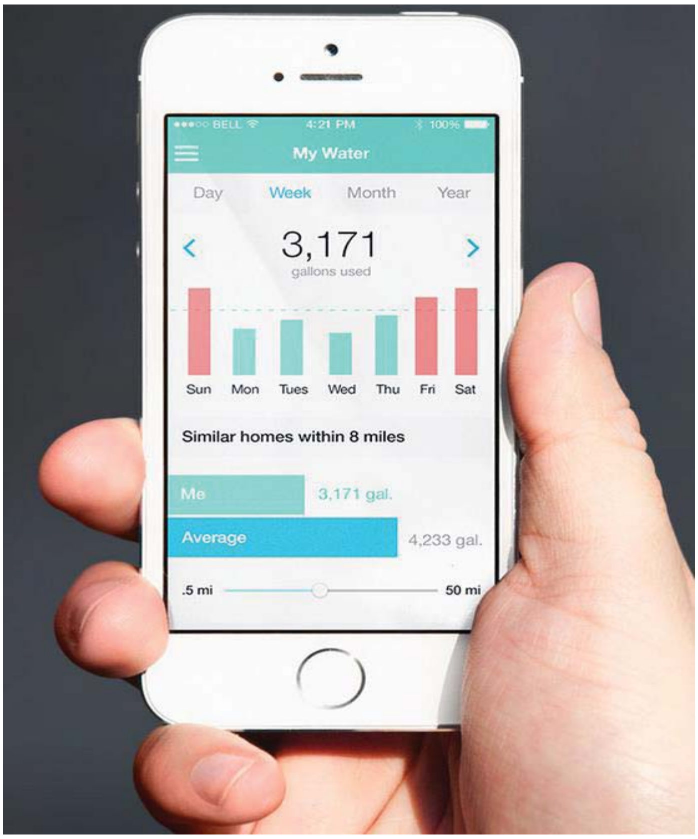


Figure 13: Dropcountr app

NextDrop[10]**:**

NextDrop was implemented in Bangalore, India, to provide households with reliable, near real-time information about water arrival via the mobile phone infrastructure by allowing them to receive SMS alerts on water supply disruptions (Figure 14) (see Box 8 for a case study example). It is also a platform through which citizens voice their water-related concerns which need to be addressed by utilities.

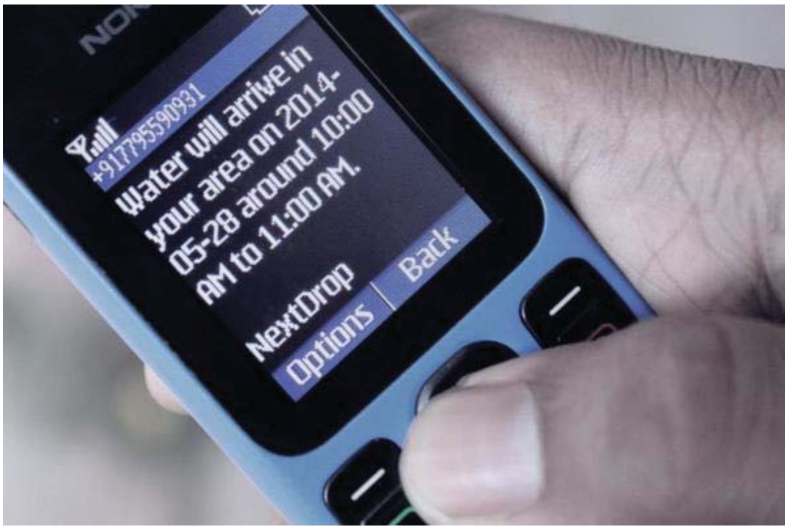


Figure 14: NextDrop app notifying user on water arrival time

For water service providers, the app enables monitoring of the utility distribution systems, improve customer satisfaction and resource efficiency. Also, NextDrop can function in simple mobile phone technology, and therefore all mobile phone owners are potential users.

The main challenge that faces NextDrop operation is that the smartphones used by valve men drain the battery rapidly, and they may only be able to upload data for a part of the day. Also, they incur extra data charges when they run out of bandwidth. If they have a prepaid plan, they will often run out of credit and not be able to upload data at all (Shah, 2015).

Some of the lessons learnt during the implementation of NextDrop include the following:

- Donor partnerships are crucial during the initial stage of project implementation, until when the value of the service is proven to attract self-sustained partnerships with a local utility.
- Focus the design on fast-paced customer feedback.
- Social incentives such as strengthening the community bond between the workforce and their customers, and professional incentives such as performance recognition are essential factors for improved workforce performance than financial gain alone (Richardson, 2014).

The challenges facing NextDrop implementation include the following:

- Language compatibility problems since NextDrop's texts are in English and many customers do not speak English.
- Gaining consistent and accurate information from the utility company workforce in the field, who often required training on how to use a mobile phone, how to use an IVR system, and how to be consistent in their information (Richardson, 2014).

[10] http://nextdrop.org/#

Box 8: Implementation of NextDrop app in Bangalore, India

Case Study: Improving water service delivery in Bangalore[11]

In Bangalore, India, the demand for potable water has far outstripped supply. This is attributed to a dramatic increase in the human population in the city. Water is rationed, and most parts of the city receive water once in two days. The supply of water is controlled by valve men (ground level staff) who manually operate valves by turning a valve key.

Valve men have not always adhered to the schedule. This delay in reconnecting water supply affected the residents of the city, especially those who earned their living while using water. The residents believed they did not have a voice.

In 2010, NextDrop started implementing a solution in the towns of Hubli and Dharwad that provided water supply alerts to residents. The source of this information was the valve men themselves who called into an IVR system with information on when a particular valve was turned on or off. This information was encoded into an SMS by NextDrop's back end and sent to only those customers who received water from that particular valve.

Recently, the Valvekey app (mobile app for Android) was developed to facilitate availability of more accurate and timely information to the customers and utility provider. However, most valve men still use the IVR system. By having this data, Bangalore's water board can monitor the movement of water, any leakages, blockages or other faulty issues. They can also keep tabs on water levels in city-owned reservoirs.

Seesaw apps[12]**:**

Seesaw (based in the South Africa) developed a range of software tailored to the particular needs of the water sector in the developing countries. The software apps were intended for use in new technologies to improve:

- Meter reading.
- Fault reporting.
- Non-revenue water.
- Customer billing and relationships in urban utilities.

Seesaw apps have mainly been implemented in eastern, western, central and southern Africa. The system allows individuals to use either a feature phone or smartphone to send information, typically over the mobile phone network. When data is received in the platform, it is integrated with existing records and analysed. The system, customised to specific use cases, allows results to be queried by email, viewed on an online map and interactive table. The platform also allows managers to track the performance of those sending in the information too.

The mobile apps developed by Seesaw are as follows:

- **SeeTell:** Allows reporters to report various issues such as availability of water, technical difficulties or revenue generated at stand posts. The app also allows reporters to send information at no cost and in real time.

---

[11] http://www.gsma.com/mobilefordevelopment/improving-water-service-delivery-in-bangalore-the-case-of-nextdrop

[12] http://www.greenseesaw.com/#!software/cjlc

- **SeeSMS:** Prompts reporters by an SMS they receive from the system, to report or send specific information through SMS (Figure 15).

Figure 15: An SMS alert asking reporter to report specific information via SMS

- **SeeRead:** Allows collection of water meter information, meter readings, pictures and GPS coordinates. This system can be integrated in the existing billing and customer relationship management software.
- **SeeSaw Reporter:** This survey-type app can be customised to specific data collection needs of clients. It can preload information on the phone and synchronise and correct existing customer information on the database.
- **DoForms:** This app entails specific templates for the water and sanitation sector, developed for initial collection of field data (baseline survey) and for periodic projects or 'evaluation' surveys.

All information collected using these systems are consolidated in one centralised platform and can be used to create maps and records that can be easily analysed to show patterns and trends. The benefits of Seesaw's platform include:

- Real-time updating.
- Automatic analysis of the data received.
- The information can be directly integrated into other systems (such as billing and accounting).
- All information is centralised, even though different sources or apps can be used to collect data.
- Accessible offline.
- Easy to use.

2.4.7 Online reporting platforms and e-Services in the City of Cape Town

The City of Cape Town Metropolitan Municipality promotes reporting of complaints by residents through online platforms such as social media (City of Cape Town Facebook page) and the e-Services website (Figure 16). In addition, the City of Cape Town Metropolitan Municipality uses the C3 Electronic Reporting System (Figure 17) (called Service Requests) to record, track and report customers' complaints. This ensures that all requests for service, called notifications, are not only recorded, but responded to appropriately.

Figure 16: City of Cape Town's e-Services (City of Cape Town, 2015b)

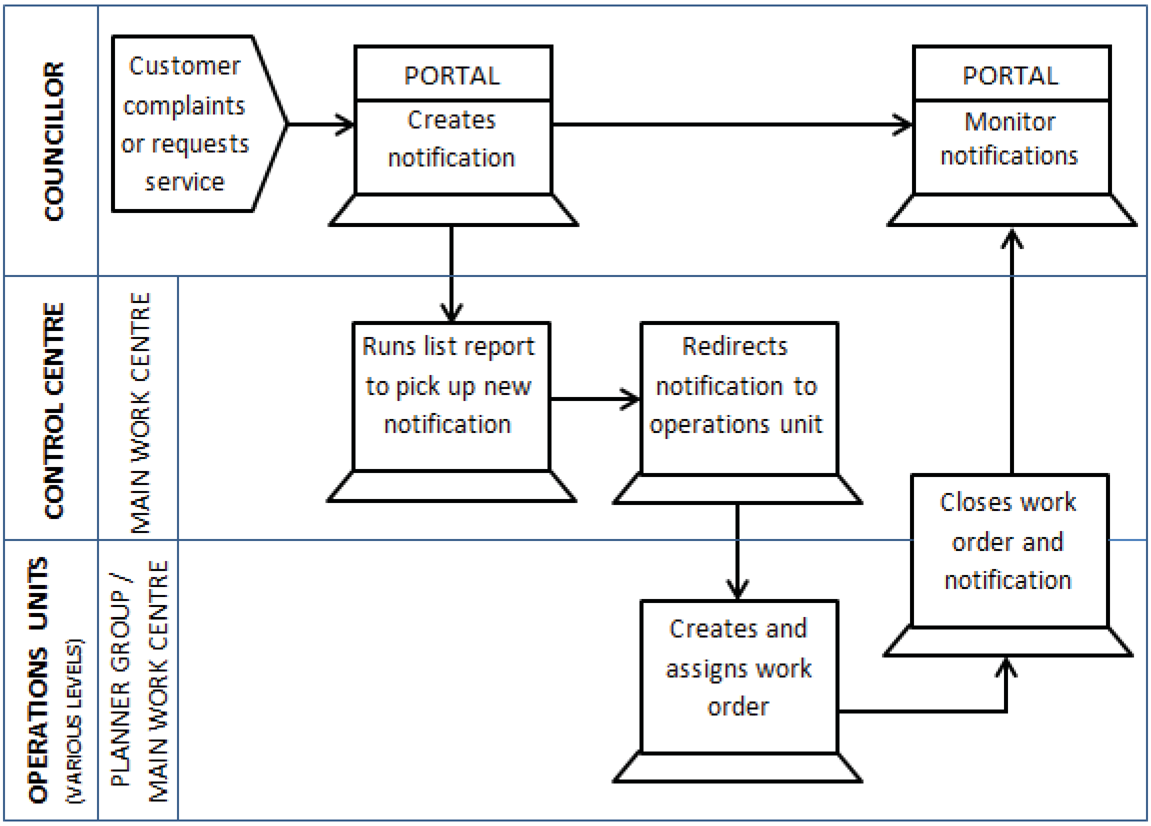


Figure 17: C3 corporate works management process via portal (City of Cape Town)

A notification is created every time a service request is received, either by phone on the city's centralised call centre, via SMS, email, over the counter or through written correspondence. The complainant is then given a reference number, allowing them to follow up on the complaint. As soon as the complaint has been dealt with, the notification will be closed (CIDC, n.d.).

2.5 Summary

This chapter has highlighted the use of ICTs for WC/WDM. The various forms of ICTs reviewed were smart metering, water management devices, and mobile apps including MajiVoice, Jisomee and Dropcountr. These apps essentially supplement existing metering strategies for households or multi-unit properties by automating meter readings as well as providing platforms on which consumers can pay their bills and send or receive information from service providers.

The effectiveness of ICTs on WC/WDC varies based on the context in which they are applied. The use of ICTs for WC/WDM is still at a developmental stage in South Africa, hence in subsequent chapters, we shall first examine the case environment of the City of Cape Town in greater detail, and then consider the implementation of the DropDrop app within this context.

3 WATER CONSERVATION IN THE CITY OF CAPE TOWN

3.1 Introduction

According to Stats SA (2014), the City of Cape Town is home to 1 669 000 households with an average household size of 3.3 persons. About 78% of the households have piped water inside their dwellings and almost 92% of households own a cellular phone for communication purposes (Stats SA, 2014). The official languages of communication are Afrikaans (34.9%), Xhosa (29.2%) and English (27.8%) (Stats SA, 2011). This chapter introduces the various WC/WDM practices in place in the City of Cape Town and highlights some key research findings from previous studies that help explain the unique context of this city.

First, some background to the overall integrated water resource planning that takes place in the City of Cape Town is explored, identifying how WDM fits within the overall water management picture of the city. Thereafter, individual WDM projects run by the city are introduced, including tariff adjustments and leak repairs. Finally, other research conducted within Cape Town that is pertinent to understanding the water demand space is reviewed.

3.2 Integrated Water Resource Planning in the City of Cape Town

The total water demand for the City of Cape Town metropolitan area amounts to approximately 904.22 Ml/day (2011/12), which is bound to increase due to the steady population increase. The average domestic water consumption is estimated at 153.67 $\ell/c{\cdot}d^{-1}$ (2010/11) for consumers with full water supply services (City of Cape Town, 2011/12). This is not considered excessive, but there are still opportunities for further efficiency gains. Estimating how water is used within a household can help identify where the opportunities to increase efficiency exist. Moreover, effective management of water use must be based on a clear and unambiguous appreciation of how human behaviour related to water use patterns (CSIR, 2010).

With the WC/WDM initiatives underway in the City of Cape Town, the next augmentation scheme was expected to be implemented by 2019. According to the research projections, the increasing demand would have surpassed the system yield or the water supply capacity by the year 2019, making effective management of water use a priority.

In 2001, Shand and Gibb conducted a study on the integrated water resource planning (IWRP) that investigated various water resources availability management initiatives. The study highlighted the initiatives to be implemented in order to reduce the demand for water or alternatively increase the supply. According to the results, WDM initiatives would have a significantly lower implementation cost, could be implemented in a shorter time frame, and were generally more environmentally and socially acceptable than water supply options (Frame & Killick 2004). Table 9 summarises the investigated options and their overall scoring. The overall scores were deduced by specialists in the technical, social and environmental fields, who established a system of scoring and weighted each criterion to reach a consensus as to the relative merit of the various options, a process known as multi-criteria decision analysis (Shand & Gibb, 2001).

Table 9: Summary of options and overall score in the City of Cape Town (Shand & Gibb, 2001)

Option	Yield	Financial	Socio-econ.	Accept-ability	Environ-ment	Overall scores
Pressure management	64	84	62	95	93	83
Elimination of automatic flushing urinals	57	76	59	94	93	79
Tariffs, metering and credit control	69	100	69	29	93	75

Option	Yield	Financial	Socio-econ.	Accept-ability	Environ-ment	Overall scores
Voëlvlei*	87	83	54	83	51	74
Leakage repair	52	64	85	75	93	73
Lourens river diversion	78	84	66	74	44	72
TMG aquifer*	70	75	73	79	39	70
Eerste river diversion	70	75	54	78	53	69
Cape Flats aquifer	66	69	57	75	70	69
Treated waste water for local urban and industrial use	41	75	31	68	97	67
Promotion of private boreholes	38	59	61	74	37	57
Desalination *	73	25	63	85	82	57
Introduction of water efficient fittings	48	50	64	38	93	56
Promotion of grey water use	29	55	28	63	82	54
Treated waste water for commercial irrigation farmers	48	72	10	26	82	51
Treated waste water reclaimed to potable standard	71	17	71	38	97	47
*Options investigated in CMA Bulk Water Supply Study						

Based on the IWRP study, the three packages identified for implementation were:

- Package 1 – comprises pressure management, user education, elimination of automatic flushing urinals, leakage repair and tariffs metering and credit control (can be implemented by the City of Cape Town).
- Package 2 – consists of the promotion of private boreholes, the introduction of water efficient fittings and the promotion of grey water use (can be implemented by individual consumers).
- Package 3 – supply augmentation options to be implemented by the City of Cape Town.

The Cape Town City Council initiated WDM initiatives in 1995. Toward the end of 1998, the Water Demand Management Strategy and Policy was developed, which was officially adopted and approved by the Cape Metropolitan Council (Frame & Killick, 2004). Since the development of the Water Demand Management Strategy and Policy and the implementation of effective WC/WDM initiatives, a significant reduction in water demand has been achieved. The strategy has since been reviewed to accommodate future initiatives up to 2020/2021. Currently, the demand is below supply but it is expected to surpass the system yield in 2016 if it is unrestricted (see Figure 18).

Although the WC/WDM initiative has succeeded in suppressing growth in water demand, tremendous savings in water demand could be achieved if water users in the City of Cape Town would actively participate in the WC/WDM initiative at household level. This could be facilitated by incorporating a suitable technology into the initiative to educate consumers and provide timely information on WC/WDM at the point of their need. In this manner, the WC/WDM would be scaled up to be implemented by the entire City of Cape Town populace.

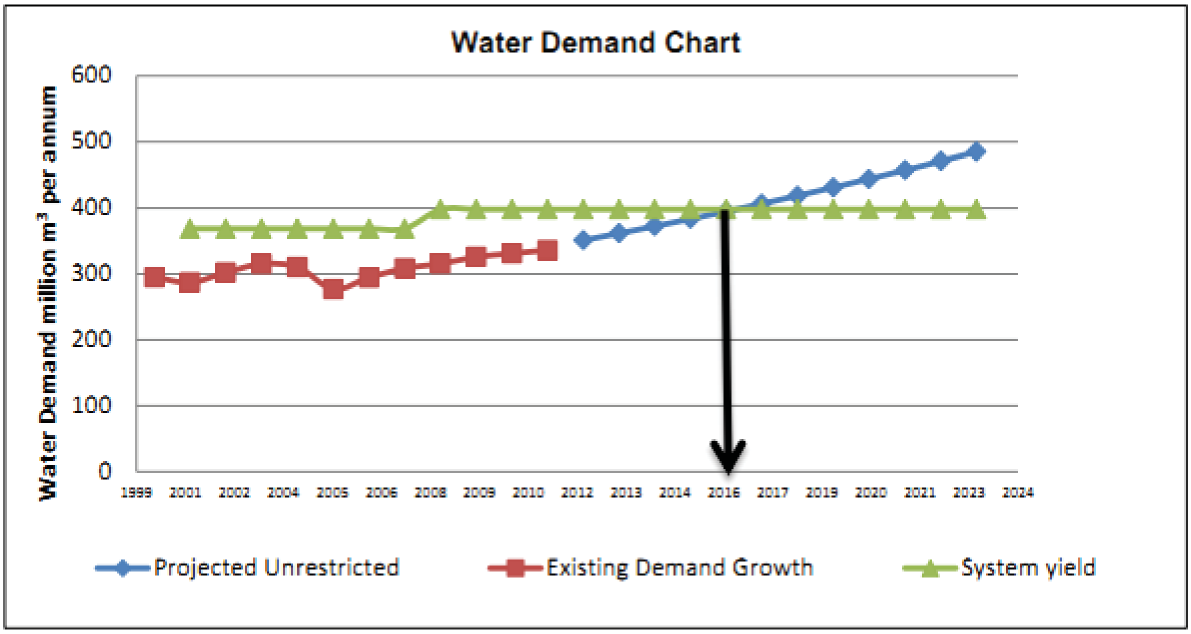


Figure 18: Water demand projection in the City of Cape Town (City of Cape Town, 2013b)

The City of Cape Town Municipality has been promoting implementation of water conservation practices through its website, which reduced household water consumption. This mode of communication targeted residents who had access to the internet. Unfortunately, over half of the population in the municipality does not have access to the internet (Stats SA, 2011). This is illustrated in Figure 19. Consumer education via the internet could be low due to the cost experienced by the customer. The cost of browsing the internet increases as time elapses, thus people would prefer spending limited time on the internet to read their emails and social media websites, such as Facebook, rather than viewing extensive water conservation information on the municipal website. As a result, very few residents become knowledgeable enough to implement the beneficial water conservation tips recommended by the municipality through their website.

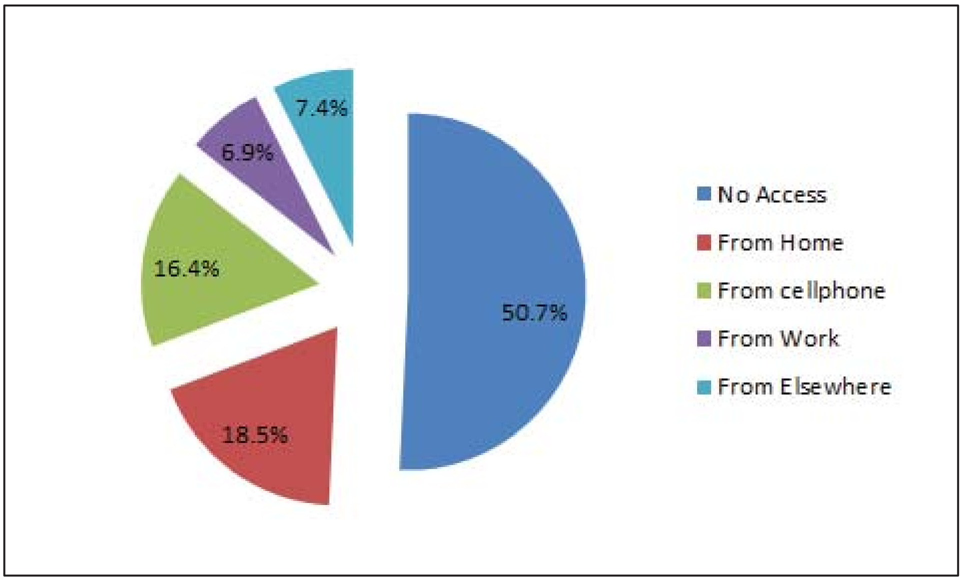


Figure 19: Access to Internet in the City of Cape Town (Stats SA, 2011)

The challenges in educating consumers via the municipal website can be addressed by adding incentives to encourage consumers to cooperate, by, for example, adding a customer status (e.g. green customers) (Sinske et al., n.d.). Alternative options of utilising mobile phones may facilitate education. In the City of Cape Town, 91.3% of the households own mobile phones (Stats SA, 2011). This figure is higher than ownership of computers (37.9%), radios (70.1%) or televisions (87.3%) in households (see Figure 20).

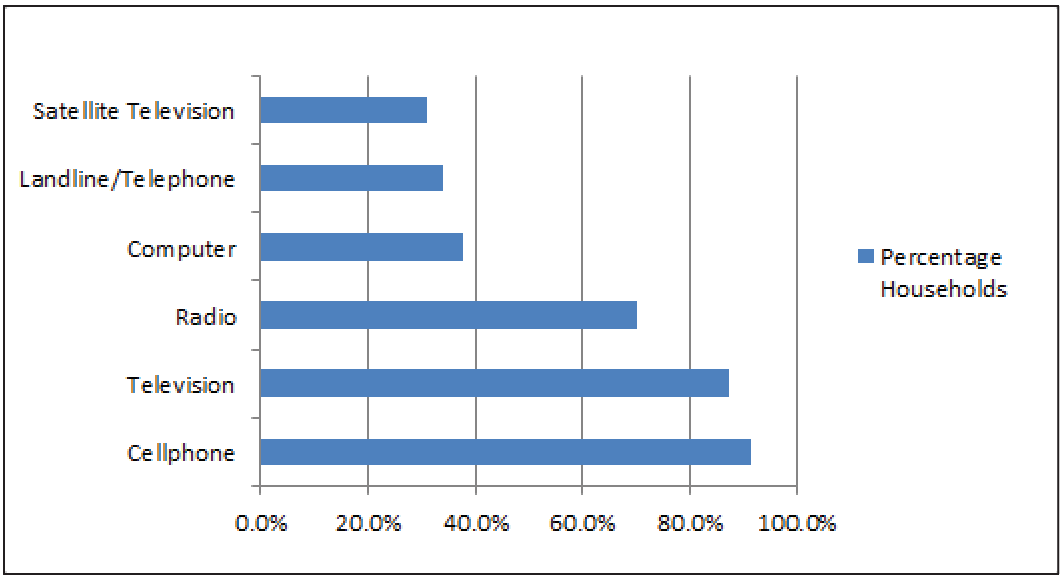


Figure 20: Household goods in the City of Cape Town (Stats SA, 2011)

Therefore, progress in consumer education could be achieved if water users had both online and offline access to the relevant and comprehensible educational information through their mobile phones.

3.3 WC/WDM Initiatives in the City of Cape Town

The City of Cape Town runs a variety of water conservation projects in order to curb demand. In addition to leak detection and education campaigns, block water tariffs are also applied to curb unnecessary water consumption. Each of these will be explored in turn in the sub-sections that follow.

3.3.1 Municipal policies – water tariff policy for the City of Cape Town

An effective tariff scheme can be used to ensure water is used efficiently. To achieve this, suitable tariffs must be formulated by all the relevant stakeholders in the water services sector. Water service authorities (in the form of municipalities) are mandated by the Water Services Act (South Africa, 2001) and the Municipal Finance Management Act (South Africa, 2004) to review tariff policies and formulate tariffs annually. Many municipalities in South Africa use increasing block tariffs for water, where the first block covers the free basic water portion (6 kilolitres per household per month). For sanitation, various municipalities adopt different tariff structures such as metered volume of effluent, tariff mark-up on metered water use, tariff per household and flat rate (DWS, 2013b).

The City of Cape Town adopted the tariff mark-up on metered water use to determine the bill for household effluent. Table 10 shows the tariff rates for both water and sanitation services in the City of Cape Town Municipality as at 2015/2016. The rate structure (rising block tariff) is such that consumption level at which the last step begins aims at encouraging water conservation.

Table 10: Water and sanitation tariffs in the City of Cape Town (City of Cape Town, 2015a)

Water consumption: metered		Sanitation tariffs	
Category	Tariff 2015/2016 Rand/kl (incl. VAT)	Category	Tariff 2015/2016 Rand/kl (incl. VAT)
Domestic full[13]		**Domestic full**	
Step 1 (0 ≤ 6 kl)	0.00	Step 1 (0 ≤ 4.2 kl)	0.00
Step 2 (> 6 ≤ 10.5 kl)	11.07	Step 2 (> 4.2 ≤ 7.35 kl)	10.44
Step 3 (> 10.5 ≤ 20 kl)	15.87	Step 3 (> 7.35 ≤ 14 kl)	18.53
Step 4 (> 20 ≤ 35 kl)	23.51	Step 4 (> 14 ≤ 24.5 kl)	20.26
Step 5 (> 35 ≤ 50 kl)	29.03	Step 5 (> 24.5 ≤ 35 kl)	21.27
Step 6 (> 50 kl)	38.30		
Domestic cluster[14]		**Domestic cluster**	
Step 1 (0 ≤ 6 kl)	0.00	Step 1 (0 ≤ 4.2 kl)	0.00
Step 2 (> 6 kl ≤ 10.5 kl)	13.57	Step 2 (> 4.2 ≤ 7.35 kl)	11.45
Step 3 (> 10.5 ≤ 20 kl)	15.87	Step 3 (> 7.35 ≤14 kl)	18.53
Step 4 (> 20 ≤ 35 kl)	23.51	Step 4 (> 14 ≤ 24.5 kl)	20.26
Step 5 (> 35 ≤ 50 kl)	29.03	Step 5 (> 28 ≤ 35 kl)	21.27
Step 6 (> 50 kl)	38.30		

Understanding the water rate tables and how consumption fits in a tariff block can be helpful in setting targets and therefore limiting overconsumption in households. Regular access to water consumption information can enable consumers to reduce their consumption in order to stick to as low a tariff level as possible. Table 10 shows that the waste water tariff is directly linked to the amount of potable water consumed. Waste water is invoiced at 70% of the fresh water consumption. Therefore, higher water consumption will attract higher sanitation fees. This is an incentive to efficient use of water since the resulting lower consumption is a double reward as both the water and sanitation bill will be lower.

Other issues affecting WC/WDM and addressed by the tariff policy (City of Cape Town, 2015a) include:

- The need to estimate consumption: Should it not be possible to take a reading on the appropriate date; the city reserves the right to adjust consumption to reflect its best estimate.
- Plumbing leaks: The city seeks to address the problem of underground leaks on private property by granting an underground rebate for claimants of such plumbing leaks, who have made appropriate application for a rebate.

[13] Domestic full: consumers with access to both controlled and uncontrolled volume of metered water supply; i.e. single residential properties

[14] Domestic cluster: where one metered connection point serves a multi-residential unit development.

- Disputed consumption: An owner/accountholder who doubts the validity of the consumption stated on any account may apply for the meter to be tested at his/her cost as per the miscellaneous tariff schedule.

3.3.2 Leak repair projects

The city's five-year leak detection plan was developed in 2010 and was intended for implementation in 2013/14 financial year. Two projects were designed, namely, the Leaks Project and the Integrated Water Leaks Repair Project (IWLRP) (City of Cape Town, 2010a). Both projects were aimed at educating water users and creating water conservation awareness in the City of Cape Town.

3.3.2.1 Distribution management: Active leak detection and repair[15]

The objective of active leak detection was to minimise the time between a minor leak occurring and its repair. Minor leaks on the water main can run undetected for months or years, resulting in the loss of considerable amounts of water, hence the need for the initiative. Priority areas for leak detection were determined and were based on areas in which pressure management was implemented but the minimum night flows remained higher than expected. In a residential area where there is no industrial water usage, it can be concluded that most of the minimum night flows recorded from data logging is water wastage made up of the following:

- Leaks within the households/properties (i.e. plumbing leaks).
- Indiscriminate wastage of water (i.e. people leaving taps open).
- Leaks in the distribution systems.

The Distribution Management Project was implemented in 2013 in three areas: Kuilsriver, Highbury and Highbury Park. It was noted that the residents of these regions were also educated on how to read their water meters and identify underground leaks. The Highbury and Highbury Park leak detection pilot project was reported to achieve a total potential annual water savings of 38 473.92 m^3 per year and a financial saving of R327 797.80. In this project, detection and repair of leaks were done on the water mains that run from municipal reservoirs up to the water meter at the properties. Beyond the water meter, the households or water users were expected to take the responsibility to detect and repair leaks.

3.3.2.2 IWLRP

The IWLRP was a one-off project supplementary to the Distribution Management Project. It was implemented in low-income or indigent households in the City of Cape Town. The project targeted the distribution lines that spanned from the water meter to the fixtures or water outlets in properties. Besides fixing leaks, the focus was on creating awareness regarding the importance of consumer participation in water conservation. In addition, it educated water users about the water resources in the City of Cape Town and water conservation measures, which include reading water meters, identifying leaks and managing personal water demand.

A detailed handbook on the IWLRP was released by the municipality for the water users in the City of Cape Town. An important component of this project was to raise the awareness of consumers toward their daily water consumption. Figure 21 is an extract from the handbook showing a spreadsheet that was designed for consumers to track their water consumption by reading the water meter regularly. The IWLRP sought to establish collaboration between water users and the municipality in order to enhance efficiency in both water conservation and service delivery within the municipality. The outcome of the pilot projects was beneficial since the average domestic consumption in the project areas reduced. This is illustrated in Table 11.

---

[15] https://www.dwa.gov.za/Projects/RS_WC_WSS/Docs/Overview%20of%20WC%20&%20WDM.pdf

.

It was noted that consumer education and awareness (on saving water) helped to mitigate inefficient water usage (City of Cape Town, 2013a) and contributed to the overall success of the project. Also, transferring of infrastructure management responsibility to community members was found to be significant in facilitating demand management (City of Cape Town, 2013a). Other techniques employed during the project included retrofitting and installing water management devices in some homes.

Table 11: Outcome of the retrofitting and leak fixing project (City of Cape Town, 2013a)

Description	Samora Machel	Fisantekraal	Ravensmead
Number of households	500	1 233	1 423
Average consumption before intervention (kl)	21	29	31
Average consumption after intervention (kl)	12	17	21
Difference (kl)	9	12	10
Total annual consumption (kl)	4 500	14 796	14 230
Cost of the project (R)	1 100 000	3 700 000	4 200 000
Annual average savings (R)	54 000	177 552	170 760
Payback period (years)	1.7	1.7	2.0

KEEPING TRACK OF YOUR WATER CONSUMPTION

1. Note the date. (Column 1)
2. Read the meter – all the figures, black and red (Column 3).
3. Read the meter a number of days later at approximately the same time of the day – preferably 7 days (1 week).
4. Note the date.
5. Calculate and note (in column 2) the number of days since the previous reading.
6. Calculate and note (in column 4) the water consumption for the period = difference between the current and previous meter reading. (column 3)
7. Calculate and note (in column 5) the estimated monthly consumption = Column 4 x 30.417 ÷ Column 2. (The average number of days in a month is 365 days in a year ÷ 12 months = 30.417). Note – round the consumption off to the nearest kilolitre.
8. Calculate the estimated bill by following the steps outlined in "How to calculate your water and waste water (sewerage) account". Note that because it is an estimated monthly (30.417 days) account the tariff blocks do not need to be adjusted.
9. Note: to get the best estimate use a 7 day period.
10. If your water consumption is too high take immediate steps to reduce it.

Use this to keep a track of your water consumption:

1	2	3	4	5	6
Date	**Period - Days between readings**	**Meter Reading**	**Water Consumption for the period**	**Estimated Monthly Consumption**	**Estimated Monthly Bill**

Figure 21: Spreadsheet for consumers to monitor consumption (City of Cape Town, 2010)

3.4 Recent Water Conservation Research Findings

Water conservation awareness and education projects (most of which are ongoing) include the comprehensive Water Conservation Consumer Perception Assessment. These user education initiatives have resulted in an increased awareness among water users of the value of water. Despite the awareness initiatives conducted by circulating pamphlets, doing radio adverts, campaigning in libraries and school, and the Extended Public Works Programme, the level of awareness was generally just above average (see Figure 22 and Figure 23). The findings implied that further interventions that aim at enhancing WC/WDM in households should be explored.

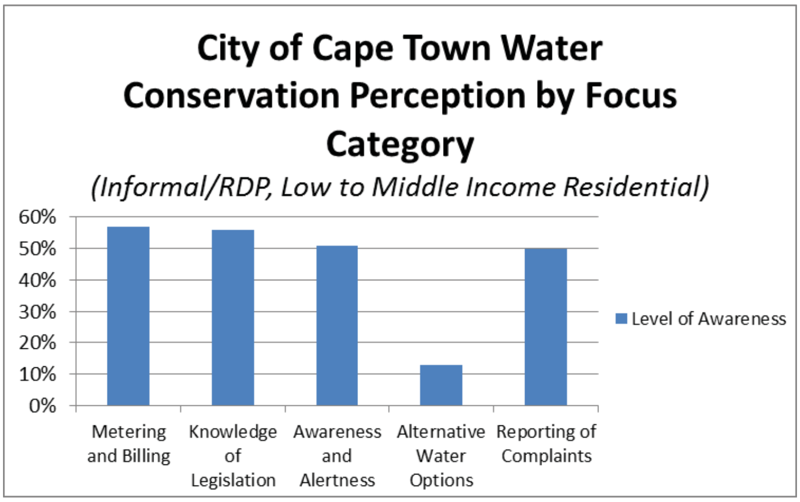


Figure 22: Water conservation perception by focus category (City of Cape Town, 2014)

From Figure 22, the level of awareness on reporting of complaints is about 50%. These water users have the least awareness on alternative water options as a method of conserving the municipal water. Although the water users are fairly aware of metering and billing, their level of awareness on the location of their water meter and stopcock was very low i.e. 24%. This is illustrated in Figure 23.

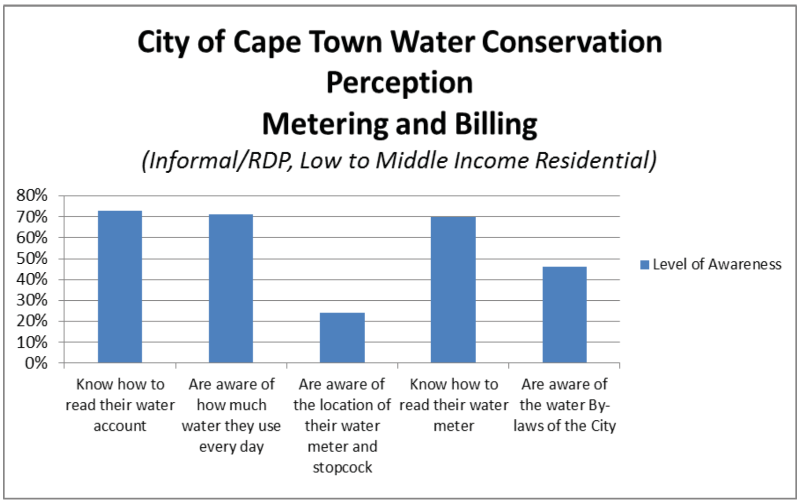


Figure 23: Water conservation perception by conservation perception (City of Cape Town, 2014)

Figure 23 shows that the population is relatively knowledgeable not only on how to read their water meter but also on their daily water consumption. However, the level of awareness can be enhanced by exploring innovative ways of providing consumers with explicit real-time information on their water use. The major lesson learnt was that without access to information, citizens are ill-equipped to shift their behaviour toward desired conservation measures.

4 EXPLORING WATER CONSERVATION AND MOBILE PHONE USAGE IN CAPE TOWN

4.1 Introduction

As noted previously, one aspect of this project was conducting an assessment of the general suitability of mobile phones as a medium for WDM within the unique context of the City of Cape Town. The aim of this was to identify current mobile phone usage, willingness to pay for information and commitment to partake in research across a representative sample of social classes of Cape Town households. This chapter outlines how the research was conducted, as well as the findings that helped inform the approach to the primary research questions.

4.2 Methodology for Research

The research was based on a quantitative survey interviewing mobile phone owners. Previous research had revealed various factors that influence the usage of mobile phones including gender, affordability, social and behavioural influences and age. In order to understand to what extent this was relevant for Cape Town, the sampling was conducted across varying social classes of Cape Town.

A non-probability convenience sampling approach was followed, considering the limited timeframe and financial resources available. While this did not allow a probability assessment across a sample and therefore did not allow to extrapolate across the population, it was assessed that a sample of 200–350 participants would be adequate for the purposes of this study. A total 236 participants took part in the study.

Data collection was done face-to-face in public spaces such as malls in six suburbs of Cape Town, i.e. City Bowl, Northern Suburbs, Southern Suburbs, Atlantic Seaboard, South Peninsula and Cape Flats. Responses were collected, validated, checked for completeness, and stored electronically and password protected to ensure security and confidentiality. All survey questionnaires were treated as strictly anonymous and did not require the respondents to disclose any personal information such as their name and contact details. The information received through the questionnaires was not shared or distributed for any purpose. Software used to analyse the data was password protected, and only granted access to the researchers. There was no exclusion to interview respondents that did not own a mobile phone, since mobile phone usage is not necessarily connected to mobile phone ownership.

4.2.1 Questionnaire

A questionnaire was prepared to assess the main reasons for using mobile phones and identify any factors that may influence the willingness to pay. The survey consisted of two main sections. Section A focused on the uses of mobile phones. This section included demographic information such as age, gender and income.

Information regarding usage was gathered using proxies such as communication, social media, safety and access to the internet. Section B addressed the aspects related to the willingness to pay for information. Statements were presented, and respondents were asked to select their preferred response using a five-point Likert-type scale where 1 indicated strong disagreement and 5 strong agreement.

A pilot questionnaire was done to assess the accuracy and ease of use of the survey instrument. The pilot test highlighted a number of shortcomings and the questionnaire was revised based on the input and feedback received.

4.2.2 Model for determining willingness to pay for information

There are several models that can be used to measure user adoption, usage of technology, user perceptions and behavioural intentions to pay for products, services and information. For this study, the Uses and Gratification Theory was used to analyse willingness to pay. The Uses and Gratification Theory is based on the hypothesis that usage of a technology is influenced by the satisfaction and gratification the user gains from it (North et al., 2014). The theory assists in measuring the user's social and psychological perspectives and determines the motivators toward using a technology (North et al., 2014). Figure 24 shows the uses and gratification framework.

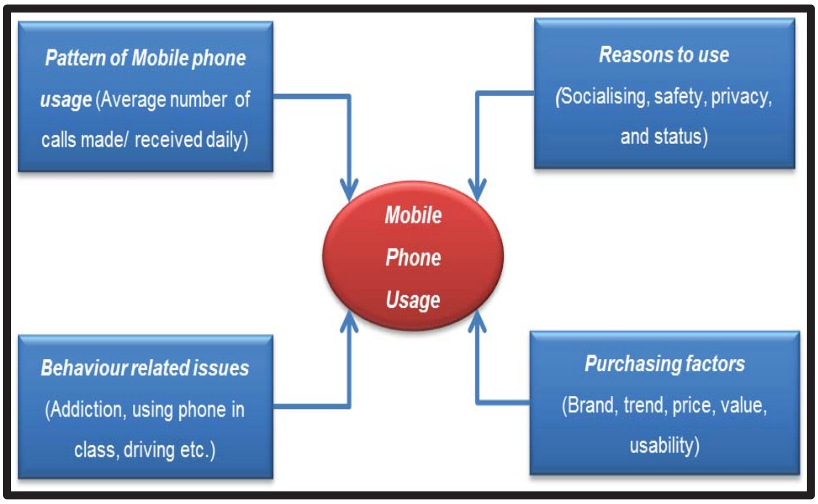


Figure 24: Uses and gratification framework (North et al., 2014)

As depicted in Figure 24, mobile phone usage is influenced by the following distinct and measurable factors:

- Reasons for use, which may range from socialising to safety or status aspects.
- Pattern of use, which focuses on measuring the amount of time a phone and its apps are used.
- Purchasing factors, which include market trends, brand, value and features.
- Behavioural impact a phone may have on the user, where the gratification has a direct impact on the well-being of the user.

It was also important to understand if there are differences between social classes in their willingness to pay. Social classes are defined as "a group of individuals who occupy a similar position in the economic system of production" (De Clercq et al., 2014). For the purpose of this study, social classes were defined by household income. In South Africa, five classes are distinguished by personal income estimates:

- Lower class (R0 and R50 000 per annum).
- Working class (R50 000–R100 000 per annum).
- Middle class (R100 000–R300 000 per annum).
- Upper middle class (R300 000–R500 000 per annum).
- Upper class (more than R500 000 per annum).

4.3 Research Findings and Analysis

The findings and analysis of the survey are discussed in the sub-sections that follow.

4.3.1 Access to water-related information

For the analysis section, some factors that conveyed the respondents' level of knowledge and awareness were compared with the water conservation practices implemented by respondents. The sample populations' knowledge and awareness of water conservation, prior to the study period are illustrated in Figure 25.

As can be seen, few respondents (18%) knew of the municipal water hotline for reporting water-related concerns. More than half of the sample population were unaware of both their daily water consumption and the ongoing water conservation initiatives that were run by the municipality. An example of these initiatives was the IWLRP, which was implemented in some parts of the City of Cape Town Municipality to mainly fix water leaks in properties. More than half of the participants indicated that they were aware of the water tariff used in billing water in the City of Cape Town. The assessment of knowledge and awareness and the resulting water conservation practices are discussed below.

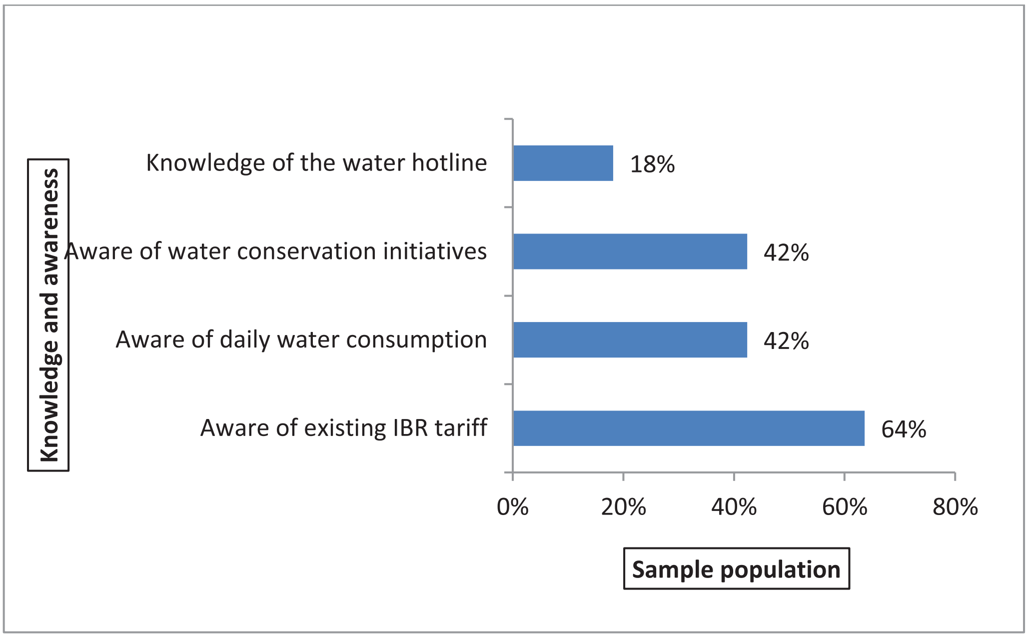


Figure 25: Population knowledgeable of conservation initiatives

4.3.2 Mode of accessing water conservation information

Access to water conservation information is a prerequisite for gaining knowledge. In turn, knowledge empowers water users to conserve water. Therefore, popular modes of accessing water-related information were investigated to determine how mass consumers can be informed. Figure 26 shows the extent to which various communication media are known and used by the sample population to access water conservation information.

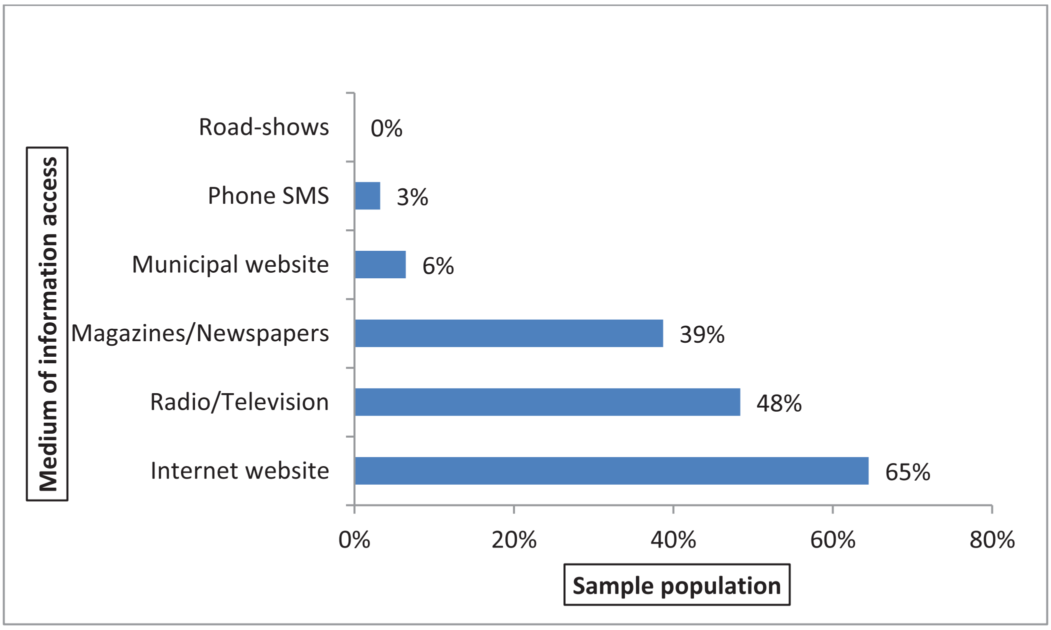


Figure 26: Modes of accessing conservation and other water-related information

Figure 26 shows that most respondents (65%) indicated that they used the internet to access water-related information. However, fewer participants were aware of the water conservation campaigns and initiatives that were ongoing within the City of Cape Town. Area-specific conservation information could not be accessed by most of the targeted customers.

Newspaper and radio/television were used by almost half of the sample population to access water-related information whereas none of the respondents received water conservation education through roadshows. This indicates that water conservation education through roadshows was inappropriate for these particular consumers.

Despite having water-related apps and education materials such as the conservation tips[16], the municipal website was visited by a few respondents only (6%). This observation could explain why less than half of the sample population were not aware of both their daily consumption and the ongoing conservation initiatives implemented by the municipality. It also affirms the study findings of Silva et al. (2010) that customers do not usually regard utility websites as a particularly effective method of communication.

A comparison between methods of accessing water-related information and respective water conservation participation level reveals that more of the participants, who accessed water-related information through the internet website, were aware of their daily consumption. More of these participants also trusted the utility bill. This is illustrated in Figure 27.

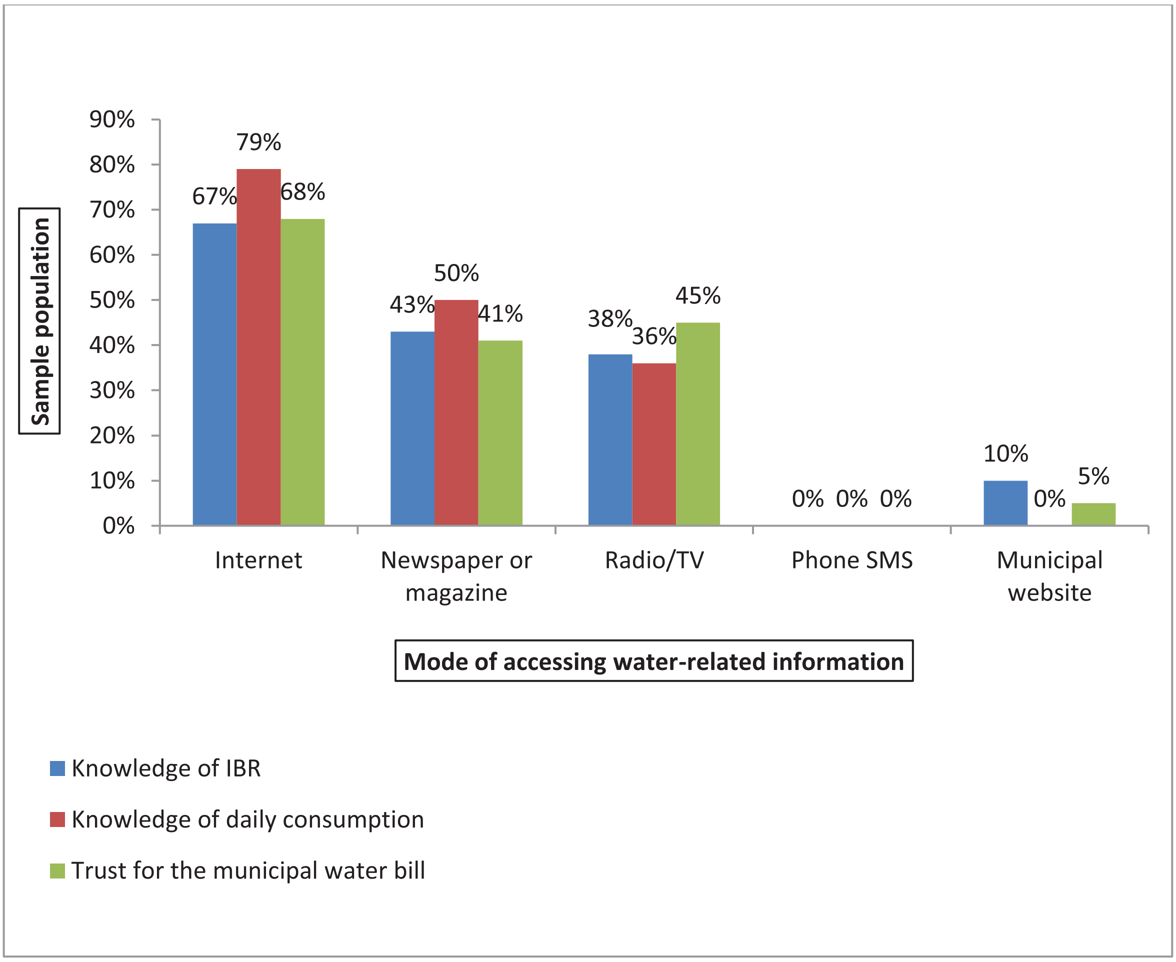


Figure 27: Comparison of respondents' knowledge to mode of accessing water-related information

[16] https://www.capetown.gov.za/en/KeepSavingWater/Pages/Watersavingtips.aspx

Figure 27 shows that the water-related information acquired from the internet imparted general knowledge (unlike area-specific knowledge) of water conservation among water users more effectively than other methods such as SMS, radio/television, print media and roadshows. From Figure 27 it can also be noted that none of the participants, who accessed water-related information through the municipal website, knew their daily water consumption. This implies that none of these participants accessed or utilised the water audit located in the municipal website.

4.3.2.1 Access to water conservation slogan

Of the respondents, 64% accessed water-related information through the internet website, yet only 9% saw the "Keep Saving Water" theme on the internet website. In this study, 45% of the participants had never heard or seen the water-saving slogan "Keep Saving Water." Figure 28 shows how the proportions of the sample population accessed the "Keep Saving Water" slogan. The education tools[17] on the municipal website contained the "Keep Saving Water" slogan. Water savings can be realised if the target audience accessed and implemented the information conveyed by the campaign. Knowledge of these slogans can infer that the water users are conversant with the water conservation information contained in the water conservation initiative or campaign. About 30% of the respondents heard or saw the "Keep Saving Water" slogan through radio and television advertisements whereas 24% saw it on the outdoor ads. Few respondents saw the slogan in the local newspaper and education event. Figure 28 could imply that half of the sample population did not access the water conservation information bearing the "Keep Saving Water" slogan and were therefore unaware of the conservation information disseminated with the slogan.

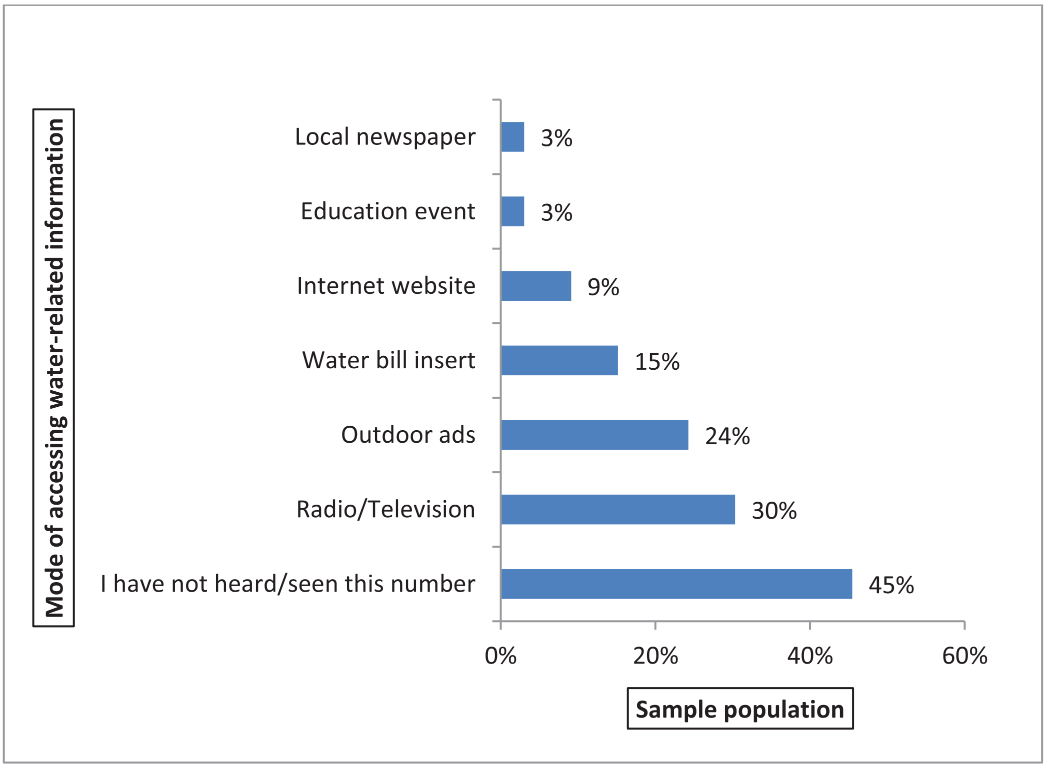


Figure 28: Mode used by sample population to access the "Keep Saving Water" slogan

Generally, more than half of the respondents who were knowledgeable about the "Keep Saving Water" slogan implemented the water conservation practices which were listed in the questionnaire. This is illustrated in Figure 29.

---

[17] https://www.capetown.gov.za/en/KeepSavingWater/Pages/Educationaltools.aspx

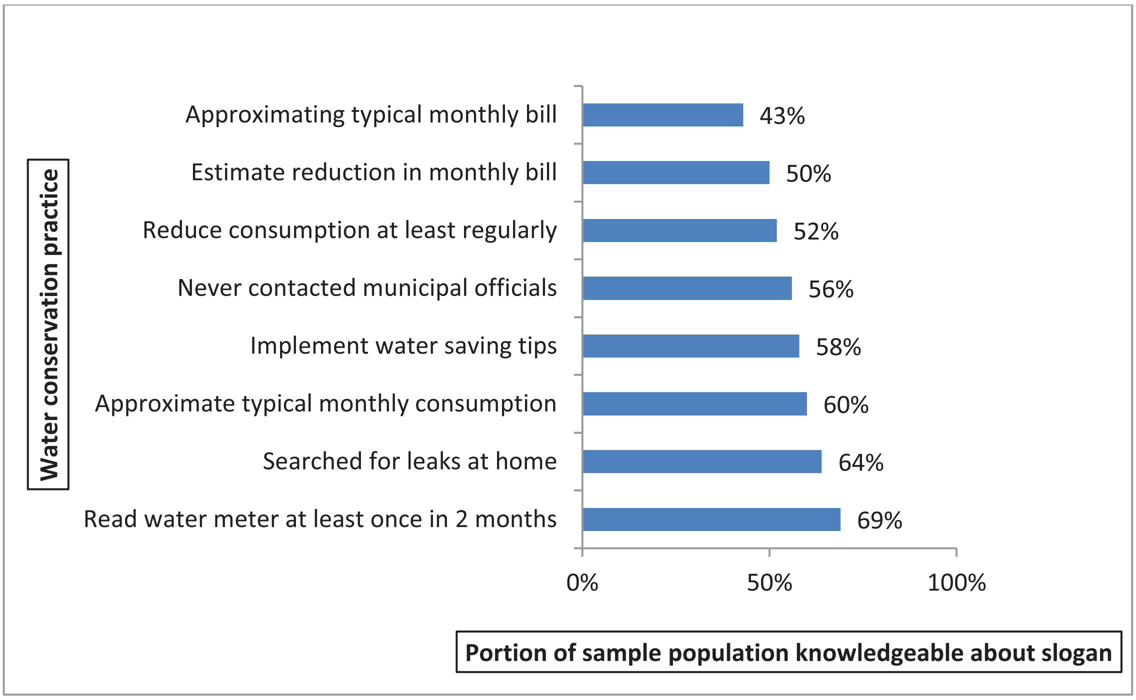


Figure 29: Proportions of the sample population knowledgeable on the "Keep Saving Water" slogan

The previous slogan, "Saving Water is a Way of Life", also appeared in many documents that contained water-saving tips for home. However, 70% of the respondents had neither seen nor heard about it.

4.3.2.2 Access to water hotline

The City of Cape Town Municipality's water hotline (086 010 3054) was intended for residents to contact water services directly for complaints, enquiries, or to report incidents concerning water or sanitation (sewerage) pipes and infrastructure, such as water leaks. However, 82% of the respondents had neither heard nor seen the municipal water hotline. The modes through which the participants accessed the water hotline are illustrated in Figure 30.

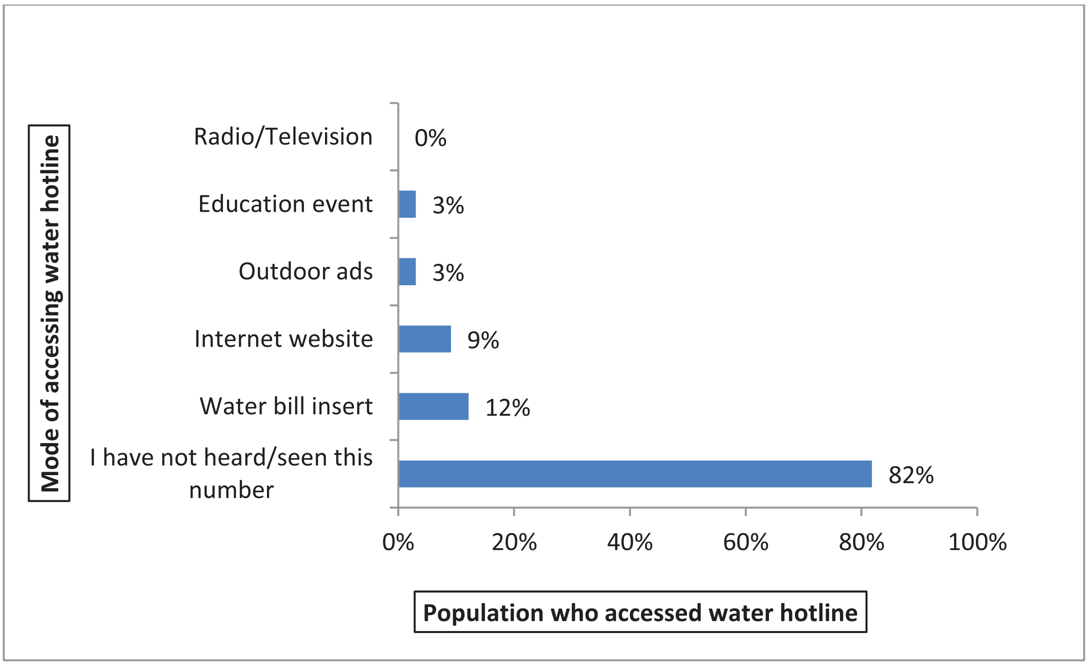


Figure 30: Mode of accessing the municipal water hotline

This observation could explain why most respondents did not call the City of Cape Town's technical operations centre (TOC) to report water-related concerns and faults. Only 21% of the respondents who never contacted the municipal call centre knew about the water hotline. The remaining 79% indicated that they once contacted the TOC once. This is shown in Figure 31.

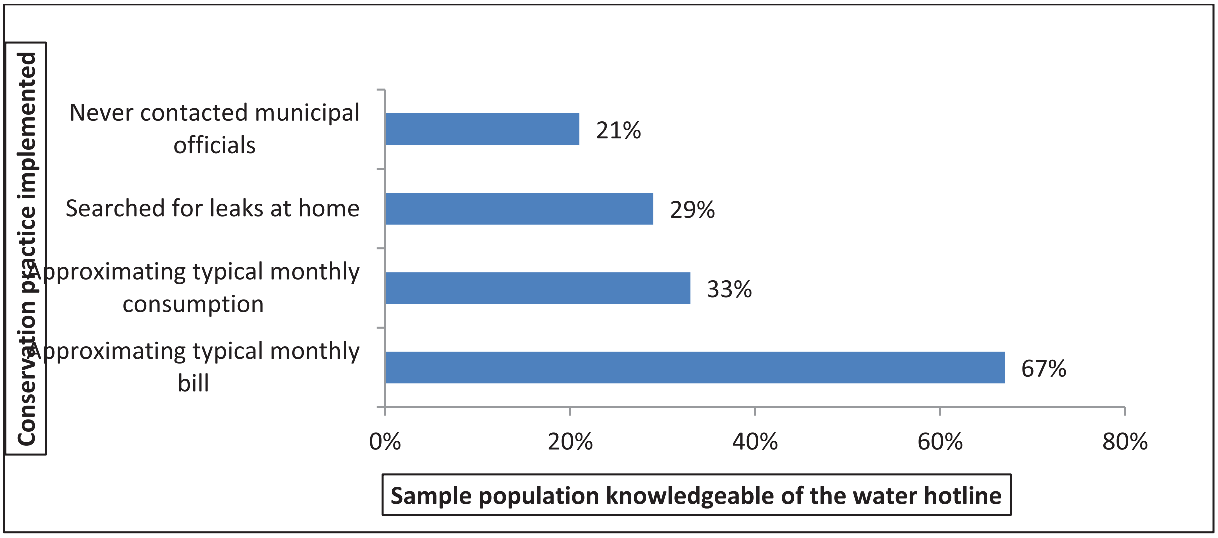


Figure 31: Knowledge of water hotline compared with some conservation practices

Of the participants, 67% knew that the water hotline indicated that they approximated their typical monthly water bill. Of the respondents who indicated that they approximated their monthly bill, 34% did not approximate their consumption; however, knowledge of consumption would be needed to approximate water bill. Nevertheless, these respondents estimated their monthly bill and would easily contact the municipality in case of a disputable utility bill.

4.3.2.3 Trust for the municipal monthly utility bill

Figure 32 shows that most participants trusted their municipal utility bill as a true record of their water consumption.

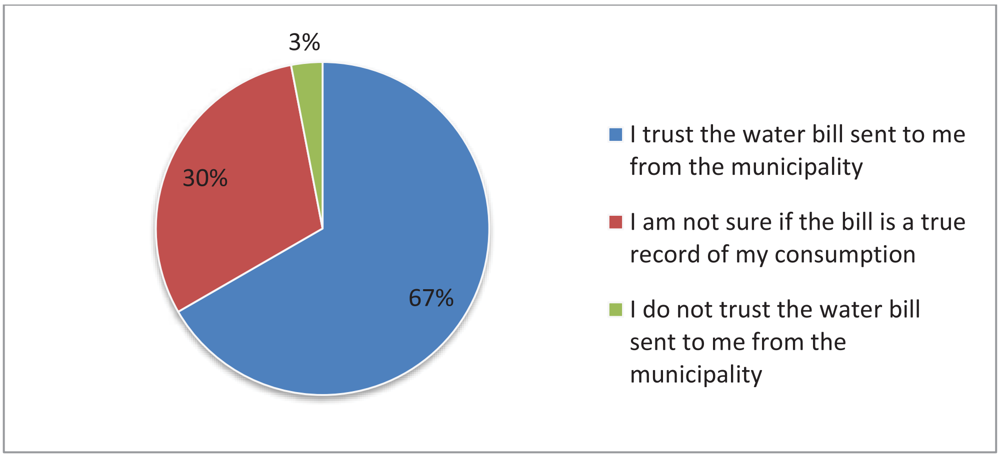


Figure 32: Proportion of the sample population who trust the utility/water bill

The participants who were not sure whether their bill was a true record of their consumption (30%) were unlikely to have estimated their water bill. Such water users would be reassured of whether or not the bill is trustworthy by providing them with information about their daily water usage. The information on the water bill enabled 41% of the consumers to monitor their water consumption. This is illustrated in Figure 33. Of the respondents, 34% indicated that they could not utilise the information provided in the utility bill to monitor their water consumption.

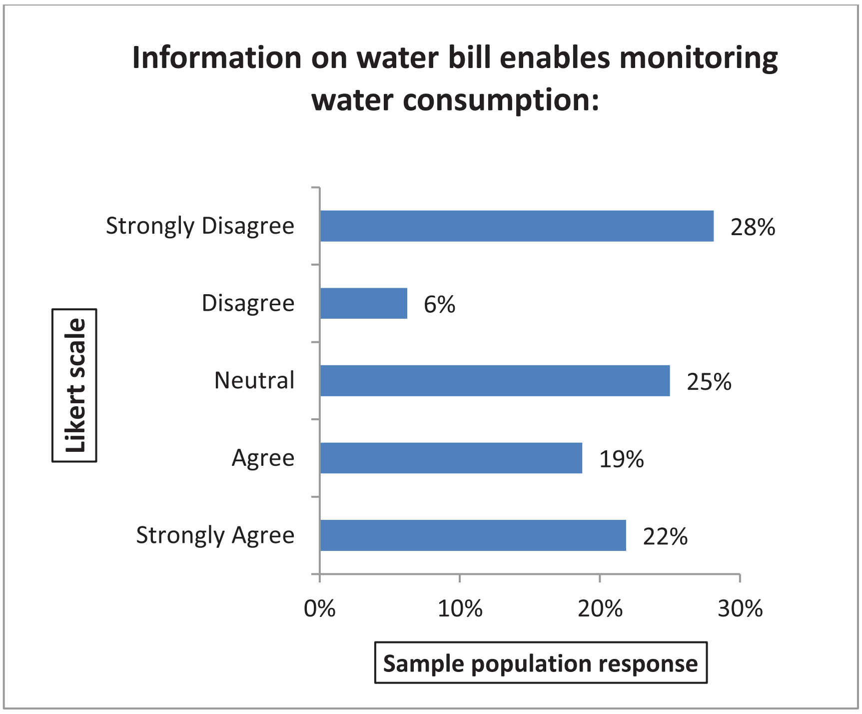


Figure 33: Effectiveness of the information on the utility bill

4.3.3 Reasons for conserving water

The reasons for conservation of water by participants ranged from “avoiding wastage” (73%) as the most common, to “South Africa being dry and water scarce” (48%) as the least common. Participants’ reasons for water conservation are illustrated in Figure 34. Respondents were generally provoked by a cause to conserve water. It can be noted that fewer respondents (55%) indicated that they conserved water to reduce their monthly water bill and save money.

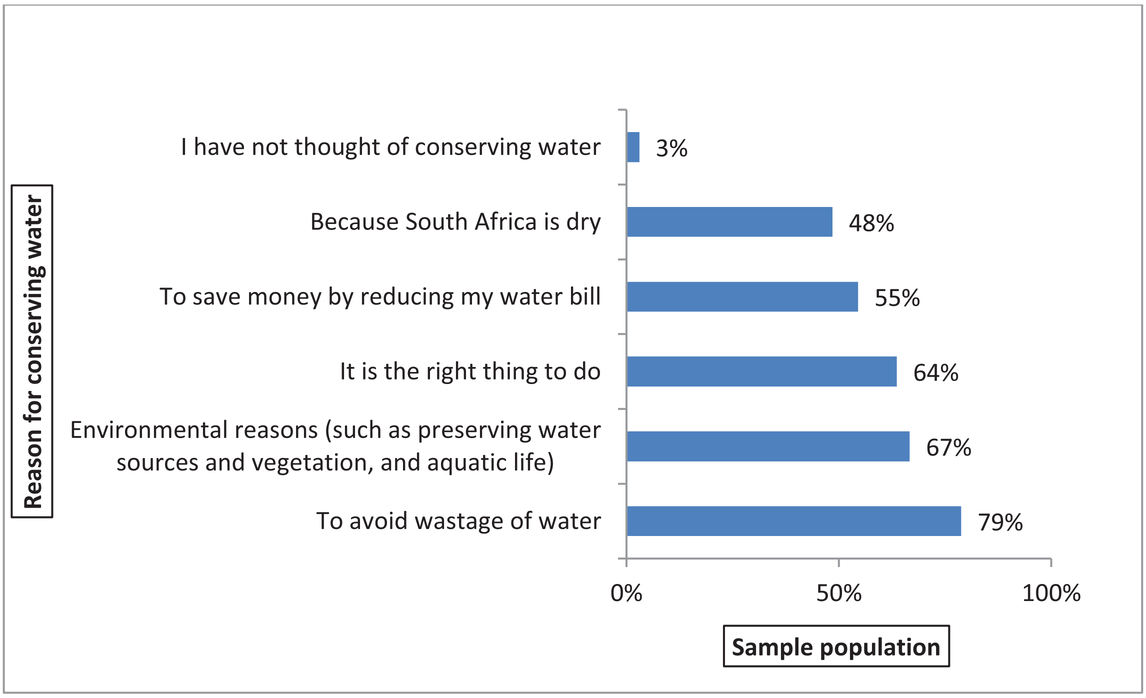


Figure 34: Reason for water conservation by sample population

Most participants who conserved water aimed to avoid wastage more than saving money. This implies that they understood that portable water was scarce. Therefore, water conservation campaigns that emphasise the need to avoid wastage can be more effective than those that underscore monetary savings. Silva et al. (2010) assert that consumers may be convinced to perform tasks more efficiently in order to reduce their water demand and the linked energy demands for providing, treating and heating water, and even leads to decreased greenhouse gas emissions. The latter two benefits alone may influence consumers to save water at a time when they seek to understand how they can contribute to curbing climate change (Silva et al., 2010).

4.3.4 Mobile phone usage and willingness to pay for information

The analysis in this section relates to the study undertaken to assess residents of the City of Cape Town's mobile phone usage and willingness to pay for information.

4.3.4.1 Demographic information

The ages of the 236 participants were distributed as shown Figure 35. The age of respondents ranged from 12% being younger than 20 years to 6% being older than 60 years. Most respondents were in the age group 31–40 years, representing 33% of the total respondents. Of the respondents, 56% were male and 44% female.

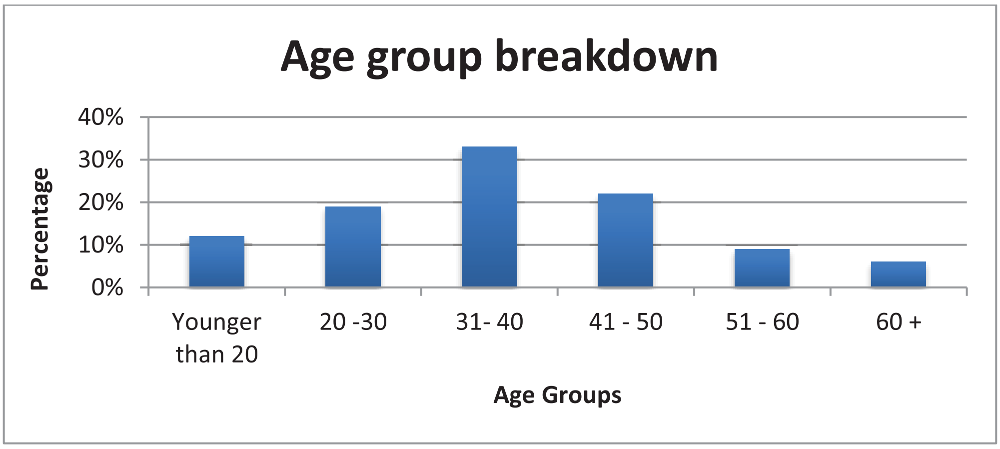


Figure 35: Age of respondents

Figure 36 shows the distribution of income classes for the study. Of the respondents, 17% were representative of the lower-class grouping with earnings of less than R5000 per month. The working class represented 38% of the respondents, middle class 18%, upper middle class 17%, and upper class 10% (Figure 36).

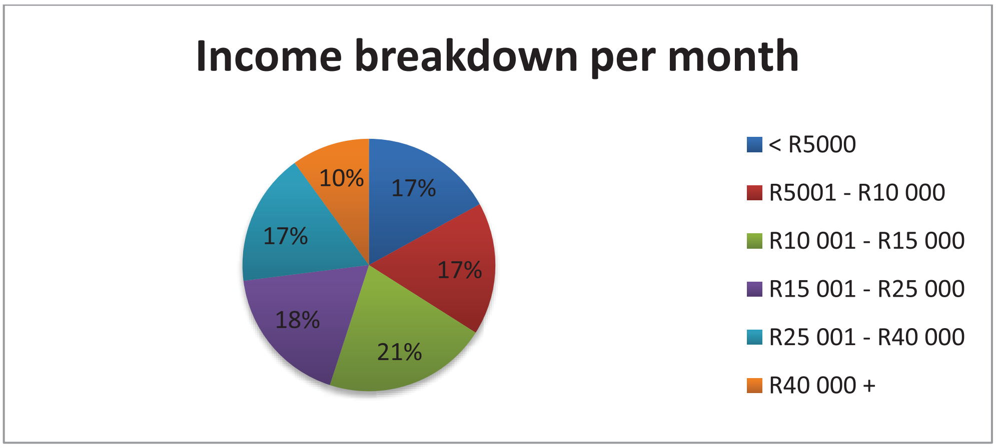


Figure 36: Income classes

4.3.4.2 Mobile usage

Figure 37 shows that 86% of respondents indicated that they owned a smartphone, with 51% using a prepaid (pay-as-you-go) tariff plan and 49% being on a post-paid (i.e. contract) tariff plan. There was no correlation between mobile phone type (smartphone vs. feature phone) and the tariff type.

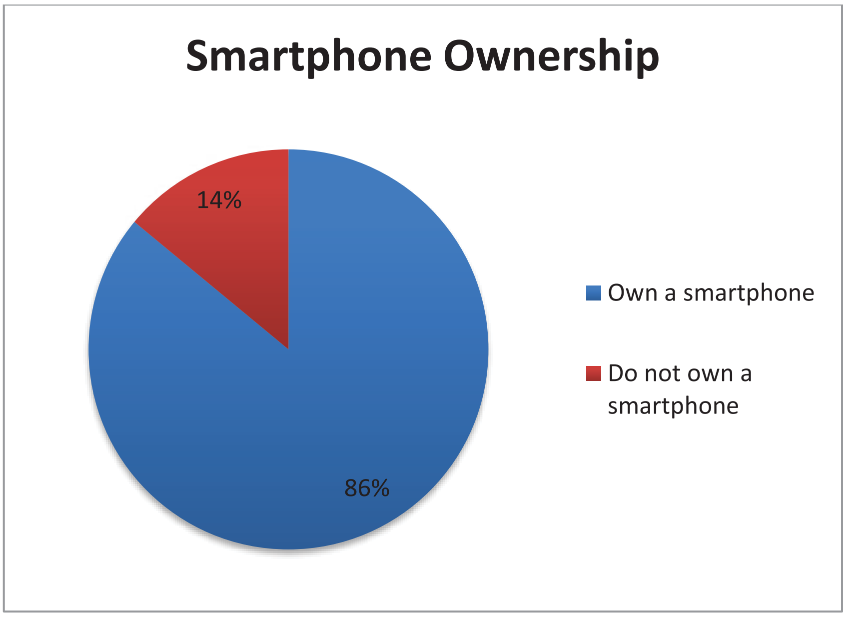


Figure 37: Smartphone ownership

Figure 38 shows that 99% of respondents interviewed indicated they use their mobile phone for making and receiving calls. Of the same sample group, 91% use their mobile phones for sending receiving text messages. The third-highest usage was the use of the camera with 86% of participants. Of the sample group, 83% used their phone for social networking. The use of mobile phones for entertainment, in the form of playing games (78%) and watching videos (66%), was also relatively high. Of the respondents, 58% indicated that they used their mobile phones for purchasing of products and services. Interesting to note was how mobile phone usage varied between different age groups, income classes and gender. For example, respondents older than 60 years old mainly used their mobile phones for sending and receiving text messages and making phone calls. None indicated using their mobile phones for listening to music or podcasts. Contrary to this, respondents from the age groups 20–30 years, 31–40 years and 41–50 years used their mobile phones for listening to music, playing video games, accessing the internet, taking, sending and receiving photos, and using social media almost as much as they used it for texting and calling. For respondents younger than 20 years, playing music and video games ranked substantially higher than using mobile phones for social media (Figure 38).

Figure 38 shows that 95–100% of respondents used their mobile phones for making and receiving phone calls regardless of income class. For each of the other uses offered by smartphones it was found that, in general, the higher the income class of a respondent, the more likely they made use of a particular feature. Hardly any respondents listened to podcasts, regardless of income class (Figure 38).

Looking at gender, it was interesting to note that more female respondents made use of smartphones features than male respondents. In particular, more female respondents indicated using their smartphones for playing video games, playing music, taking photos, recording videos, watching videos and purchasing products or services than male respondents.

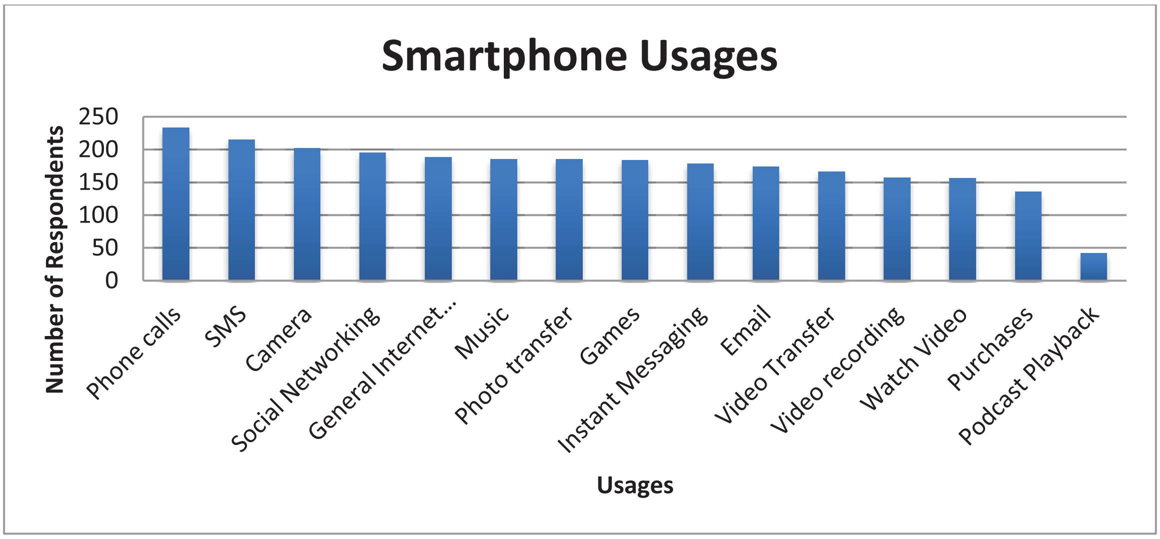


Figure 38: Smartphone usage

4.3.4.3 Willingness to pay for information

Section B of the instrument focused on the reasons that drive respondents to pay for information as well as factors that may influence a users' willingness to pay for information. A summary of their responses is given in Figure 39.

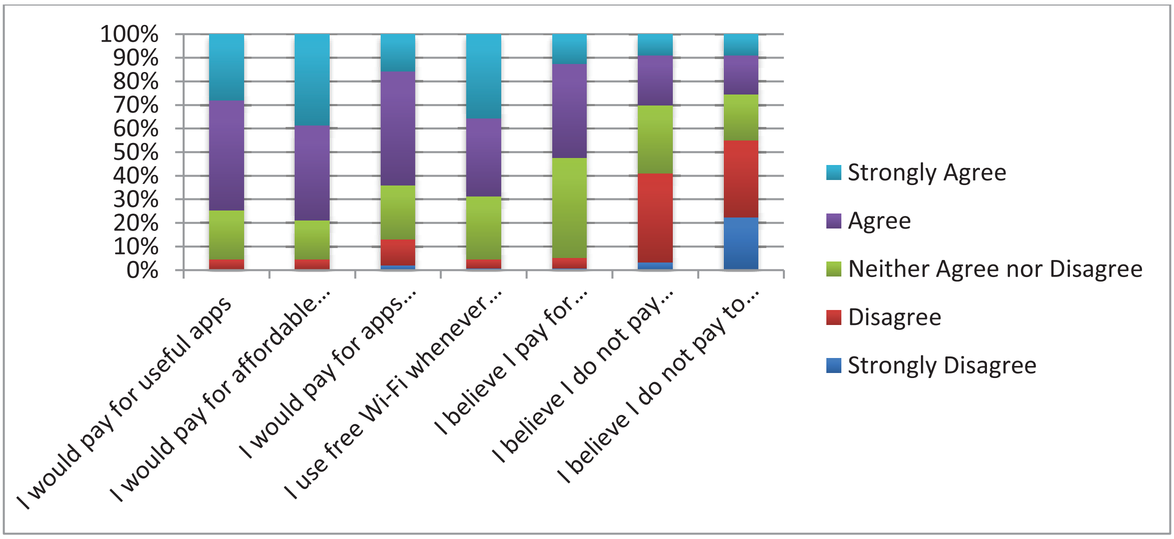


Figure 39: Reasons to pay for information

The three highest-ranking reasons, where respondents agreed and strongly agreed to a statement were:

- I would pay for affordable apps (79%).
- I would pay for useful apps (75%).
- I would pay for apps providing me a service (64%).

This is however for all respondents. Looking at the responses per age group, income class and gender shows some interesting results. Table 12 and Table 13 show the rankings according to reasons to pay for an app per age group and income, respectively. Looking at Table 12 we see that the majority of respondents, regardless of age, are concerned with the affordability of an app. Looking at Table 13 we see that in the case of income classes, there is an equal split in the reason to pay for an app. The two lower and the highest income classes are concerned with affordability. The middle-income classes are concerned with usefulness.

Table 12: Highest reason to pay for an app per age group

Younger than 20 years old	21–30 years old	31–40 years old	41–50 years old	51–60 years old	Older than 60 years old
I would pay for affordable apps (64%).	I would pay for affordable apps (76%).	I would pay for useful apps (83%). I would pay for affordable apps (83%).	I would pay for useful apps (86%).	I would pay for affordable apps (72%).	I would pay for affordable apps (87%).

Table 13: Highest reason to pay for an app per income class

Less than R5000 per month	R5001 to R10 000 per month	R10 001 to R15 000 per month	R15 001 to R25 000 per month	R25 001 to R40 000 per month	More than R40 000 per month
I would pay for affordable apps (73%).	I would pay for affordable apps (77%).	I would pay for useful apps (80%).	I would pay for useful apps (81%).	I would pay for useful apps (88%).	I would pay for affordable apps (100%).

Table 14 shows that for both males and females, affordability is the highest reason whether they would pay for an app. Overall, it was generally the case that respondents across all age groups, income levels and gender strongly agreed or agreed that although they would pay for useful apps, they had to be affordable apps in the first instance.

Table 14: Highest reason to pay for an app per gender

Male	Female
I would pay for affordable apps (76%).	I would pay for affordable apps (83%).

In an additional test to determine factors influencing respondents' willingness to pay for apps and/or information, respondents were presented with a few statements to choose from. These statements appear in Figure 40. For the statements 'App is fun', 'App is cool' and 'App is new', the interpretations by respondents were based on their understandings of the concepts 'fun', 'cool' and 'new'. With reference to Figure 40, the four overall factors that influenced respondents' willingness to pay for information the most were:

- App is easy to use (85%).
- App is not too expensive (82%).
- App provides information (72%).
- The information provided is useful (54%).

Looking at the responses to these statements across age groups, income classes and gender provided some interesting insights. Older generations were willing to pay for an app if it was affordable (not too expensive), provided information, the information it provided was useful and it was easy to use – the same as the four overall factors that influenced respondents' willingness to pay for information the most. They did not care much for the app being 'fun', 'cool' or 'new' nor the ability to share it with friends. On the other hand, for respondents younger than 20 years, an app being 'new', 'fun' and 'cool' and the ability to share it with friends ranked quite highly relative to the other age groups. That said, the younger respondents still placed more emphasis on an app being affordable and easy to use. The middle age groups (20–50 years old) rated useful information and affordability higher than the older and younger generations did.

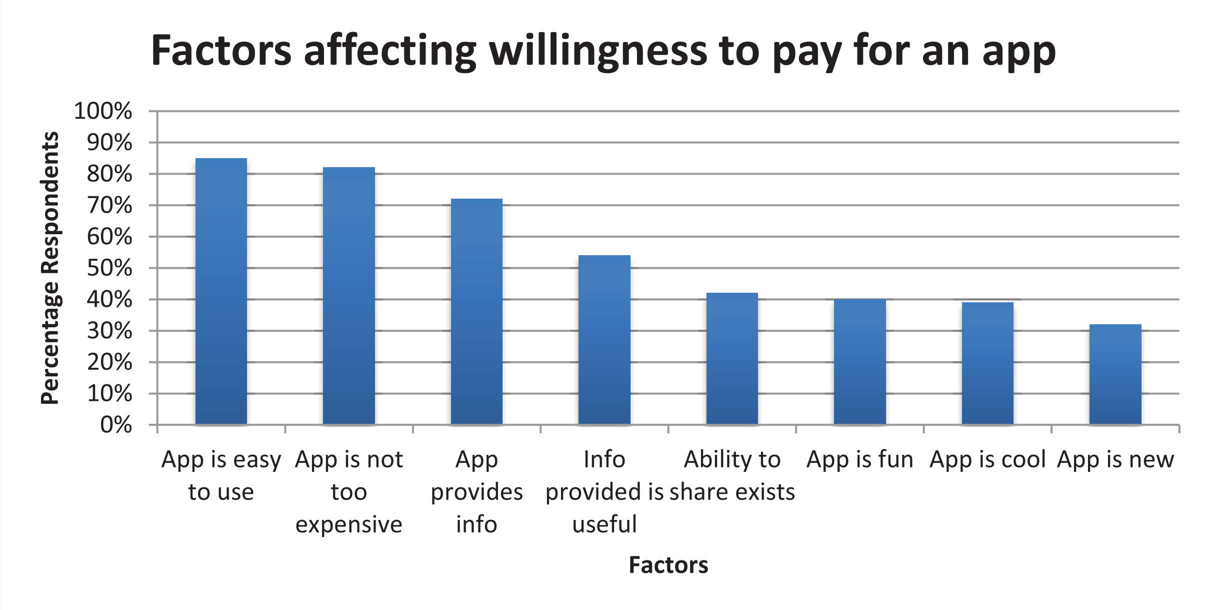


Figure 40: Factors influencing willingness to pay

In terms of income classes, for respondents earning less than R5000 per month, an app being easy to use was most important. Interestingly this was true for those earning between R15 001 and R25 000 and more than R40 000 per month too. An app being affordable was more important for respondents from the following income classes: R5001–R10 000, R10 001–R15 000 and R25 001–R40 000 per month. This however seems to contradict the reasons given by the various income classes in Table 13 to pay for an app. The reason for this apparent contradiction was not clear. There was very little difference between male and female respondents in their responses to the statements given, except for one: 'I would buy an app if I could share it with friends'. 26% more female respondents than male respondents indicated this as a factor influencing their willingness to pay for an app.

4.4 Summary

In terms of smartphone usage, it was found that older generations in Cape Town used their smartphones for functionality such as texting and calling. Younger generations, while using their phones for these functions too, used their phones for an entire myriad of other functions. These included listening to music, playing video games, accessing the internet, taking, sending and receiving photos, and using social media. This aligns with what Conci et al. (2009) said: that younger generations are typically motivated by the social capital attached to the use of a mobile phone and social networking, whereas older generations rely on the more functional uses of being in contact. It is also consistent with previous studies by Balakrishnan and Raj (2012), Hsiao and Chen (2015) and North et al. (2014).

While certain age groupings and income levels rate an app's ease of use as the highest reason to pay for it, overall it is its affordability that influenced most peoples' decision to pay for an app. This was true for both males and females. Interestingly, however, more females than males were willing to pay for an app if they could share it with friends. Affordability outweighs usefulness as a factor in deciding to pay for an app or not, which contradicts Biswas and Roy (2016) who stated that the decision to pay for information is predominantly driven by the perceived benefit, the users' understanding of the product or information and their attitude toward it. An easy-to-use, useful app was seen as important, but would be disregarded if the app was not affordable in the first instance.

5 DESIGN, DEVELOPMENT AND IMPLEMENTATION OF THE MOBILE APP

5.1 Introduction

This chapter outlines the methodology to design and develop the mobile app. The chapter provides details of how the stages of the system development life cycle, from initial design of the app through to implementation on the Android platform, took place.

5.2 Design and Development of DropDrop

A user-centred design approach was adopted to develop the mobile app. An iterative process was followed, including multiple cycles of requirements collection, prototyping and evaluation in order to address the gap between the researcher's perceptions of the challenges faced, and the real-life knowledge and experiences of the community. In the first iteration, a prototype was developed to form the foundation of discussion with users.

Initial requirements were gathered by interviewing experts who work with underresourced communities. Based on these requirements, a first prototype was designed. This prototype was tested on university students and staff to eliminate any major usability or functional flaws. The second iteration incorporated enacting changes to the app based on feedback from the previous evaluation, followed by the provision of the app for use in a two-week field study in a local community. Training on smartphones and a basic introduction to the app were provided for participants to reduce any potential biases against the general utility caused by possible design flaws or poor general understanding of smartphones.

5.2.1 ICT system design

As described in the research methodology, the design of the system was approached iteratively and with a user-centric approach. Following the initial iterations, a final design was researched that was based upon water information available on the City of Cape Town website and input from participants.

5.2.2 Functionalities of the DropDrop mobile app

The DropDrop app allows users to access information about their daily water usage, predicted estimate of their end-of-month water bill, water conservation methods, municipal contacts and information about water resource. In order to generate water usage data, the user needs to enter the water meter readings into the DropDrop app on a regular basis. Figure 41 shows the opening screen of the DropDrop app.

Figure 41: The opening screen of the DropDrop mobile app

Further water-related information can be accessed by tapping one of the five tabs aligned at the bottom of the opening screen of the DropDrop app screen given in Figure 41. When these tabs are selected, they open: (1) Water Usage; (2) Water Savings; (3) Reports; (4) Knowledge Base; and (5) Attribution screens. These are illustrated in Figure 42.

(a) (b)

(c) (d)

Figure 42: Functionalities of the DropDrop mobile app

The four functionalities of the DropDrop mobile app illustrated Figure 42 are:

- ***Water Usage.*** Water Usage is the opening screen. It enables users to locate and read their water meter and detect leaks through a stepwise procedure, enter new readings from the water meter, and view analysed daily water usage information. The analysed consumption information includes daily usage amount, surplus consumption, anticipated end-of-month consumption and the estimated monthly utility bill. The water usage information is also presented in a bar graph to allow easy visual comparison of consumption for each day.
- ***Water Savings.*** The Water Savings functionality lists water conservation methods, which when selected displays the amount of both money and water that would be saved at the end of the month if the tip was implemented.
- ***Reports.*** The Reports functionality provides the contact information of the municipal TOC where faults, disputed water bills and other water-related issues can be channelled. It also enables the user to a keep record of calls made when reporting water-related issues.
- ***Knowledge Base.*** The Knowledge Base functionality contains educational material on rainwater harvesting, domestic water conservation tips and the procedure for fixing a leaking tap.

The above-named functionalities of the DropDrop mobile app constituted the water-related information, whose effect on water conservation practice is assessed in this study. Table 15 outlines the information provided by the DropDrop app and relates it to the respective questions asked in the questionnaire (impact factors).

Table 15: Matching information from the DropDrop app with impact factors

<table>
<tr><th colspan="2">Information from the DropDrop App</th><th>Factor investigated by the study</th></tr>
<tr><td rowspan="6">Water usage information</td><td>Daily water consumption amount</td><td rowspan="6">Knowledge of daily consumption; frequency of reading the water meter; actions influenced by information from the DropDrop</td></tr>
<tr><td>Monthly consumption prediction</td></tr>
<tr><td>Estimate monthly bill prediction</td></tr>
<tr><td>Estimate monthly waste water bill prediction</td></tr>
<tr><td>Comparison of daily water consumption to average consumption</td></tr>
<tr><td>Graphical/tabulated record of consumptions</td></tr>
<tr><td colspan="2">Leak detection procedure</td><td>Ability to detect leaks</td></tr>
<tr><td colspan="2">Methods for saving water – how much water can be saved</td><td>Implementation of water-saving tips</td></tr>
<tr><td colspan="2">Contact details for reporting faults and complaints</td><td>Contact/engagement with municipality</td></tr>
<tr><td colspan="2">Information on accessing alternative water sources, and fixing leaking tap</td><td>Not addressed</td></tr>
</table>

5.2.3 Indicators of the effect of water-related information

The indicators that reveal development trends of water conservation participation by householders over the study period were chosen to be:

- Recognition of the value of water.
- Implementation of water conservation tips as a norm.
- Knowledge of personal consumption and actions pertaining to the knowledge.

- Consumers' level of knowledge and awareness of consumption, saving demand management at the beginning and at the end of the study period.
- Water consumption trend.

These indicators constitute the water-related information provided by the DropDrop mobile app. Examining these indicators before and after the study period to check for consistent performance of water conservation practice would reveal the effect that the water-related information had on householders. However, complete adoption of a behaviour is not realistic (Silva et al., 2010). Respondents' knowledge and awareness were categorised into four types of water-related information that constitute the DropDrop app. These include information on: (1) water price and rates; (2) consumption; (3) conservation measures; and (4) water resource. The respondents' knowledge and awareness were matched against various water conservation activities (see Table 16), which would indicate the level of conservation participation by the respondents.

Table 16: Matching information accessible on DropDrop to knowledge and activity

Type of water-related information in the App	Knowledge and awareness of:	Water conservation activities
Water price and rates	Water rate	Water conservation activities; frequency to lower consumption; implement water conservation tip; action when price influenced consumption; frequency of reading the water meter; leak detection; municipal engagement; approximate typical monthly bill and typical monthly consumption
Water consumption	Average daily consumption	
Conservation measures/tips	Conservation initiatives/slogans	
	Conservation tips	
Knowledge of water system	Reason for water conservation	
	Awareness of water hotline	
	Trust for the municipal bill	
	Alternative water sources	

5.3 Impact of Mobile App on Water Conservation

5.3.1 Introduction

DropDrop is a stand-alone mobile app developed for Android smartphones. This was selected as the preferred platform due to it facilitating quick development of a fully functioning prototype with a fast turnaround to be accepted onto the platform download channel – the Google Play Store. Despite having been developed for Android, the app is not constrained to be used exclusively on this platform as it was implemented through the use of the PhoneGap framework version 2.9.0.[2]. The HTML and JavaScript source code should be able to run on any phone with a browser more current than 2010. Following development in accordance with the methodology described in the previous sections, the app was made available on the Google Play Store, and participants in the study were encouraged to download and use the app.

This section provides an overview of the methods used within this research in order to establish the effect of water-related information on the WC/WDM at household level, as well as unpacking the results of making the app available to citizens.

5.3.2 Research methodology

This study used both quantitative and qualitative data analysis techniques to assess the effect of water-related information on water conservation at a household level. These effects are assessed by: (1) measuring and evaluating participants' water consumption during the study period; (2) evaluating and comparing the frequency of accessing water-related information with conservation practice; and

(3) evaluating the range of conservation practices and knowledge gained from a water conservation mobile app by population size of participants. Primarily, the study approach is such that it provides a rational explanation that attempts to deduce relationships between knowledge gained due to the water-related information and the resulting conservation practices and consumption trend. For the primary field study, longitudinal data was collected by issuing questionnaires at the beginning and at the end of the three-month study period, that is, from the beginning of August 2014 to end of October 2014. Data collected from the questionnaires was analysed to draw correlations among variables and also relate the variables with the water consumption data.

5.3.3 Study population selection and description

The sample population for the study resided in houses whose water supply was metered in the City of Cape Town Municipality. Two groups of participants were determined, namely, the treatment group and the control group. The participants in both the treatment and control groups lived in houses whose water supply was metered.

5.3.3.1 Selection of the treatment group

Participants in the treatment group volunteered in response to an appeal to participate in the study. The selection process was conducted in two ways. The first approach was performed by municipal officials. It entailed sending water conservation email survey to all customers who had municipal water meter accounts and whose contact details were recorded in the municipal customers' database. The email survey inquired if the customers would be interested in implementing the DropDrop mobile app. A total of 62 out of 217 customers who responded showed interest in implementing the DropDrop mobile app. However, this number dwindled down from 62 to 7 final participants. This could be attributed to long unavoidable delays before commencing the study; hence, most participants withdrew their participation.

The second selection process entailed both mailing and approaching individuals residing in the vicinity of the University of Cape Town to seek their willingness to implement DropDrop and participate in the study. Eligible individuals had to own an Android smartphone and have metered water supply at their house. This approach secured 30 willing participants. The total number of participants who installed and started implementing the DropDrop mobile app at the beginning of the study period was 37.

5.3.3.2 Selection of the control group

The control group was intended to monitor treatments or conditions that could have influenced residents to save water, other than water-related information provided by the DropDrop mobile app. It therefore facilitated measurement of consumption to evaluate savings due to the water-related information. In this case, differences in monthly consumption between the treatment and control groups, if large enough to rule out natural chance variability, could then be attributed to the effect the water-related information would have had on the participants' water conservation practices (Utts & Heckard, 2015). The consumption data of the participants in the control group was obtained from the municipal consumption records. The participants in the control group did not implement the DropDrop mobile app. This group was made up of close neighbours of the participants in the treatment group.

5.3.4 Methodology for analysing the effectiveness of water consumption

The baseline questionnaire (Appendix A) and follow-up questionnaire (Appendix D) were prepared on Google Forms and sent to the participants in the treatment group through email. The data from the questionnaires was analysed to determine if and how the water-related information influenced water conservation participation by householders. Water consumption data of the participants was also collected.

The main technique used to correlate data was cross-tabulation analysis (Torres-Reyna, n.d.). Cross-tabulation analysis was used to compare the relationship between knowledge (and awareness) and various water conservation practices.

5.3.4.1 Participants' consumption data

The water consumption data of the participants in both the treatment and control groups were obtained by reading the participants' water meters, and also from the City of Cape Town's SAP and GIS systems. During the study period, the meters of 59% (i.e. 22 out of 37) of the participants in the treatment group were read. The remaining 41% of the participants submitted their meter readings for the first month of the study period only. Their water meters were also inaccessible due to unavailable residential address details.

The consumption data for the participants in the control group was extracted from the City of Cape Town's GIS mapping system with consent and assistance by municipal officials. The consumption data in the municipal GIS mapping system is usually unadjusted; it is calculated from the monthly meter readings and populated on the system without being manipulated. To extract the consumption data of the participants in the control group:

- The water meter account numbers of the participants in the treatment group were extracted from the submitted questionnaires (issued at the beginning of the study period) and used to search their street address using the City of Cape Town's SAP system.
- The returned result of street address was then entered into the City of Cape Town's GIS mapping system and used to identify the close neighbours of respective participants in the treatment group. These neighbours formed the control group.
- The consumption details of the identified neighbours were searched in the municipal GIS mapping system, which returned their monthly water consumption details.
- The major setback with this method was that some participants in the treatment group did not provide correct water meter account numbers. As a result, the SAP system did not recognise those account numbers and consequently returned no result. The consumption data of only eight participants (in the control group) were extracted. Although this population (eight participants) was too low to represent the actual consumption pattern of the entire sample population, it assisted with illustrating variations in consumption trends between the treatment and control group.

5.3.4.2 Historical consumption data for participants

The historical monthly consumption trend of the participants was evaluated to observe the participants' water consumption trends prior to the study period. In this case, the participants' monthly consumption records from 2010 were extracted from the City of Cape Town's SAP system. The consumption data for individual participants was searched using the respective water meter account numbers as completed in the questionnaire. The consumption data in the municipal SAP system was adjusted, that is, it was rounded off to the nearest kilolitre. The data from the SAP system was preferred to data from the GIS system since it could extract a five-year period record of customer's consumption data. The historical consumption data was extracted as follows:

- ***Participants in the treatment group.*** The historical consumption data of 21 participants was extracted from the SAP system. The remaining 16 participants' records could not be located in the database due to incorrect water meter account details.
- ***Participants in the control group.*** The historical consumption data of only eight participants in the control group could be extracted from the SAP system.

The challenge met with using the SAP system was patches of missing consumption data between 2010 and 2011. Also, the consumption data for the year 2013 was unavailable, thus the trend for that year was not evaluated. For the case of missing consumption data, average monthly consumption for the month was computed and completed in the blank cells.

5.3.5 Questionnaire design

5.3.5.1 Baseline or initial questionnaire

The main purpose of conducting the household water conservation survey before implementing the DropDrop app was to determine consumers' level of knowledge and awareness about water, water conservation, water consumption and billing. The level of knowledge and awareness was then compared with some selected water conservation practices. The initial or baseline questionnaire investigated the background knowledge and awareness that respondents had before the study period. It also examined the existing conservation practices implemented by the respondents. The aim was to relate the participants' knowledge and awareness to water conservation participation at their homes. Out of the 37 participants who installed the DropDrop mobile app, 33 completed and submitted the baseline questionnaire that was issued at the beginning of the study period. This implies a response rate of 89%.

5.3.5.2 Follow-up or final questionnaire

The follow-up questionnaire was issued to the participants after they used the DropDrop mobile app for three months. It aimed at establishing the influence of the water information provided by the app on the WC/WDM practices of the participants. For the follow-up questionnaire, the response rate was 54%. The findings of this questionnaire were compared with those in the baseline questionnaire to determine the variation in knowledge and awareness, and water conservation practices by householders. Another set of questions in the follow-up questionnaire investigated the general usability of the DropDrop mobile app to determine how it facilitated or hindered access to the water-related information contained therein.

5.3.6 Response rates by region

Table 17 shows the distribution of the participants who completed and submitted their questionnaires by suburb or region. Most respondents resided in middle- to high-income residential areas such as the Southern Suburbs, Southern Peninsula and the Northern Suburbs. The control group participants resided in the Southern Suburbs (5) and the Southern Peninsula region (3). According to Butler & Memon (2006), this sample population represents a population who is generally knowledgeable about water conservation. Therefore, the responses obtained from this sample population might only represent the behaviour or practices of the middle- to high-income residential population.

Table 17: Response rates by region (both baseline and follow-up questionnaire)

Name of region	Baseline questionnaire		Follow-up questionnaire	
	Respondents	Percent (%)	Respondents	Percent (%)
Southern Suburbs	18	55	13	65
Southern Peninsula	7	21	5	25
Northern Suburbs	3	9	0	0
Cape Flats Region and Helderberg	3	9	1	5
Blouberg Region	2	6	1	5
Total	**33**	**100**	**20**	**100**

All respondents indicated on the baseline questionnaire that they resided in their respective residences all year round. Of the participants, 82% of the dwellings were freestanding houses and had metered water supply. The respondents who lived in semi-detached houses (12%) and cluster houses (3%) resided in the Southern Suburbs.

5.4 Research Findings and Analysis

This section assesses the variations in water conservation knowledge, awareness and practice of participants due to implementation of the DropDrop mobile app. It compares the findings at the beginning of the study period to those established at the end of the study period to note variations in conservation knowledge, awareness and practices of the sample population. In addition, participants' record of water consumption is evaluated in order to observe variations in consumption during the study period.

5.4.1 Use of the DropDrop app compared with conservation practice

During the study period, 35% of the participants entered the meter reading into the DropDrop mobile app once in two weeks in order to read and determine their water consumption. The pie chart shown in Figure 43 classifies usage of the DropDrop app by the frequency at which the sample population used it to read and determine water consumption.

Assessments of some WDM practices implemented during the study period were compared with the frequency at which the respondents used the DropDrop mobile phone app. The comparison is illustrated in Figure 44. All the participants who operated the DropDrop app at least weekly read their water meters at least weekly as well. Of these participants, 83% checked for water leakage whereas 67% indicated that they could estimate the daily amount of water they consumed. Also, most of the participants who used the app most frequently implemented the WDM practices outlined in Figure 44. On the other hand, the participants who did not use the DropDrop app throughout the study did not implement the WDM practices shown in Figure 44 except for leak detection.

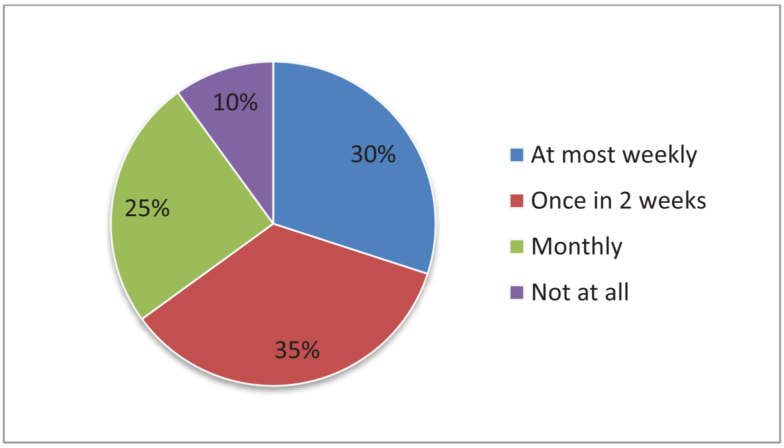


Figure 43: Frequency of using of the DropDrop by population to read and determine consumption

These findings affirm the observation of Clifford et al. (2014) that a high level of consumer awareness facilitates conservation initiatives such as rainwater harvesting and grey water reuse. This was evident as most of the participants who used the DropDrop mobile phone app more frequently implemented some conservation practices and demand management measures such as leak detection and daily consumption tracking. Frequent access of water-related information facilitates a concerted attempt by consumers to integrate conservation practices into everyday life.

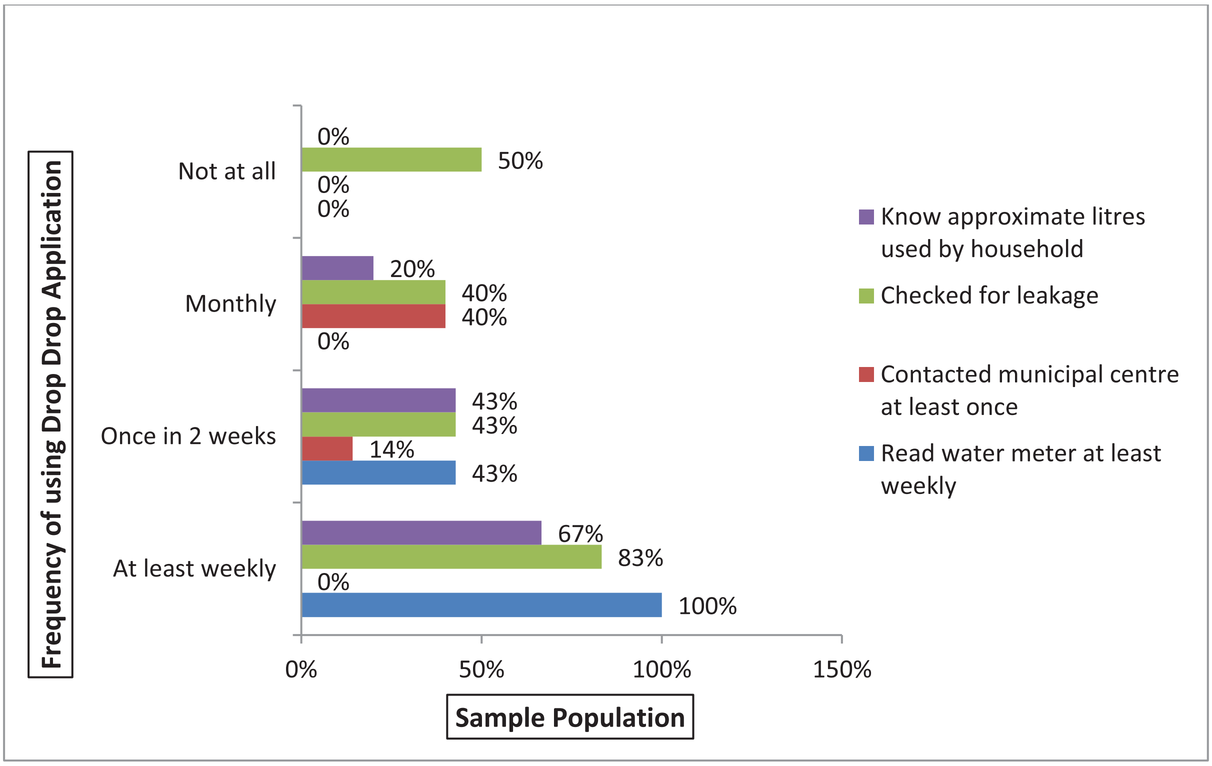


Figure 44: Frequency of using the DropDrop against implementation of some WDM activities

5.4.2 Awareness of daily consumption

Figure 45 shows that the water-related information enabled some respondents to be aware of their daily water consumption. After the study period, the population of respondents who were aware of their daily water consumption increased from 42% to 74%, whereas the respondents who were still unaware decreased by more than a half (i.e. from 58% to 26%). This observation asserts that more participants became aware of their average water consumption. The DropDrop app displayed the anticipated monthly water consumption. Therefore, entering the meter readings at shorter intervals (at most weekly) enabled the users to monitor their consumption closely so as to plan on minimising consumption earlier before the end of the month.

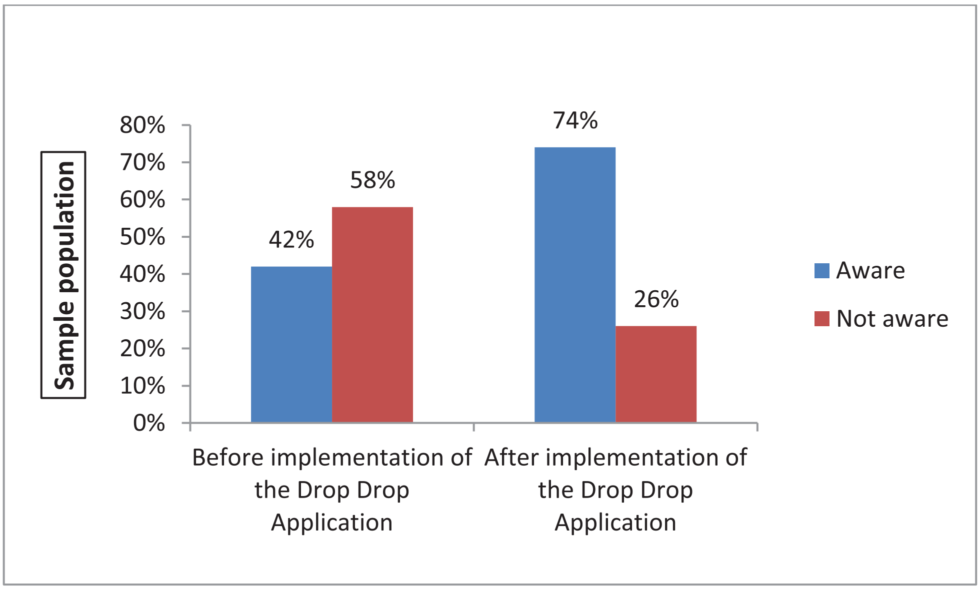


Figure 45: Effect of water-related information on the knowledge of daily water consumption

5.4.3 Reading the water meter

As shown Figure 46, the frequency at which the participants read their water meters, at most monthly, increased from 27% to 95% after the implementation of the DropDrop mobile app. Before implementation, almost half of the respondents never read their water meters. Another 24% of the sample population read their water meters once in two weeks. After implementation of the app, the population who did not read the water meters dropped to 5%. None of the participants indicated inability to read the figures on their water meters. The water-related information from the DropDrop mobile app prompted the participants to monitor their consumption regularly during the study period.

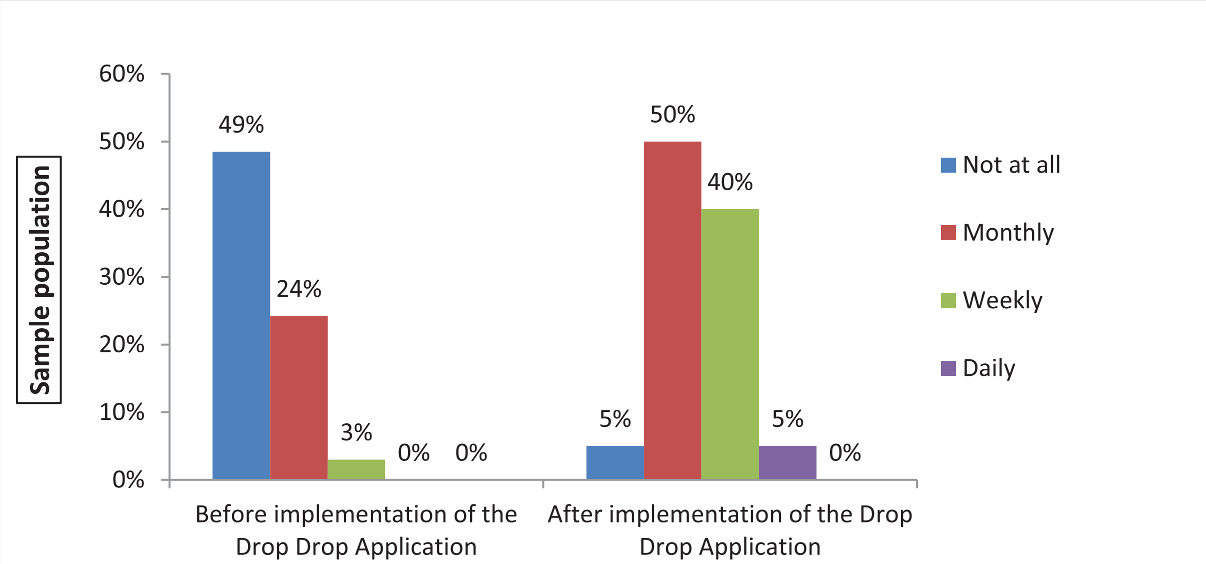


Figure 46: Frequency of reading the water meter before and after the study period

5.4.4 Leak detection

The number of participants who checked for leakage (using the procedure outlined in the DropDrop mobile app) during the study period was 55% whereas those who had been checking for leakage before implementation of the DropDrop mobile app was 45%. This implies 10% increase in the population who checked for leakages during the study period. Figure 47 shows the variation in leak detection before and after the study period. As illustrated in Figure 47, 45% of the population did not check for leakage during the study period. Out of the 55% of the population who checked for leakage, 40% did not find leakage in the pipes and fixtures whereas 15% found leakage. These observations indicate that the water-related information raised the participants' awareness for leak detection.

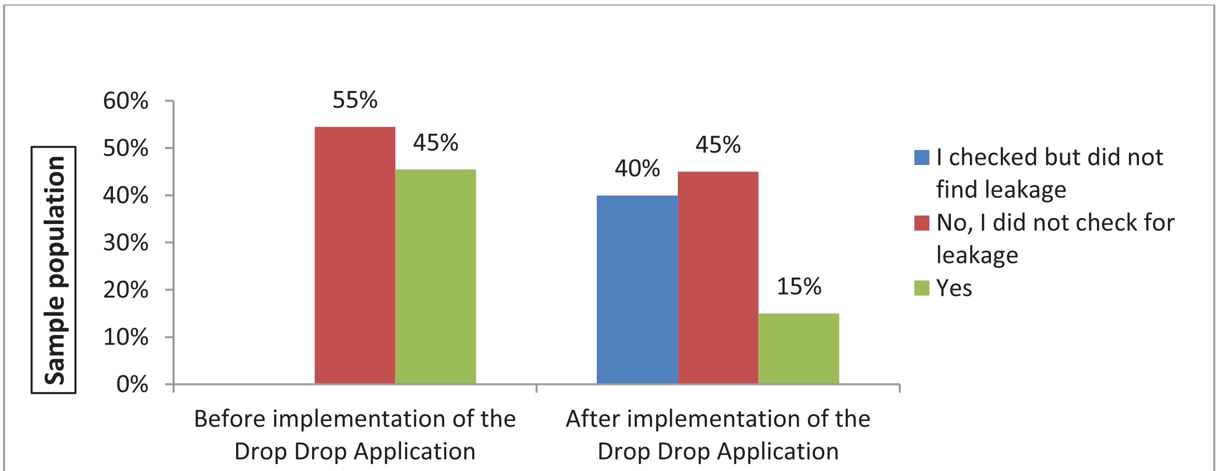


Figure 47: Leak detection before and after the study period

5.4.5 Engagement with municipality and fault reporting

As shown in Figure 48, only 15% of the participants contacted the municipal technical operations centre during the study period to report water-related concerns. It is likely that the participants did not receive disputed utility bills, did not identify a pipe burst on the water mains near their properties, or find any water-related concern worth reporting to the municipal call centre.

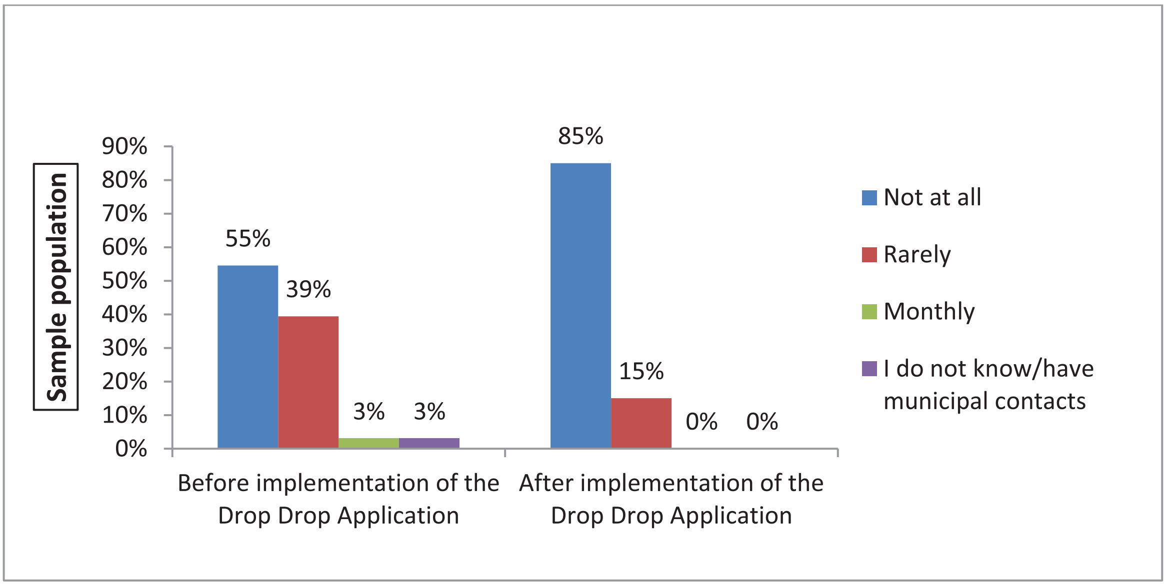


Figure 48: Engagement with the municipal call centre

5.4.6 Monthly consumption trend

The consumption trend of the control group was investigated and compared with that of the treatment group. Table 18 shows the average monthly consumptions of the study participants during the study period.

Table 18: Average monthly consumption during the study period

Study period (2015)	Average consumption (kilolitres)	
	Treatment group (n = 8)	Control group (n = 8)
August	16.2	17.1
September	14.1	15.5
October	16.3	19.1
Mean	**15.5**	**17.2**
Median	**12.0**	**15.0**
Std. Dev.	**8.84**	**8.89**

5.4.6.1 Consumption trends between households in the control and treatment groups

Figure 49 compares the cumulative water consumption trend between some households in the control group and corresponding households in the treatment group during the study period. The graph shows that the cumulative consumption of both the treatment group and control group follow a similar trend, i.e. cumulative consumption for the month of September 2015 reduces and increases in the month of October 2015. This observation can be attributed to the change in seasons. Toward October 2015 (end of the study period), summer was approaching in Cape Town. Therefore, households tend to use more water due to dryer weather conditions.

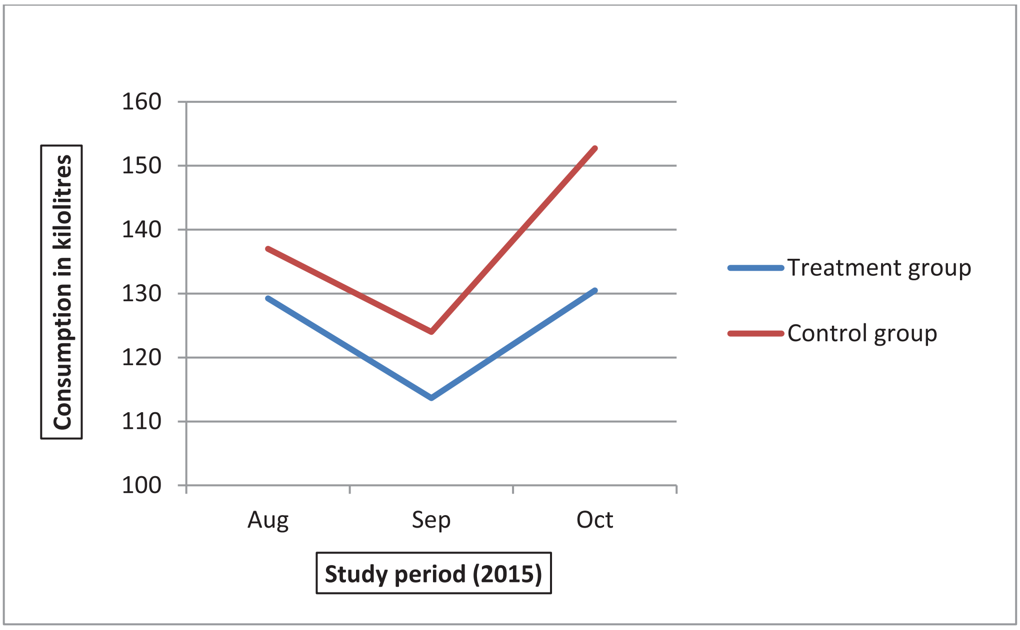


Figure 49: Cumulative consumption trend between participants in treatment and control groups

The cumulative monthly water consumption of the participants in the treatment group was lower than the cumulative consumption of participants in the control group. However, a significant observation shown in Figure 49 is that the gap between cumulative consumption of the treatment group and that of the control group widens with time. This observation implies lower rate of water consumption in the treatment group than in the control group. Similarly, it can be attributed to intensified water conservation practice by participants in the treatment group due to the water-related information provided by the DropDrop app.

5.4.6.2 Historical water consumption trend of the treatment and control groups

The average monthly household consumption from the year 2010 to 2015 (excluding 2013) was plotted to observe how the consumption trend varies before and during the study period. As mentioned, this data was drawn from the City of Cape Town's SAP system. Although the consumption data for the year 2013 was unavailable, the consumption data for the other years was deemed sufficient to show a typical historical trend of average monthly consumption. Figure 50 to Figure 54 depict the trend of average household consumption for the participants from 2010 to 2015 (excluding 2013).

In 2010, the average consumption of participants in the control group was lower than that of the treatment group. In addition, the average monthly consumptions for both control and treatment groups followed a similar trend. The average household consumption of the control group was generally lower than that of the treatment group in 2011. Average monthly consumptions for both control and treatment groups generally followed a similar trend. In 2012, the average household consumption of control group was generally lower than the average consumption of the treatment group, except for the months of September and October. The trends of average monthly consumptions for control and treatment groups were different, except for the months of March and June, when both average consumptions decreased due to rainy weather. In 2014, the average household consumption of control group was lower than that of the treatment group until September, when it surpassed the average consumption of the treatment group. The trend of average monthly consumptions for both control and treatment groups were generally similar.

Over the years (since 2010), the average monthly consumption of households in the treatment group had been generally higher than that of the households in the control group. In addition, the average monthly consumptions for both control and treatment groups generally followed a similar trend. This observation indicates consistent variation in water demand between the two groups. However, in August 2015 the average consumption of participants in the treatment group became consistently lower than that of the control group. This implies that the water demand of participants in the treatment group reduced.

During the study period, i.e. August to October 2015, the gap between the average consumption of the control group and treatment group widened. The participants had begun using the DropDrop mobile phone app in this period. Therefore, these observations could affirm that the water-related information provided by the DropDrop app enabled its users to economise water.

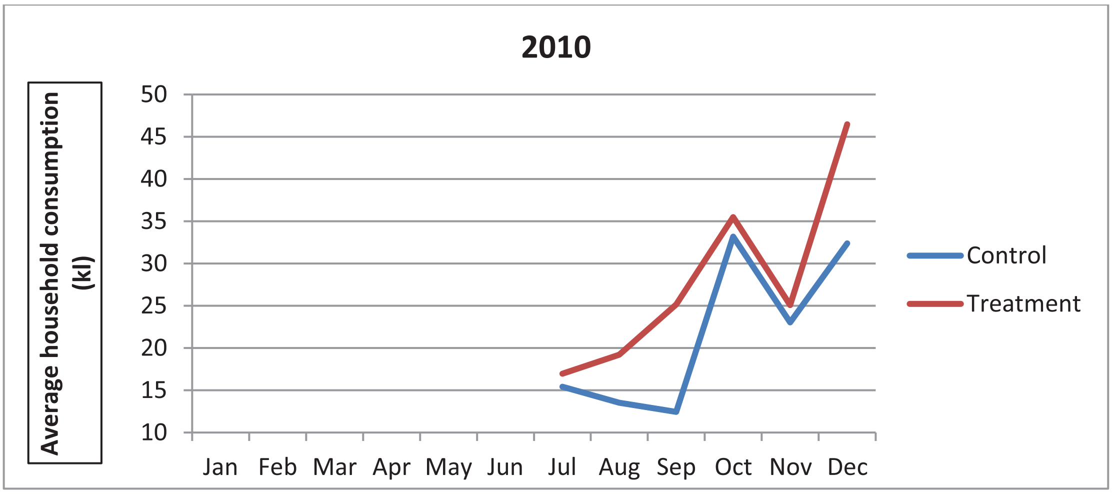


Figure 50: Average household consumption for the year 2010

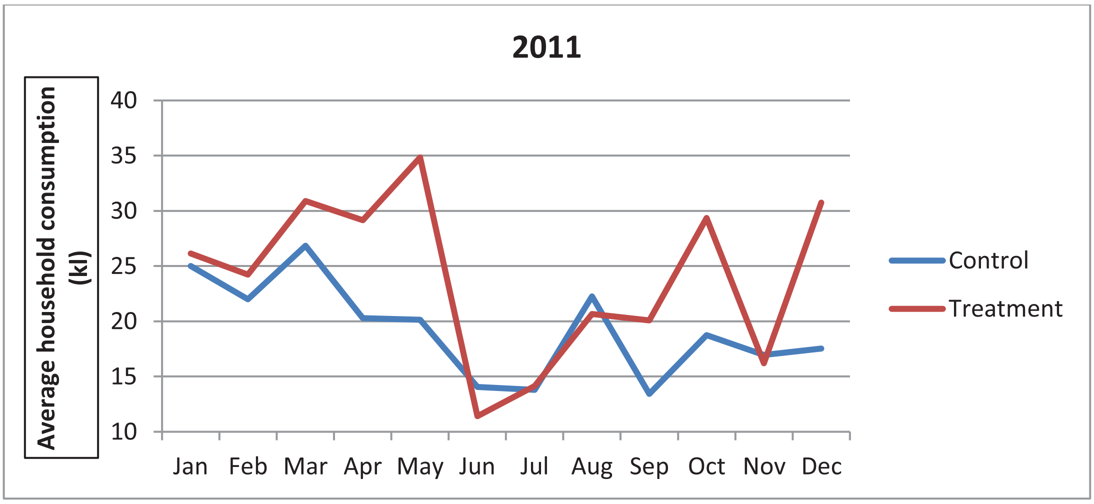


Figure 51: Average household consumption for the year 2011

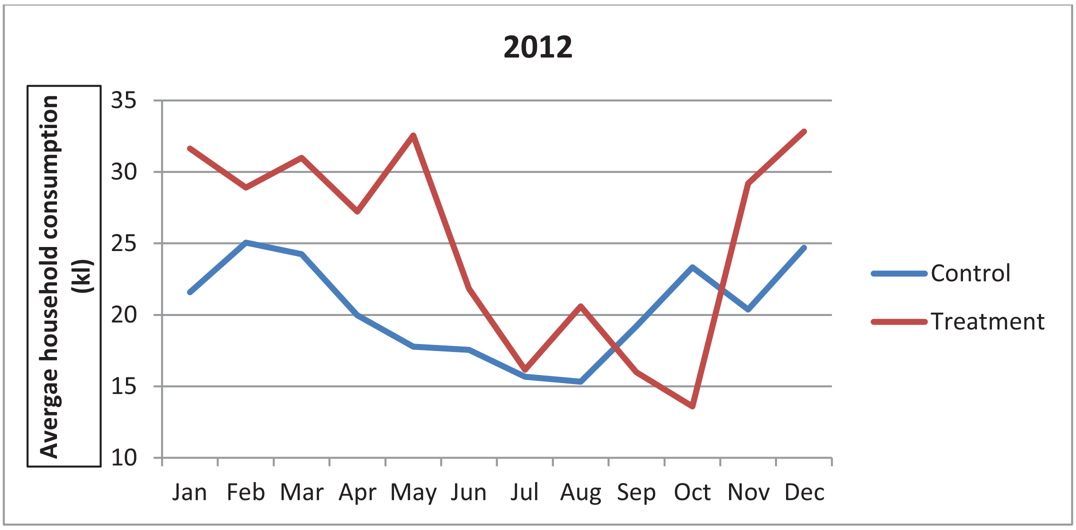


Figure 52: Average household consumption for the year 2012

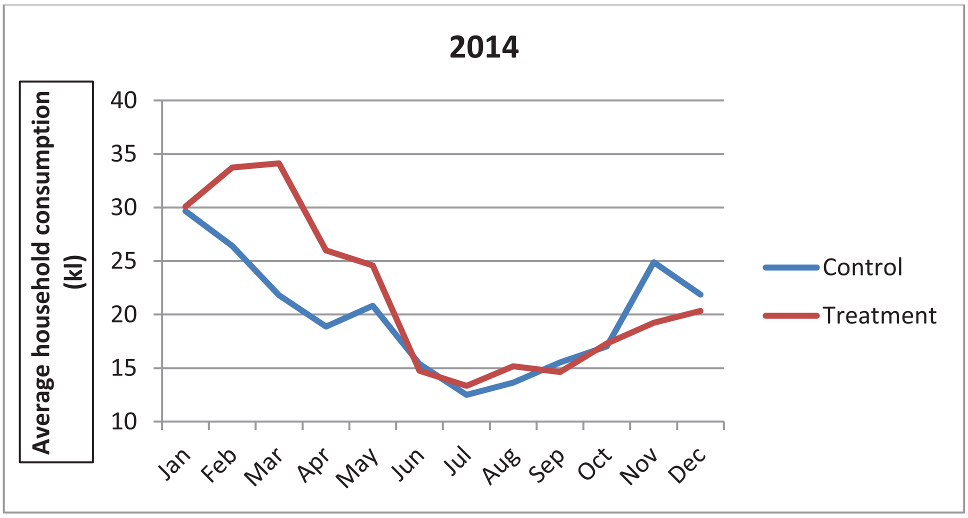


Figure 53: Average household consumption for the year 2014

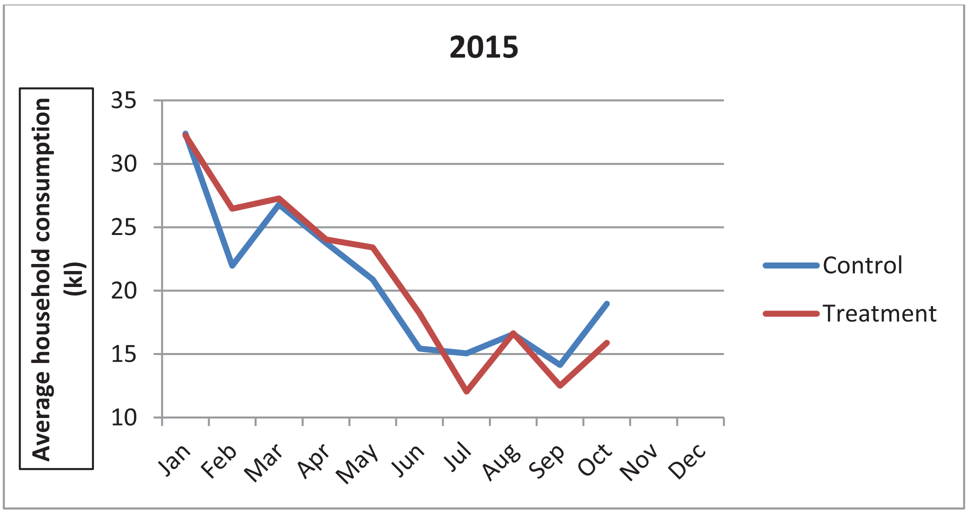


Figure 54: Average household consumption for the year 2015

5.4.7 Effect of usability of the DropDrop mobile app on its use

The functionalities in DropDrop that contained the water-related information were also investigated to determine if the use of DropDrop facilitated or hindered water conservation participation by householders. Figure 55 shows the proportion of respondents who used the respective functionalities of the DropDrop app.

The “Water Usage” functionality was mostly used by the respondents, followed by the “Knowledge Base.” The “Water Savings”, “About” and “Reports” functionalities were accessed by 39% of the participants. This corroborates the observation that more participants (74%) became aware of their daily consumption at the end of the study period.

Generally, 85% of the participants agreed that the domestic water-related issues were addressed by the DropDrop mobile phone app. The remaining 15% of the respondents who disagreed indicated that more details on how waste water was measured should be added to the app.

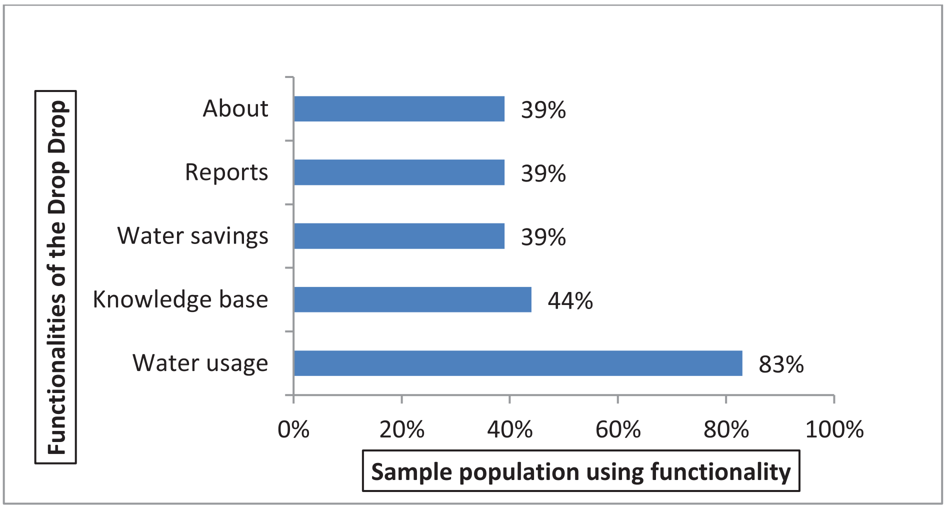


Figure 55: Proportions of the sample population who implemented various functionalities

5.4.7.1 Time taken to learn how to use the app

The longest time taken to learn how to use the DropDrop mobile phone app was one day whereas the shortest was indicated to be “immediately”. Most of the respondents (68%) took less than 15 minutes to learn how to use the app while others did not quantify the time they took to learn how to use the app. As illustrated in Figure 56, 85% of the respondents indicated that the app was easy to use whereas 10% answered that it was somehow easy. However, some respondents did not use other functionalities. It was therefore impossible to determine if they experienced difficulties while using the app.

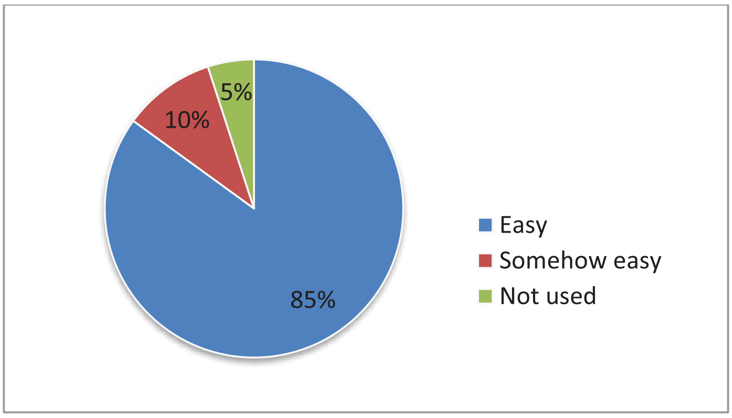


Figure 56: Ease of use of the DropDrop App

The respondents' experience with the functionalities in the DropDrop app is shown in Figure 57. Of the respondents, 80% could enter new meter readings into the DropDrop app easily. Out of the 68% of the respondents who viewed the water usage information, only 50% interpreted the water usage graph to understand consumption trend. Of the respondents, 45% did not interpret the usage graph to understand their water consumption whereas 5% indicated that it was challenging to interpret the water consumption graph.

A contradiction on the participants' response regarding leak detection was noted. Although 55% (Figure 57) of the respondents indicated that they checked for leakage during the study period, 70% indicated that they did not use the "Leak Detection" functionality on the DropDrop mobile app. This implies that 25% of the sample population checked for leakage without the help of the leak detection procedure outlined in the DropDrop mobile app. There is a possibility that these participants were already knowledgeable on leak detection.

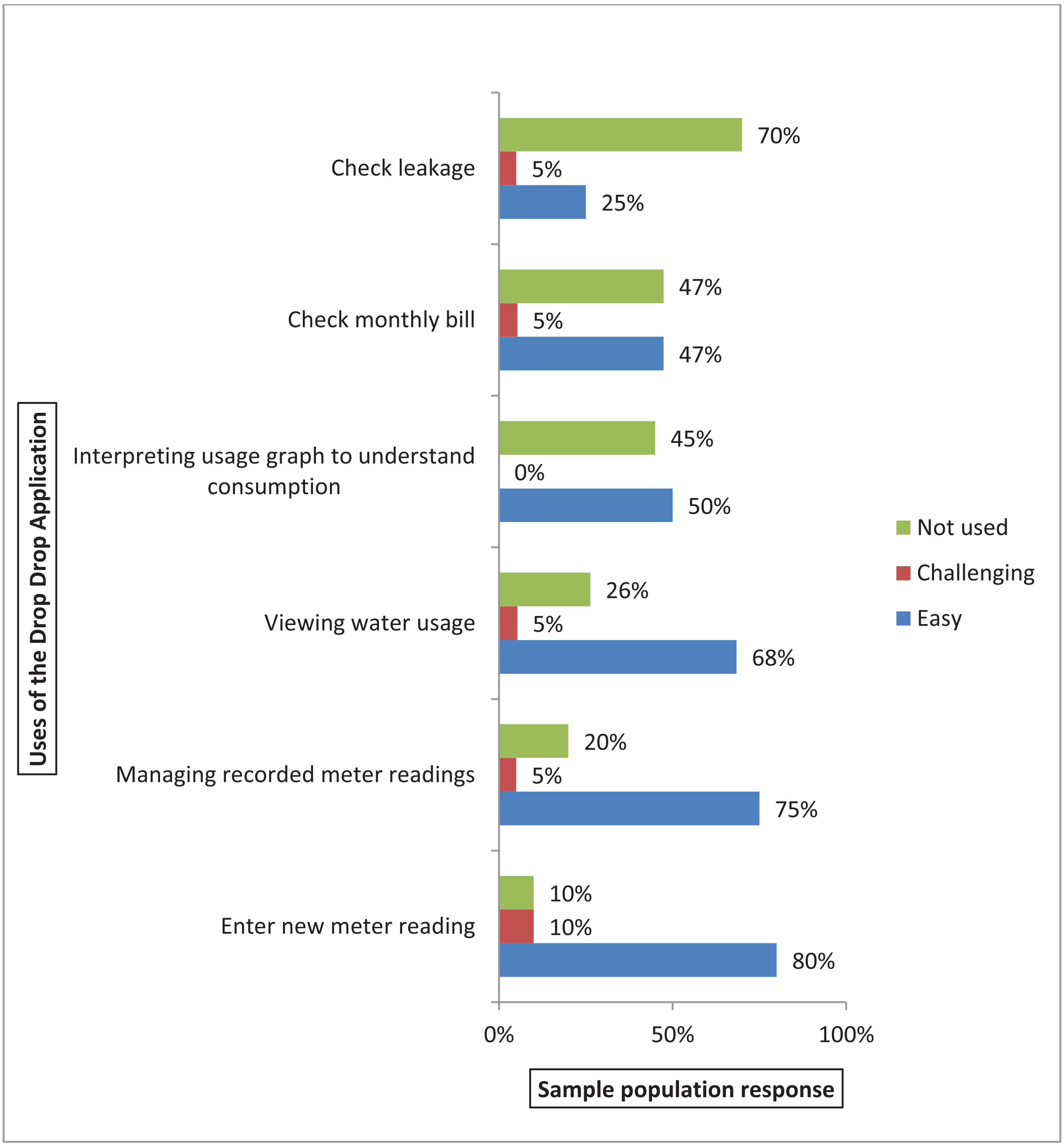


Figure 57: Participants' experience of using the DropDrop mobile app

5.4.7.2 *Satisfaction with the implementation of the DropDrop App*

The overall satisfaction of the respondents while implementing the DropDrop app is illustrated in Figure 58. Of the respondents, 85% said that they were satisfied with the DropDrop mobile phone app whereas 10% were not satisfied. Similarly, 45% of the respondents indicated that they would like to continue using the DropDrop app after the study period. Of the respondents, 35% indicated that they would like to continue using the app if it was improved to show reminders and give details about the water and waste water rates. Of the respondents, 20% would not like to continue using the app after the study period.

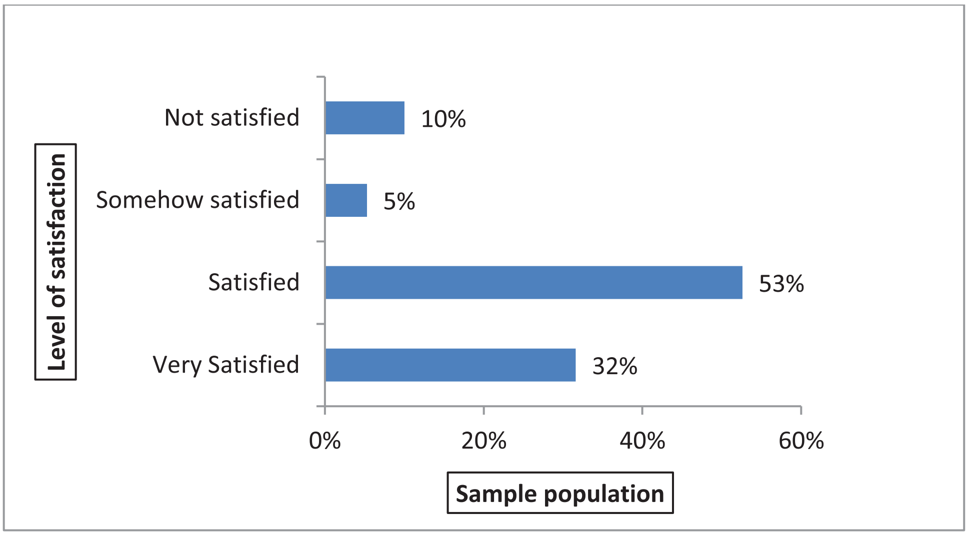


Figure 58: Overall satisfaction by respondents

5.4.7.3 *Limitations of the DropDrop mobile app*

The limitations of the DropDrop app were identified as follows by participants in the study:

- No alert in the app to remind the user to take the reading – built-in reminder recommended.
- Manual entry of the meter reading – automate capture of the meter readings using technologies such as optical character recognition.
- Inability to edit an incorrect meter reading and export the data to Microsoft Excel or another app software for further manipulation.
- The app did not display the actual average consumption but rather drew a line on the graph to show the average use instead.
- The app was not linked to the municipal database.
- Lack of water usage breakdown – include proportions of water used for various tasks such as watering the garden, e.g. for householders with garden, about 70% of total consumption goes to watering the garden.

5.4.8 Challenges encountered by participants during the study period

The challenges encountered by the participants during the study period are discussed in below.

5.4.8.1 *Remote location of the water meter*

The water meters of some participants were located far behind their houses. In order to access them, participants had to walk a long distance up to where the water meters were located. Due to this hindrance, the affected participants read their water meters less often. As a result, these participants might be less aware of their consumption and therefore not prompted to implement conservation measures.

5.4.8.2 Obscured water meter screen and heavy metal covers

The screen of a water meter was old and stained. This made it difficult for the participant to read the water meter accurately. This is shown in Figure 59.

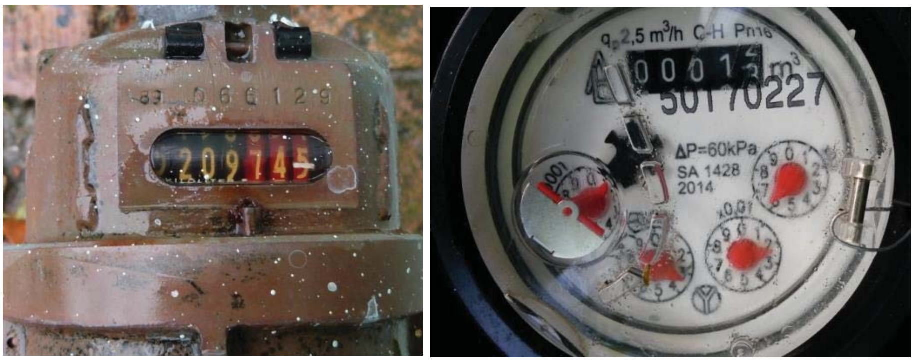
Figure 59: Obscured water meter screen

Another challenge was that some meter boxes containing the water meters were covered with heavy metallic lids as shown in Figure 60. These lids were too heavy to lift, and thus discouraged the participants from taking meter readings more frequently.

Figure 60: Heavy metallic lid covering the meter box

5.4.8.3 Error due to incorrect measurement units

The DropDrop mobile phone app requires the user to convert the meter reading from cubic metres to litres. Different water meters display readings differently, as shown in Figure 61.



(a) (b)

Figure 61: Various types of water meter display

Some of the participants, with similar water meters than those shown in Figure 61b, did not enter the correct meter reading into the DropDrop app. They entered the figures displayed on the rotating wheel (dark section on the screen) and omitted those displayed on the circular scales. This observation shows that the information contained in the app (see Figure 62) for educating on how to read various types of water meters was not accessed.

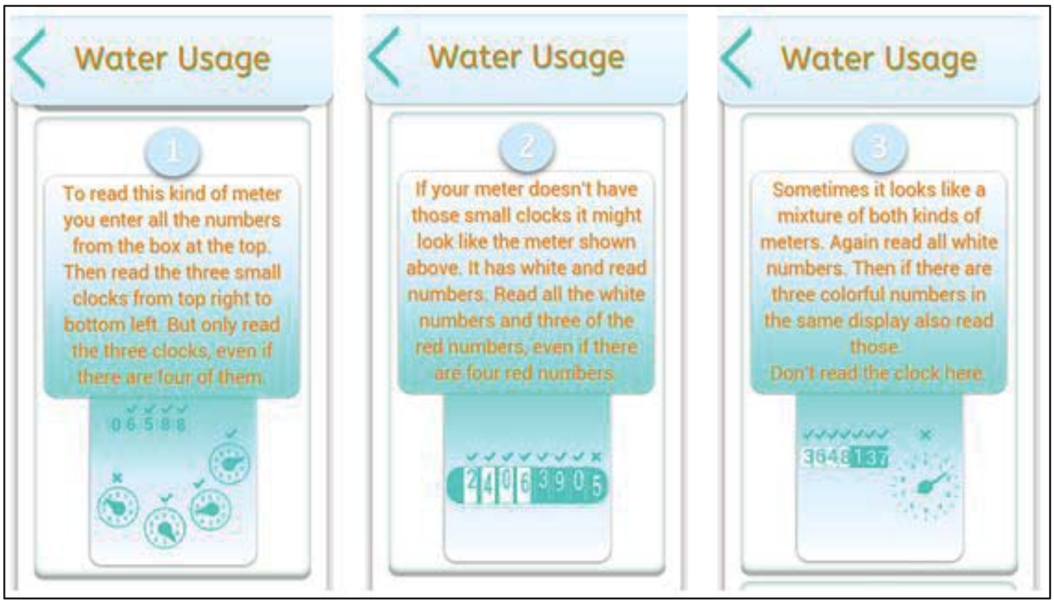


Figure 62: Guidelines on how to read various water meters – the DropDrop app

As a result, the water consumption and bill generated by the DropDrop app was much less than the actual amount. Upon realising the mistake, some participants deleted the water meter readings saved in the records in the app and started entering the correct meter readings again. Incorrect entry of the water meter reading could indicate that users are not exploring the app thoroughly to gain knowledge on issues such as meter reading, leak detection and fixing a leaking faucet.

5.5 Summary

This study assessed the effect of water-related information provided by a mobile phone app on water conservation participation at household level. The objectives of the study were met as follows:

- Consumers' background knowledge of water conservation and their mode of accessing water-related information was assessed.
- Level of water conservation practice due to frequency of accessing water-related information during the study period was evaluated.
- Conservation knowledge and practices gained from a water conservation mobile app by population size of water users was assessed.
- Usability of the source of water-related information on educating users was determined.
- The challenges obstructing implementation of water-related information were determined.

The sample population represented a population who was generally knowledgeable about water resources and water conservation. However, only a few participants were aware of the utility provider's water conservation messages, water hotline and initiatives/campaigns run by the utility provider despite: (1) ample availability of such information on the municipal website and outdoor and media ads; and (2) most participants accessing water-related information on the internet web.

The water-related information from the DropDrop mobile app generally increased water conservation knowledge and awareness of the sample population. After the study period, more participants were aware of their daily water consumption. Similarly, more participants monitored their water consumption regularly and checked for water leakage.

Other areas impacted by the water-related information included knowledge of municipal fault-reporting lines (although few participants contacted the municipal call centre) and water conservation measures. However, opportunities for more extensive and consistent conservation participation can be realised if water conservation information was presented through media (such as mobile phones) that are easily and mostly accessed by consumers.

During implementation of the DropDrop mobile app, the cumulative monthly water consumption of the participants in the treatment group was consistently lower than the cumulative consumption of participants in the control group. In addition, the gap between cumulative consumption of the treatment group and that of the control group widened. This implied a lower rate of cumulative water consumption in the treatment group than in the control group. The lower cumulative consumption was attributed to intensified water conservation practice by participants in the treatment group, due to using the water-related information provided by the DropDrop mobile app.

The average historical (from July 2010 to October 2015) household consumption of the control group was generally lower than that of the treatment group. However, the average monthly consumption of the treatment group was consistently lower than the control group as from the month of August 2015. In addition, the gap between the average consumption of the control group and treatment group also widened during this time. These observations could affirm that the water-related information provided by the DropDrop app enabled the participants to economise water.

Most participants acknowledged that the DropDrop app was easy to learn and use. Participants were satisfied with the app except for a few who indicated that more details on the water rates and how waste water was measured should be added to the app to make it satisfactory. The DropDrop app was generally usable in providing water-related information.

The main challenges that hampered implementation of the DropDrop mobile app included: (1) remote location of some water meters thus discouraging participants to read them regularly; (2) obscured screen for some water meters, which were difficult to read; (3) heavy metal covers on some water meter boxes, which were heavy to lift; and (3) error in reading the water meter hence incorrect figure entered into the DropDrop app. Another crucial challenge observed during the study period was to enable access to water-related information and personalised tracking of water consumption in a non-enforcing and invasive way.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

The purpose of this final chapter is to provide conclusions based on the analysis and findings as discussed in the previous chapters in line with the aims of the project. The initial aims of the study were:

- To identify the successes and failures of residential WC/WDM initiatives in the City of Cape Town through a literature review.
- To conduct household surveys to identify current mobile phone usage, willingness to pay for information, and commitment to partake in research across a representative sample of social classes of Cape Town households.
- To gather household information on water consumption, charges and municipal engagements through questionnaires and interviews.
- To implement the use of a mobile application (called DropDrop) in households for three months and observe its use.
- To evaluate the water consumption and charges in households and engagement with the municipality based on the findings of the field study.
- To examine how to DropDrop to be more useful by determining the functionalities that are heavily relied on and the recommended functionalities.

6.2 Aim 1: Successes and Failures of Residential Water Conservation

The literature review, presented in Chapter 2, outlined the successes and failures of residential WC/WDM locally within the City of Cape Town, and nationally within South Africa, and explored the ICTs used to manage water demand. Some of the various forms of ICTs reviewed included smart metering, water management devices, MajiVoice, Jisomee and Dropcountr. These apps essentially supplement existing metering strategies for households or multi-unit properties by automating meter readings, as well as by providing platforms on which consumers can pay for their bills and send or receive information from service providers.

From initial formation of WDM initiatives in 1995, the Cape Town City Council shifted focus to try to moderate the high growth in demand, fuelled by an increasing urban population. In an IWRP study, water demand controls were identified as the most promising for ensuring that supply met demand based on their low cost and ease of implementation, and when implemented, they were shown to successfully reduce demand. Leak detection initiatives were also run with strong successes in identifying leaks and reducing water losses.

It was observed that the City of Cape Town's residents have limited access to the internet, which limits the ability for educational programmes about water usage to reach people through this medium. The City of Cape Town website is not currently well used for retrieving information about water, but it has been noted that there are incentives that can be built into the site to promote its use. It was also observed that mobile phones may be a suitable medium for communication with residents as the ownership of mobile phones in South Africa is higher than other traditional options, such as TVs, radio, and landline telephones.

Surveys were undertaken in the City of Cape Town that indicated that further interventions around WC/WDM in residential households should be explored to address the lack of awareness on a variety of factors related to water, including awareness of how a water meter works and city by-laws pertaining to water. Without knowledge, citizens are not empowered to undertake many of the options they have at their disposal for reducing water usage.

6.3 Aim 2: Current Mobile Phone Usage and Willingness to Pay for Information

A study was conducted within the City of Cape Town to interrogate mobile phone usage, and individual's willingness to pay for information and to participate in research studies of this sort. The intention was that these findings would help to anticipate practical considerations for how to undertake the overall research project, as well as to highlight personal attributes that may affect the success, such as demographics, income and ICT skills.

In terms of smartphone usage, it was found that older generations in Cape Town used their smartphones for functionality such as texting and calling. Younger generations, while using their phones for these functions too, used their phones for an entire myriad of other functions. These included listening to music, playing video games, accessing the internet, taking, sending and receiving photos, and using social media. This aligns with the statement by Conci et al. (2009) that younger generations are typically motivated by the social capital attached to the use of a mobile phone and social networking, whereas older generations rely on the more functional uses of being in contact. It is also consistent with previous studies by Balakrishnan and Raj (2012), Hsiao and Chen (2015), and North et al. (2014).

While certain age groupings and income levels rate an app's ease of use as the highest reason to pay for it, overall it is its affordability that influenced most peoples' decision to pay for an app. This was true for both males and females. Interestingly, however, more females than males were willing to pay for an app if they could share it with friends. Affordability outweighed usefulness as a factor in deciding to pay for an app or not, which contradicts Biswas and Roy (2016) who stated that the decision to pay for information is predominantly driven by the perceived benefit, the users' understanding of the product or information and their attitude toward it.

An easy-to-use, useful app was seen as important, but would be disregarded if the app was not affordable in the first instance.

6.4 Aim 3: Gather Household Information on Water Consumption

A key aim of this project was gaining an understanding of the overall experience and perception of households in relation to WDM, and in doing so, attempt to identify barriers and enablers of implementing water conservation practices in households. This was addressed in detail within Chapters 2, 3 and 4 of this report.

More than half of the sample population were unaware of both their daily water consumption and the ongoing water conservation initiatives run by the municipality. More than half of participants were aware of water tariffs used; however, few respondents (18%) knew about the municipal water hotline for reporting water-related concerns.

Despite the widespread awareness of tariffs, most of the participants who conserved water aimed at avoiding wastage rather than saving money. This implies that they understood that portable water was scarce. Therefore, water conservation campaigns that emphasise the need to avoid wastage can be more effective than those that underscore monetary savings.

6.5 Aim 4: Implement and Monitor DropDrop Mobile App in Households

One of the primary aims of the project was to use mobile phones to facilitate participants to monitor their water use via the mobile app DropDrop. Following implementation, monitoring took place for three months during which time the participants were invited to comment on the perceived ease of use and usefulness of the app. Interviews were conducted at the end of the period to gather additional data in order to verify the findings of the study and provide additional depth and richness in understanding.

The water-related information from the DropDrop mobile app generally increased water conservation knowledge and awareness of the sample population. After the study period, more participants were aware of their daily water consumption. Similarly, more participants monitored their water consumption regularly and checked for water leakage.

Other areas impacted by water-related information included knowledge of municipal fault-reporting lines (although few participants contacted the municipal call centre) and water conservation measures. However, opportunities for more extensive and consistent conservation participation can be realised if water conservation information was presented through media (such as mobile phones) that are easily and mostly accessed by consumers.

During implementation of the DropDrop mobile app, the cumulative monthly water consumption of the participants in the treatment group was consistently lower than the cumulative consumption of participants in the control group. In addition, the gap between cumulative consumption of the treatment group and that of the control group widened. This implied a lower rate of cumulative water consumption in the treatment group than in the control group. The lower cumulative consumption was attributed to intensified water conservation practice by participants in the treatment group due to using the water-related information provided by the DropDrop mobile app.

The average historical (from July 2010 to October 2015) household consumption of the control group was generally lower than that of the treatment group. However, average monthly consumption of the treatment group was consistently lower than the control group as from the month of August 2015 only, when the study period began. In addition, the gap between the average consumption of the control group and treatment group also widened during this time. These observations could affirm that the water-related information provided by the DropDrop app enabled the participants to economise water.

6.6 Aim 5: Evaluate Household Water Consumption, Charges and Municipality Engagement

The sample population represented a population who was generally knowledgeable about water resources and water conservation. However, only a few participants were aware of the utility provider's water conservation messages, water hotline and initiatives/campaigns run by the utility provider despite: (1) ample availability of such information on the municipal website and outdoor and media ads; and (2) most participants accessing water-related information on the internet web.

One of the greatest challenges faced within the study concerned residents' difficulties in accessing and interpreting their water meters. Although guidelines were provided within the DropDrop app, many of the participant's water meters were either placed under heavy lids that made them difficult to reach or were the meters were showing different measurement units (litres versus cubic metres). These aspects make it cumbersome for residents to keep track of their water usage, with or without access to a mobile app.

6.7 Aim 6: Suggest Functional Improvements to DropDrop

Most participants acknowledged that the DropDrop app was easy to learn and use. More participants were satisfied with the app, except for a few who indicated that more details on the water rates and how waste water was measured should be added on to the app to make it satisfactory. The DropDrop app was generally usable in providing water-related information. The following recommendations are provided as a guide for future enhancements to the app:

- Add an alert to remind residents to check their water reading and introduce other behavioural nudges to encourage compliance, such as comparison between personal usage and usage of others within the neighbourhood.
- Automate capture of the meter readings using technologies such as optical character recognition to make it easier for residents to track usage and participate.
- Allow incorrect meter reading to be edited.
- Allow export of the data to Microsoft Excel or another type of app software for further manipulation.
- Display the actual average consumption alongside the graph.

- Link the app to the municipal database so that individuals are not required to capture the bill information, and so that water rates are kept up to date.
- Provide an indication of the water usage breakdown within households, e.g. garden/bathroom.
- Allow consumption to be input in litres or cubic metres to remove the risk of error in conversions.

BIBLIOGRAPHY

Allen, C., 2010. A study of water rates in the counties of San Luis Obispo and Santa Barbara. POLS 590 Graduate Seminar, California State Polytechnic University, San Luis Obispo, CA.

Allon, F. & Sofoulis, Z., 2006. Everyday water: cultures in transition. *Australian Geographer*, 37(1), pp.45–55.

Balakrishnan, V. & Raj, R.G., 2012. Exploring the relationship between urbanized Malaysian youth and their mobile phones: A quantitative approach. *Telematics and Informatics*, 29(3), pp.263–272.

Biswas, A. & Roy, M., 2016. A study of consumers' willingness to pay for green products. *Journal of Advanced Management Science*, 4(3), pp.211–215.

Blom, A., Cox, P. & Raczka, K., 2010. Developing a policy position on smart water metering. WPI Interactive Qualifying Project.

Butler, D. & Memon, F.A., 2006. Water demand management. In *Water Demand Management*. London: IWA Publishing, pp. 1–26.

Champanis, M., Rivett, U., Gool, S. & Nyemba-Mudenda, M., 2013. ICTs in the water sector: Where do we stand? Report No. TT571/13, Water Research Commission, Gezina.

Claremont Improvement District Company (CIDC), n.d. Ratepayers urged to use city's C3 notification system. CIDC, Claremont.

City of Cape Town, 2010a. Be part of the Integrated Water Leaks Repair Project. Cape Town.

City of Cape Town, 2010b. FAQs. Cape Town.

City of Cape Town, 2013a. Retrofit and leaks repair projects. Cape Town.

City of Cape Town, 2013b. Update and additions to existing long-term water conservation and water demand management strategy. Cape Town.

City of Cape Town, 2015a. Tariff policies 2015/16. Policy Number 21144C, 16(21144). Cape Town.

City of Cape Town, 2015b. Welcome to the City of Cape Town's e-Services website. Cape Town.

Clifford, E. et al., 2014. Interactive water services: The Waternomics approach. In *16th Conference on Water Distribution System Analysis, WDSA 2014*. Elsevier Ltd, pp. 1058–1065.

Conci, M., Pianesi, F. & Zancanaro, M., 2009. Useful, social and enjoyable: Mobile phone adoption by older people. Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 5726 LNCS(PART 1), pp.63–76.

Corbella, H. & Pujol, D.I., 2009. What lies behind domestic water use? A review essay on the drivers of domestic water consumption. *Boletín de la Asociación de Geógrafos*, (50), pp.297–314.

Cornwall, A. & Gaventa, J., 2001. Bridging the gap: Citizenship, participation and accountability. In *PLA Notes: Deliberative Democracy and Citizen Empowerment,* (February), pp.32–35.

Council for Scientific and Industrial Research (CSIR), 2010. A CSIR perspective on water in South Africa. CSIR, Pretoria.

De Clercq, P.B. et al., 2014. Personal income estimates for South Africa, 2011–2014, Cape Town.

Deloitte & GSM Association, 2012. Sub-Saharan Africa mobile observatory 2012. GSMA Report, (November), p.91.

Department of Water Affairs, 2003. Strategic Framework for Water Services. Department of Water Affairs (September), p.73.

Department of Water and Sanitation (DWS), n.d. Water Service Institutions. DWS, Pretoria.

Department of Water and Sanitation (DWS), 2001. 2020 Vision for water project environmental conservation in South African Schools. DWS, Pretoria.

Department of Water and Sanitation (DWS), *Blue Drop No Drop Handbook.* DWS, Pretoria.

Department of Water and Sanitation (DWS), 2004a. National Water Resource Strategy. DWS, Pretoria.

Department of Water and Sanitation (DWS), 2004b. Water Conservation and Water Demand Management Strategy for the industry, mining and power generation sectors. DWS, Pretoria.

Department of Water and Sanitation (DWS), 2009. Water for growth and development in South Africa. DWS, Pretoria.

Department of Water and Sanitation (DWS), 2013a. National Water Resource Strategy. DWS, Pretoria.

Department of Water and Sanitation (DWS), 2013b. Strategic overview of the water sector in South Africa. DWS, Pretoria.

Van Drunen, R. & Stoker, P., n.d. Water Use App.

Frame, J. & Killick, M., 2004. Integrated water resource planning in the city of Cape Town. *Water Institute of South Africa (WISA) Biennial Conference*, 30(5), pp.100–104.

Frankson, L., 2014a. Municipality slaps water wasters with fines. *Infrastructure News and Service Delivery*. 10 December 2014.

Frankson, L., 2014b. Polokwane water supply still under strain. *Infrastructure News and Service Delivery.* 6 November 2014.

Frankson, L., 2015a. eThekwini implements water rationing. *Infrastructure News and Service Delivery.* 26 June 2015.

Frankson, L., 2015b. Govt pours millions into leak prevention programme. *Infrastructure news and service delivery*. 31 August 2015.

Frankson, L., 2015c. Presidential project supplies water to rural KZN. *Infrastructure news and service delivery*. 29 June 2015.

Gillwald, A., Moyo, M. & Stork, C., 2012. What is happening in ICT in South Africa: A supply-and demand-side analysis of the ICT sector. *Evidence for ICT Policy Action*, (7).

Gleick, P.H., 1996. Basic water requirements for human activities: Meeting basic needs. *Water International*, 21.

Go, A. et al., 2013. Population futures: Revisiting South Africa's National Development Plan 2030. *African Futures Paper*, (7), p.13.

Habel, D., 2014. Kenya: Kayole slum dwellers pay water bills through mobile phones. *The Star*. 29 September 2014.

Hedden, S. & Cilliers, J., 2014. The emerging water crisis in South Africa. *African Futures Paper*, (11).

Hellström, J. & Jacobson, M., 2014. You can't cheat the community anymore: Using mobiles to improve water governance. In I. Niang & C. Scharff, eds. *Proceedings of 4th International Conference on M4D Mobile Communication for Development*. Dakar, Senegal, pp. 48–59.

Herbertson, P. & Tate, E., 2001. Tools for water use and demand management in South Africa. Technical Reports in Hydrology and Water Resources. World Meteorological Organization, Geneva.

Hope, R., Foster, T., Money, A., Rouse, M., Money, N., Thomas, M., 2011. *Smart Water Systems*. Oxford: Oxford University.

Hsiao, M. & Chen, L., 2015. Telematics and informatics smart phone demand: An empirical study on the relationships between phone handset, Internet access and mobile services. *Telematics and Informatics*, 32(1), pp.158–168.

Hutchings, M. et al., 2012. mWASH: Mobile phone applications for the water, sanitation, and hygiene sector. Nexleaf Analytics, Los Angeles, CA.

Inman, D. & Jeffrey, P., 2006. A review of residential water conservation tool performance and influences on implementation effectiveness. *Urban Water Journal*, 3(3), pp.127–143.

Jacobs, H., Geustyn, L. & Loubser, E., 2004. Estimating residential water demand in southern Africa. *Journal of the South African Institution of Civil Engineering*, 4(46), pp.2–13.

Jacobs, H., Geustyn, L. & Loubser, E., 2006. Water: How is it used at home? In *Proceedings of the Water Institute of Southern Africa*.

Jacobs, H. et al., 2007. Analysis of water savings: A case study during the 2004/05 water restrictions in Cape Town. *Journal of the South African Institution of Civil Engineering*, 49(3), pp.16–26.

Jacobs, H., 2008. Residential water information management. *SA Journal of Information Management*, 10.

Kashian, R. et al., 2012. An estimation of the elasticity demand for tap water. *Journal of Strategic Innovation and Sustainability*, 7(3), pp.100–108.

Katchmark, W. et al., 2011. Hampton Roads Regional Water Supply Plan. Hampton Roads Planning District Commission, Chesapeake, VA.

Koohang, A., Harman, K. & Britz, J., 2008. *Knowledge Management: Theoretical Foundations*, CA: Informing Science Press.

Lana, 2014. South Africans and their cell phones.

Mckenzie, R., Siqalaba, Z. & Wegelin, W., 2012. The state of non-revenue water in South Africa. Report No. TT522/12, Water Research Commission, Gezina.

Mckenzie, R. & Wegelin, W., 2008. Challenges facing the implementation of water demand management initiatives in Gauteng Province. *Water SA*, 35(2), pp.168–174.

McKinsey & Company, 2012. Transforming learning through mEducation. McKinsey & Company, New York, NY.

Molden, D., 2007. *Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture*. D. Molden, ed., London: Earthscan.

Moraa, H., Salim, A. & Nduati, L., 2012. Technology in solving society's water problems in Kenya. iHub Research.

Mutikanga, H., Sharma, S. & Vairavamoorthy, K., 2011. Investigating water meter performance in developing countries: A case study of Kampala, Uganda. *Water SA*, 37(4), pp.567–574.

Nairobi City Water and Sewerage Company (NCWSC), 2012. Nairobi Water Company launches innovative social connections program to serve low-income settlements. NCWSC, Nairobi.

Nairobi City Water and Sewerage Company (NCWSC), 2014. Use of mobile technology in service delivery. In *2014 World Water Week in Stockholm*. Stockholm.

Nguyen-Khoa, S. et al., 2012. Global water framework. In *6th World Water Forum*. Marseille: IFC Secretariat, p. 125.

Nkondo, M., Van Zyl, F.C., Keuris, H. & Schreiner, B., 2012. Proposed National Water Resource Strategy 2 (NWRS 2): Managing water for an equitable and sustainable future. Department of Water Affairs, Pretoria.

North, D., Johnston, K. & Ophoff, J., 2014. The use of mobile phones by South African university students. *Information Science and Information Technology*, 11, pp.115–138.

Ooko, S., 2014. Digital forum revolutionises the way water bills are paid. *Business Daily*. 12 November 2014.

Parker, J.M. & Wilby, R.L., 2013. Quantifying household water demand: A review of theory and practice in the UK. *Water Resources Management*, 27(4), pp.981–1011.

Pollark, M., 2009. Devices help save water and money. City of Cape Town.

POST, 2000. Water efficiency in the home. POST Technical Report 135, House of Commons, London.

Postel, S., 1992. *Facing Water Scarcity*, Washington DC: W. W. Norton & Company Ltd.

Powers, M., 2015. Water scarcity: Multiple ways of assessing threats to water: Supply-side and demand-side problems. FEW Resources.org, Washington, DC.

Richardson, F., 2014. Case study: NextDrop. GSMA, Mobile for Development.

Sarah Slabbert Associates, 2010. Towards standards for municipal invoices in South Africa. Report No. TT458/10, Water Research Commission, Gezina.

Schaub-Jones, D., 2012. ICT in the water sector: Trends, issues and challenges., (May).

Schouten, T., 2013. Changing relationships: ICT to improve water governance. In *World Water Week*, Stockholm.

Shah, R., 2015. Improving water service delivery in Bangalore: The case of NextDrop. GSMA, Mobile for Development.

Shand, N. & Gibb, A., 2001. Integrated Water Resource Planning Study. City of Cape Town.

Sierra Wireless Inc., n.d. Unlock the potential of smart water metering with cellular communications. Sierra Wireless Inc., Pueblo, CO.

Silva, T. et al., 2010. Water Conservation: Customer Behavior and Effective Communications, Water Research Foundation, US EPA.

Sinske, A., Jacobs, H. & Geustyn, L., n.d. Internet-based water demand management. CES Consulting Engineers.

Smith, L.A., Villeneuve, T.G. & Kizzire, D.W., 2004. Residential Water Management System (RWMS). US Patent US20040206405A1, pp.1–11.

Stats SA, 2011. City of Cape Town. Stats SA, Pretoria.

Stats SA, 2014. General household survey 2013. Statistical release P0318, (May), pp.1–173. Stats SA, Pretoria.

Stellenbosch Municipality, 2013. Water quality and blue drop status. Stellenbosch Local Municipality, Stellenbosch.

Stephens, C., 1996. Healthy cities or unhealthy islands? The health and social implications of urban inequality. *Environment and Urbanization*, 8(2), pp.9–30.

Still, D., Erskine, S., Walker, N. & Hazelton, D., 2008. The status and use of drinking water conservation and savings devices in the domestic and commercial environments in South Africa. Report No. TT358/08, Water Research Commission, Gezina.

South Africa, 1998. National Water Act. Pretoria: Government Printer.

South Africa, 2000. Municipal Systems Act: Government Gazette. Pretoria: Government Printer.

South Africa, 2001. Water Services Act. Pretoria: Government Printer.

South Africa, 2004. Local Government: Municipal Finance Management Act. Pretoria: Government Printer.

The World Bank, 2012a. Social connections increase access to water for Kenya's urban poor. *The Worlkd Bank: News*. 9 November 2012.

The World Bank, 2012b. The transformational use of information and communication technologies in africa. eTransform Africa, p.17.

The World Bank, 2012c. World development indicators.

Torres-Reyna, O., n.d. Getting started in frequencies, crosstab, factor and regression analysis. Princeton University, Princeton, NJ, p.28.

United Nations. United Nations Environment Programme: Other water conservation practices. *Newsletter and Technical Publications*.

Utts, J.M. & Heckard, R.F., 2015. *Technology Manual to Accompany Mind on Statistics,* 5th ed. M.S. Melissa, ed., California, PA: Cengage Learning.

Washplus, 2015. Small doable actions: A feasible approach to behavior change. *Washplus Learning Brief* (August).

Water Institute of Southern Africa (WISA), 2015. Smart metering challenges. *Water & Sanitation Africa*.

Water Service Regulatory Board (Wasreb), n.d. About MajiVoice. *MajiVoice*.

Wegelin, W. & Jacobs, H., 2012. The development of a municipal water conservation and demand management strategy and business plan as required by the Water Services Act. *Water SA*, 39(3).

Whitcomb, J.B., 2005. Florida water rate evaluation of single-family homes. University of Florida.

White, S., 1998. Wise water management: A demand management manual for water utilities. Report No. WSAA86, WSAA, Melbourne.

Wolfson, E., 2014. A water project cleans up Nairobi's slum. *Newsweek*, 9 November 2014.

World Health Organization (WHO), 1997. *Guidelines for Drinking-Water Quality*, 3rd ed. Geneva: World Health Organisation.

Van Zyl, J., 2011. Introduction to integrated water meter management. Water Research Commission, Pretoria.

Van Zyl, J. & Husselmann, M., 2006. Effect of stand size and income on residential water demand. *Journal of the South African Institution of Civil Engineering*, 48(605), pp.12–16.

Page left blank intentionally

APPENDICES

Appendix A Start of Survey Questionnaire

Start-of-Survey Questionnaire

Declaration: This questionnaire is meant for research purpose only and the information provided will remain confidential

Please fill in this questionnaire and tick (√) the appropriate boxes **Questionnaire number:**

Property Details

a) Name of your suburb/residential area:

b) Type of property/house:
☐ Freestanding House (detached dwelling) ☐ Semi-detached house
☐ Cluster house in complex ☐ Other (Please specify)

c) How long have you lived at this current address?
☐ Less than 1 year ☐ 1 – 3 years ☐ 3 – 7 years ☐ 7 or more years

d) Please indicate the number of people who reside at this address year-round:
☐ 1 – 2 ☐ 3 – 4 ☐ 5 – 6 ☐ More than 6

e) Enter your Municipal Water Account Number: ____________________________

Knowledge on cost and consumption:

1. Do you agree with this: I know that as I use more water, the price per kilolitre increases.
   ☐ Yes ☐ No ☐ Not sure
2. Do you agree with this: I know the water rates and the tariff block within which my water consumption fits.
   ☐ Yes ☐ No
3. Please indicate if you are aware of your average daily water usage.
   ☐ Not aware ☐ 0 – 200 litres ☐ 200 – 400 litres ☐ 400 – 600 litres
   ☐ More than 600 litres
4. Have you taken any action to lower your water consumption so as to avoid higher water bills?
   ☐ Not at all ☐ Sometimes ☐ Regularly ☐ Frequently
   Please give examples of the actions taken:

5. Which of the following best describes your thinking (especially in situations where water price influenced you to use less water)?
   a) Not applicable/I have never really thought about water prices.
   b) I knew my water bill would go down if I used less water, but I did not take the time to estimate by how much.
   c) I thought about the total amount of money of my past water bills to guess how much my water bill might change if I used less water.
   d) I estimated about how many litres of water I would probably save, and calculated my water bill savings using the water price.

Information access; conservation awareness:

6. Are you informed about water conservation initiatives in your area?
   ☐ Yes, frequently ☐ Rarely ☐ Not at all

Start-of-Survey Questionnaire

Declaration: This questionnaire is meant for research purpose only and the information provided will remain confidential

Please fill in this questionnaire and tick (√) the appropriate boxes **Questionnaire number:**

If Yes/Rarely, how do you access or receive information on water conservation/saving?

☐ Computer/laptop via internet ☐ Phone SMS ☐ Municipal website
☐ Radio/Television ☐ Road-shows ☐ Magazines/Newspapers
☐ Others (Please specify)

7. Have you implemented water conservation tips/methods e.g. turn off tap while brushing teeth and installing water-saving device?
   ☐ Yes ☐ No
8. For each of the messages below, please indicate where you saw or heard each message:
   a) Keep Saving Water
      ☐ Internet website ☐ Radio/TV ☐ Water bill insert ☐ Education event
      ☐ Outdoor ads ☐ I did not hear/see this message ☐ Other (Please specify)_____________
   b) Our Water, Our Pride
      ☐ Web site ☐ Radio/TV ☐ Water bill insert ☐ Education event ☐ Outdoor ads
      ☐ I did not hear/see this message ☐ Other (Please specify)____________________
   c) Saving Water is a Way of Life
      ☐ Web site ☐ Radio/TV ☐ Water bill insert ☐ Education event ☐ Outdoor ads
      ☐ I did not hear/see this message ☐ Other (Please specify)____________________
   d) Save Water, Make your Bill More Affordable
      ☐ Web site ☐ Radio/TV ☐ Water bill insert ☐ Education event ☐ Outdoor ads
      ☐ I did not hear/see this message ☐ Other (Please specify)___________________
   e) Water Hotline: 086 010 3054
      ☐ Web site ☐ Radio/TV ☐ Water bill insert ☐ Education event ☐ Outdoor ads
      ☐ I did not hear/see this message ☐ Other (Please specify)____________________
   f) City Call Centre: 086 010 3089
      ☐ Web site ☐ Radio/TV ☐ Water bill insert ☐ Education event ☐ Outdoor ads
      ☐ I did not hear/see this message ☐ Other (Please specify)____________________

Meter reading; house data; billing; metered sources; knowledge of contact lines:

9. How often do you read your own water meter?
   ☐ Daily ☐ Weekly ☐ Monthly ☐ Once in 2 months ☐ Yearly ☐ Not at all
   ☐ I cannot locate my meter ☐ I do not know how to read the water meter
10. The information on my monthly bill (about my water consumption) enables me to monitor my water consumption. Do you agree?
    ☐ Strongly Agree ☐ Somewhat Agree ☐ Neutral
    ☐ Somewhat Disagree ☐ Strongly Disagree
11. Do you trust your water bill sent to you from the municipality?
    ☐ Yes ☐ No
12. Status of home ownership?
    ☐ Owned ☐ Renting ☐ Other (Please specify)
13. Which period is the house occupied?
    ☐ All year round ☐ Holidays ☐ Other (Please specify)
14. What are the alternative sources of (household) water?

Start-of-Survey Questionnaire

<u>Declaration</u>: This questionnaire is meant for research purpose only and the information provided will remain confidential

Please fill in this questionnaire and tick (√) the appropriate boxes **Questionnaire number:**

☐ Borehole ☐ Rainwater ☐ Onsite treatment plant/reclaimed water
☐ None ☐ Others (Please specify)

Is the alternative source of water metered?
☐ Yes, metered alternative source ☐ No alternative source ☐ Unmetered alternative source

15. How often do you engage/report/call the municipal call center (or Customer Care) to inquire on water-related concerns e.g. pipe burst and unexpected water bill?
    ☐ Not at all ☐ Rarely ☐ Monthly ☐ Weekly
    ☐ I do not know/have municipal contacts

Existing conservation and monitoring trend; reasons for water conservation:

16. How do you search for water leakage in the household pipes and fixture (i.e. toilet, faucets, sprinklers...)?
    ☐ Never searched for leakage ☐ Contacted plumbers ☐ Others (Please specify)

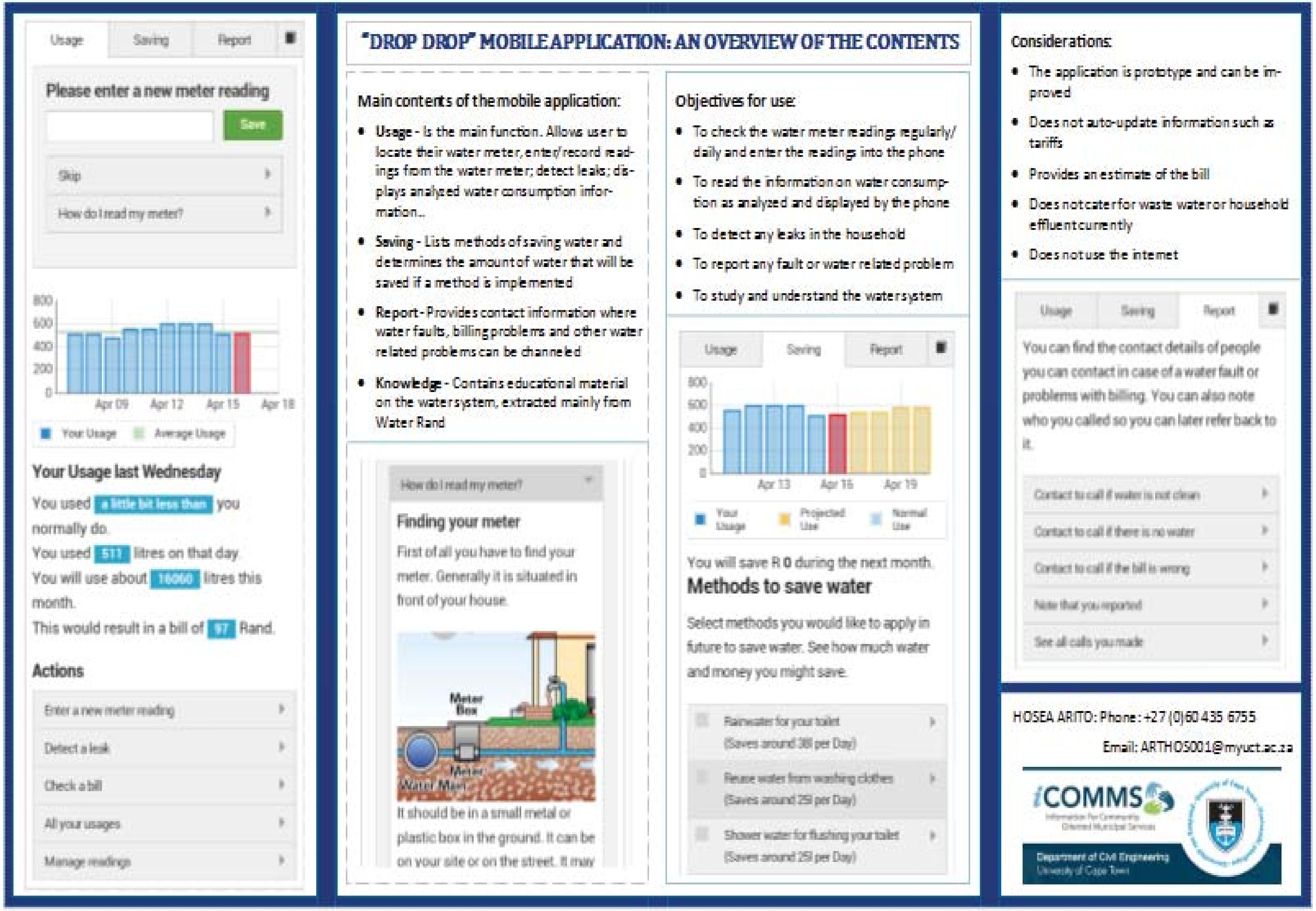
17. Without looking at recent bills, I know the approximate Rands I pay for my average (typical) monthly water bill.
    ☐ Strongly Agree ☐ Somewhat Agree ☐ Neutral
    ☐ Somewhat Disagree ☐ Strongly Disagree
    ☐ I do not exceed the free basic water limit i.e. 6kL

18. Without looking at recent bills, I know the approximate number of litres of water my household used during an average (typical) month.
    ☐ Strongly Agree ☐ Somewhat Agree ☐ Neutral
    ☐ Somewhat Disagree ☐ Strongly Disagree

19. Why do you conserve water? Tick the boxes below:-
    ☐ I have not thought of conserving water
    ☐ Environmental reasons (such as preserving water sources and vegetation, and aquatic life)
    ☐ To save money by reducing my water bill
    ☐ To avoid wastage of water
    ☐ It is the right thing to do
    ☐ Because South Africa is a dry country and water is scarce
    ☐ Others (Please mention them)

<u>Thank you for completing this questionnaire</u>

Appendix B DropDrop App Overview Flier



"DROP DROP" MOBILE APPLICATION: AN OVERVIEW OF THE CONTENTS

Usage | Saving | Report

Please enter a new meter reading

Save

Skip

How do I read my meter?

800
600
400
200
0
Apr 09 Apr 12 Apr 15 Apr 18

Your Usage Average Usage

Your Usage last Wednesday

You used a little bit less than you normally do.

You used 511 litres on that day.

You will use about 16060 litres this month.

This would result in a bill of 97 Rand.

Actions

- Enter a new meter reading
- Detect a leak
- Check a bill
- All your usages
- Manage readings

Main contents of the mobile application:

- **Usage** - Is the main function. Allows user to locate their water meter, enter/record readings from the water meter; detect leaks; displays analyzed water consumption information..
- **Saving** - Lists methods of saving water and determines the amount of water that will be saved if a method is implemented
- **Report** - Provides contact information where water faults, billing problems and other water related problems can be channeled
- **Knowledge** - Contains educational material on the water system, extracted mainly from Water Rand

How do I read my meter?

Finding your meter

First of all you have to find your meter. Generally it is situated in front of your house.

Meter Box
Meter
Water Main

It should be in a small metal or plastic box in the ground. It can be on your site or on the street. It may

Objectives for use:

- To check the water meter readings regularly/daily and enter the readings into the phone
- To read the information on water consumption as analyzed and displayed by the phone
- To detect any leaks in the household
- To report any fault or water related problem
- To study and understand the water system

Usage | Saving | Report

800
600
400
200
0
Apr 13 Apr 16 Apr 19

Your Usage Projected Use Normal Use

You will save R 0 during the next month.

Methods to save water

Select methods you would like to apply in future to save water. See how much water and money you might save.

- Rainwater for your toilet (Saves around 38 per Day)
- Reuse water from washing clothes (Saves around 29 per Day)
- Shower water for flushing your toilet (Saves around 29 per Day)

Considerations:

- The application is prototype and can be improved
- Does not auto-update information such as tariffs
- Provides an estimate of the bill
- Does not cater for waste water or household effluent currently
- Does not use the internet

Usage | Saving | Report

You can find the contact details of people you can contact in case of a water fault or problems with billing. You can also note who you called so you can later refer back to it.

- Contact to call if water is not clean
- Contact to call if there is no water
- Contact to call if the bill is wrong
- Note that you reported
- See all calls you made

HOSEA ARITO: Phone: +27 (0)60 435 6755

Email: ARTHOS001@myuct.ac.za

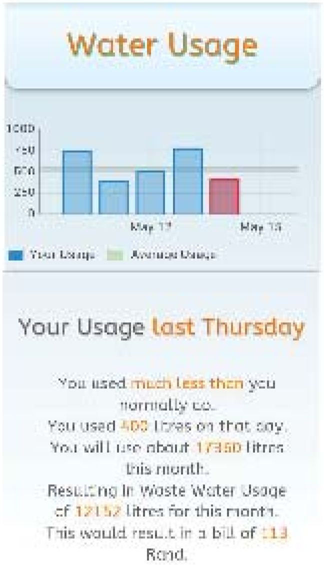
iCOMMS Information for Community Oriented Municipal Services

Department of Civil Engineering University of Cape Town

Appendix C Project Flier

AN APP FOR YOU TO TRY OUT AS WE COLLECT DATA ABOUT IT

"Drop Drop" mobile application:



- Allows you to locate your water meter, enter/record readings from water meter; detect leaks; view analyzed info about your water consumption;
- Lists water conservation tips & determines the amount of water that will be saved if a method is implemented;
- Provides contact information where faults, billing problems and other water-related issues can be channeled;
- Contains educational material on the water resource
- Can be downloaded/installed from the Google Play Store by searching "Drop Drop"

The requirements for use of "Drop Drop" include:

- An android smartphone e.g. Samsung, Huawei, HTC... (excluding, iPhones, Blackberries and most Nokia phones)
- Water meter at home

About participating in the study:

- Participants' information will be kept confidential (Ethics-approved);
- It is voluntary and participants are free to withdraw from participating;
- Fill in 2 sets of questionnaires (at the start and at the end of the study period i.e. 3 months).

Participants may be expected to:

- check meter readings regularly and enter these meter readings into the mobile phone application;
- read information on water consumption as analysed and displayed by the mobile phone application
- use any of the provided functionalities (in the App) such as leak detection; and report any fault or water-related issues
- implement any of the water conservation tips listed in Drop Drop
- study and understand the water system information in the mobile App

If you are willing to try out Drop Drop, please do not hesitate to let me know.

Your contact (email): ....

My contact:

Hosea Arito,
Email: ARTHOS001@myuct.ac.za
Phone: 060 435 6755

A/Prof Ulrike Rivett
Email: ulrike.rivett@uct.ac.za

Prof. Kobus Van Zyl
Email: kobus.vanzyl@uct.ac.za

Appendix D Questionnaire at the End of the Survey

End-of-Survey Questionnaire

__Declaration__: This questionnaire is meant for research purpose only and the information provided will remain confidential

Please fill in this questionnaire and tick (√) the appropriate boxes **Questionnaire number:**

Section A: Water Use Management

Knowledge on consumption; meter reading; contact details and municipal engagements:

1. Tick your average daily water usage as shown by 'the Drop Drop' App, when you used it?
   ☐ Not aware yet ☐ 0 – 200 litres ☐ 200 – 400 litres ☐ 400 – 600 litres
   ☐ More than 600 litres

2. How often did you read your water meter over the last 3 months?
   ☐ Daily ☐ Weekly ☐ Monthly ☐ Not at all
   ☐ I cannot locate my meter ☐ I do not know how to read the water meter

3. How often did you engage/report/call the municipal call center (or Customer Care) on water-related concerns e.g. pipe burst/leak and unexpected water bill?
   ☐ Not at all ☐ Rarely ☐ Monthly ☐ I do not know/have municipal contacts
   ☐ Other (Please specify)

Conservation practice/culture; monitoring trend:

4. Did you detect any leaking household pipes and fixtures (i.e. toilet, faucets, sprinklers…)?
   ☐ No, I did not check ☐ No, I checked but did not find
   ☐ Yes (Please specify)

5. "Without looking at past bills, I know the approximate number of litres of water my household used daily during the study period." Do you agree?
   ☐ Strongly Agree ☐ Somewhat Agree ☐ Neutral
   ☐ Somewhat Disagree ☐ Strongly Disagree

6. How frequently did you use the Drop Drop application to read and determine your water consumption in the last 3 months?
   ☐ 2 to 3 times in a week ☐ Weekly ☐ Once in 2 weeks
   ☐ Monthly ☐ 3 times a month ☐ Other (Please specify)

Information access; knowledge of water conservation and lesson learnt

7. Based on your experience, how did the Drop Drop App improve the way you managed water use and your understanding of your water meter/bill? (Tick all applicable options)
   ☐ I, now know how to read the water meter
   ☐ I read the meter readings regularly (Please mention how regular)
   ☐ I used the water-consumption information from the App to decide how I would use water
   ☐ With the predicted end-month water bill/consumption, and tips on saving water, I made decisions on how I would use water
   ☐ I now trust the water bill from the municipality
   ☐ I still do not trust the water bill from the municipality
   ☐ I am now knowledgeable on the need of, and how to conserve/save water
   ☐ I, now can contact the municipal Call Centre in case of any water-related issues

End-of-Survey Questionnaire

Declaration: This questionnaire is meant for research purpose only and the information provided will remain confidential

Please fill in this questionnaire and tick (√) the appropriate boxes **Questionnaire number:**

⇒ Please state any other reasons

Section B: Usability of the Application

8. Please tick the functionalities that you used while using the Drop Drop mobile application.
   ☐ Water usage ☐ Water savings ☐ Reports ☐ Knowledge base ☐ About

9. Please list the limitations, of the Drop Drop mobile application, that you experienced while using it.

10. Are there other water-related issues that were not addressed by the Drop Drop application, and you think you needed support about them? ☐ Yes ☐ No
    If Yes, please state them.

11. What were your expectations in taking part in the study?
    - ~~☐ To know the amount of water I use daily and predict the monthly bill~~
    - ~~☐ To detect any leaks in the household pipes and fixtures~~
    - ~~☐ Engage with the municipality in an informed manner~~
    - ~~☐ To understand the water resource and the water system and~~
    - ~~☐ Not keen to achieve these goals/objectives~~
    - ~~☐ Other objectives, please state them~~

13. How long did you take to learn how to use the Drop Drop application?

16. How easy did you find it to use the Drop Drop application?
    ☐ Difficult ☐ Somehow easy ☐ Easy ☐ Not used

17. Would you wish to continue using the Drop Drop App?
    ☐ Not at all ☐ Yes, if improved ☐ Yes

18. Do you think you had enough time using the Drop Drop application?
    ☐ Yes ☐ No

19. What was your overall satisfaction while using the Drop Drop App, for the last 3 months?
    ☐ Not satisfied ☐ Somehow satisfied ☐ Satisfied ☐ Very satisfied

20. Indicate how you encountered:-
    a) Entering a new meter reading in the Drop Drop App?
       ☐ Very complex ☐ Complex ☐ Challenging ☐ Easy ☐ Not used
    b) Detecting if there was a water leak, using the Drop Drop App?
       ☐ Very complex ☐ Complex ☐ Challenging ☐ Easy ☐ Not used
    c) Checking the monthly water bill on the Drop Drop App?

End-of-Survey Questionnaire

<u>Declaration</u>: This questionnaire is meant for research purpose only and the information provided will remain confidential

Please fill in this questionnaire and tick (√) the appropriate boxes **Questionnaire number:**

- ☐ Very complex ☐ Complex ☐ Challenging ☐ Easy ☐ Not used

d) Viewing all water usages on the Drop Drop App?
- ☐ Very complex ☐ Complex ☐ Challenging ☐ Easy ☐ Not used

e) Managing the readings (e.g. removing incorrect reading) using the Drop Drop App?
- ☐ Very complex ☐ Complex ☐ Challenging ☐ Easy ☐ Not used

f) Interpreting the water usage bar chart to understand your water consumption i.e. previous usage and projected usage trend?
- ☐ Very complex to understand ☐ Complex ☐ Challenging ☐ Easy ☐ Not used

21. Do you have any comments or suggestions about improving the Drop Drop App? Please state them.

Thank you very much for participating in this study!!!

9781431209774