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FACULTY OF ENGINEERING

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AN ANALYSIS OF THE IMPACTS OF PREPAID WATER METERS IN THREE TOWNS IN NAMIBIA

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MSc. Thesis in Integrated Water Resources Management

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In collaboration with

AN ANALYSIS OF THE IMPACTS OF PREPAID WATER METERS IN THREE TOWNS IN NAMIBIA

By

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A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Integrated Water Resources Management of the University of Zimbabwe

JUNE 2016

DECLARATION

I**, Kornelia Ndapewa Iipinge,** declare that this research report is my own work. It is being submitted for the degree of Master of Science in Integrated Water Resources Management (IWRM) of the University of Zimbabwe. It has not been submitted before for examination for any degree in any other University.

Date: ________________________

Signature: ____________________

DISCLAIMER

This document describes work undertaken as part of the programme of study at the University of Zimbabwe, Civil Engineering Department. All views and opinions expressed therein remain the sole responsibility of the author, and not necessarily represent those of the University.

DEDICATION

This thesis is dedicated to my grandparents.

Tangi unene Tate Kalunga

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ABBREVIATIONS

AREVA	société anonyme
ASE	Aqua Services and Engineering
BCM	Basin Management Committees
BPRA	Bulawayo Progressive Residents Association
CAI	Corporate Accountability International
CC	Catchment Councils
CCODP	Canadian Catholic Organization for Development and Peace
CEO	Chief Executive Officer
CMA	Catchment Management Authorities
DRC	Democratic Community Resettlement
DWA	Department of Water Affairs
DWD	Domestic Water Dispenser
FAO	Food and Agriculture Organization
FGDs	Focus Group Discussions
GPS	Global Positioning System
GRN	Government of the Republic of Namibia
GWP	Global Water Partnership
IMF	International Monetary Fund
IWRM	Integrated Water Resources Management
JMP	Joint Monitoring Programme
KTC	Karibib Town Council
LCD	Liquid Crystal Display
MAWF	Ministry of Agriculture, Water and Forestry
MDGs	Millennium Development Goals
N$	Namibian Dollars
NamWater	Namibia Water Corporation
NGO	Non-Governmental Organization
NHE	National Housing Enterprise
NHRAP	National Human Rights Action Plan
NMHD	National Mass Housing Development
NPC	National Planning Commission
NRW	Non-Revenue Water

NSA	Namibia Statistical Agency
OVC	Orphans and Vulnerable Children
PPWM	Pre-Paid Water Meter
SCC	Sub-Catchment Councils
SDGs	Sustainable Development Goals
SM	Swakopmund Municipality
SPSS	Statistical Package for Social Science
TIPEEG	Targeted Intervention Program for Employment and Economic Growth
UFW	Unaccounted-For Water
UN	United Nations
UNCESCR	United Nations Committee on Economic, Social and Cultural Rights
UNICEF	United Nations Children’s Education Fund
UNOHCHR	United Nations Office of the High Commissioner for Human Rights
US$	United States Dollars
UTC	Usakos Town Council
WHO	World Health Organization
WRM	Water Resources Management
WUA	Water User Associations
ZINWA	Zimbabwe National Water Authority

LIST OF DEFINITIONS

Cost recovery	the method to recovering an expenditure for a provision of a service.
Erf	a plot of land, usually urban, marked off for building purposes.
Erven	plural of erf.
Human right to water	entitles everyone to sufficient, safe, acceptable, physically accessible, and affordable water for personal and domestic uses.
Informal settlement	an area where residents with no or low-income have settled informally.
Postpaid water	end user first consumes water and then gets a bill for their consumption.
Prepaid water	end user first pays for water before they consume.
Shack	an improvised housing mainly made from cardboard, wood, plastic or corrugated iron.
Standpipe	freestanding pipe fitted with a tap which is installed outdoors to dispense water for a community that does not have household connections.
Tokens	used to store water units when a customer purchases water and the units are deducted from the token whilst in use
Water meter	is a device that measures the volume of water delivered to a property.
Water tariff	an appropriate price a user of water services is expected to pay.

ABSTRACT

Namibia's climate is hot and dry with erratic rainfall. Groundwater is the main source of water. Namibian municipalities are responsible for drinking water delivery in urban areas. They buy bulk water from the national water utility (NamWater) and many face challenges in paying for the water. The main objective of this study was to investigate the impacts of prepaid water metering systems in three selected towns (Karibib, Swakopmund and Usakos). The specific objectives were to investigate the drivers for the installation of Prepaid Water Meters (PPWMs), to investigate stakeholder involvement and their perceptions of PPWMs. The study also analysed the impacts of PPWMs on residents in the selected towns. Individual PPWMs in Usakos Town and communal standpipes PPWMs in the three town's informal settlements were studied. Purposive sampling method was used to identify customers that use PPWMs. Methods used to collect data included focus group discussions, household surveys, interviews with key informants and observations. A total of 321 household questionnaires investigating household/water user perceptions on service delivery, access and reliability, affordability of water and water use changes were administered. The study found out that the PPWMs were installed to recover costs as a result of poor revenue collection efficiency, illegal water connections and high debts of the water users. The study also found out that customers were not consulted before the introduction of the PPWMs. Although most of the respondents stated that PPWMs had a number of problems, such as the availability of tokens to top up credit, the majority preferred PPWMs to postpaid meters. The study established that the PPWMs were considered unreliable and are non-functional most of the time with a long cycle time for repairs between weeks to a month. The impact on the quality of life of standpipes prepaid users was said to be positive, for example, because water was perceived to be affordable and more accessible to the PPWMs system. The impact on the quality of life of PPWMs in Usakos was found to be negative, as customers first need to pay for municipal services before they can purchase water units, high cost in replacing token or meter, no service after municipal's working hours and limitations in water use.

Keywords: *Prepaid water meters, Urban water supply, Human right to water, Stakeholder participation, Cost recovery in water supply*

1. INTRODUCTION

1.1 Background

Water is the essence to life as all human activities depend on it (Savenije, 2002). According to Gleick (1996), the main human water needs include: drinking water for survival; water for hygiene; water for sanitation services and household needs, for example, preparing food. The post-2015 eight Millennium Development Goals (MDGs) and the newly adopted 17 Sustainable Development Goals (SDGs) aim at integrating social inclusion, economic development and environmental sustainability. The SDG 6.1 aims to achieve the realisation of the human right to water through universal and equitable access to available, safe and affordable drinking water for all, by the year 2030 (United Nations, 2015). The water crisis has been attributed to among other things: population growth, industrialisation, urbanization, increasing water consumption due to changes in lifestyle, climate change and variability, increasing water pollution, inefficiencies in agriculture and poor water governance. It is the result of myriad environmental, political, economic, and social forces (GWP, 2000; WHO and UNICEF, 2015; UN, 2015). This is particularly critical for Africa which still accounts for 40 percent of the population without access to safe drinking water.

Africa faces a situation of economic water scarcity, and current institutional, financial and human capacities for managing water are also lacking (WHO & UNICEF, 2012). It is for this reason that global financial institutions such as the World Bank and International Monetary Fund (IMF) proposed measures such installing prepaid water meters and water privatisation in order to improve the economic efficiency in the management of water resources (Bond & Dugard, 2008; World Bank, 2011). Water meters are used to measure the volume of water consumed by residential households and industries that are supplied with water via public or private water supply systems. Prepaid water metering, is based on meters that charge for water based on consumption and requires consumers to pay before using the service, as a form of water resource management innovation (Kumwenda, 2006).

Prepaid Water Meters (PPWMs) have been introduced in Bolivia, Colombia, Palestine and Turkey, among other countries and in more than 20 countries in Africa (Heymans *et al.*, 2014). Advocates of PPWMs see it as a way to improve customer relations, revenue, and access to services (von Schnitzler, 2008; Wanyakala, 2011; Maxwell *et al.*, 2015). Despite their advantages, the implementation of PPWMs has raised a number of questions. The South African Constitution, for an example, recognizes access to water as a human right and therefore any form of restriction on water access violates the right to water (Larson, 2010). Implications of PPWMs on residents have not been adequately considered as protests against water privatization usually breakout, for example in Bolivia and South Africa. These protests were mainly linked to the lack of participatory approach of water users at all levels of water development and management as per the second Dublin Principle.

In Namibia, PPWMs have been installed in about half of the country's towns, these include, Katima Mulilo, Keetmashoop, Otjiwarongo, Rehoboth, Swakopmund, Tsumeb and Windhoek, with the city of Windhoek being the pioneer in 1998. PPWMs were found to be installed in low-income and informal settlements (Saes, 2012). PPWMs restrict access to water, especially in a case where one has not paid for water. This not only disadvantages the poor, but it also infringes on the human right to water. Therefore, the question is how do we integrate water as an economic good and as a human right in the management of water resources? This uses the concept of the human right to water. This is defined as the right of everyone "to sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic uses" by the United Nations Committee on Economic, Social and Cultural Rights (UNCESCR) – General Comment 15, (UNCESCR, 2003:2).

However, in trying to guarantee the human right to water, most countries have to deal with the challenges of population growth, economic activity, improvement in standards of living, and water governance crisis (Gleick *et al*., 2002). The research explored the motivation behind the adoption of strategies of PPWMs and how this is impacting on the residents.

1.2 Problem statement

Globally, 783 million people do not have access to clean and safe water with 37% of those people living in sub-Saharan Africa (United Nations, 2015). The problem of limited access to water in the rural areas is partly due to the history of colonialism in the region. However, access to water has also become a major challenge in urban areas because of the rural to urban migration and the increase in poverty levels due to unemployment in urban areas. In the case of Namibia, water is a very limited resource because of the aridity of the country and largely depends on groundwater aquifers for water supply (Mendelsohn *et al*., 2013). As is the case with many developing countries, Namibia's urban water system is facing challenges such as increased demand due to urbanization, pollution of water sources, poor cost recovery and dilapidated infrastructure (Fjeldstad *et al*., 2005; Ndokosho *et al*., 2007).

In addition, Namibia's urban water suppliers are challenged by a low revenue collection due to unpaid water bills which consequently affects the quality of service delivery (Ndokosho *et al*., 2007). This is mainly due to a large proportion of low-income families living mostly in informal settlements. As such, municipalities are resorting to the installation of PPWMs, which self-disconnect households due to non-payment of water bills (Kastner *et al.*, 2005). Even though PPWMs have been introduced in several towns in Namibia, limited scientific studies have been done on the impact of PPWMs on the residents, socio-economic impacts and effects on implementing municipalities in small towns such as Aranos, Aroab, Bethanie Gibeon, Gobabis, Gochas, Grunau, Koes, Leonardville, Maltahohe, Outapi and Outjo to mention a few. This research analysed the motivation of installing PPWMs and the impacts that these PPWMs have on the livelihoods of the residents in Karibib, Swakopmund and Usakos towns in Namibia.

1.3 Study objectives

1.3.1 Main Objective

The main objective of this study was to investigate the impacts of prepaid water metering systems on the residents and local authorities in Karibib, Swakopmund and Usakos in Namibia.

1.3.2 Specific objectives:

1. To investigate the drivers for the installation of prepaid water meters in Karibib, Swakopmund and Usakos towns
2. To investigate the perceptions of residents, using prepaid water meters
3. To analyse the impacts of prepaid water meters on residents
4. To analyse the impacts of prepaid water meters on the local authorities in Karibib, Swakopmund and Usakos towns.

1.4 Justification

The Namibian Water Resources Management Act 11 of 2013, states that everyone has a right to equitable access to safe drinking water. The Act recognizes water an essential basic human right to support a healthy productive life and safe water should be available within a reasonable distance from their homes (Government of the Republic of Namibia, 2013b). The results from the study will help in developing an understanding of the impacts of PPWMs as a management instrument in urban water supply service in small towns. This study will investigate whether the PPWMs are increasing access and equity in water supply and therefore, how they are contributing towards the goal of Water Resources Management in Namibia as articulated by the Water Act of 2013. In addition, this research will show whether the SDG 6.1 can be achieved or not, with the introduction of PPWMs. SDG target 6.1 aims at "*By 2030, achieve universal and equitable access to safe and affordable drinking water for all*" (UN, 2015).

1.5 Structure of the thesis

The study consists of five chapters. Chapter One presents the introduction and general background to the study, the problem statement, objectives and justification of the study. Chapter Two outlines the literature review on prepaid water metering and water as a human right. Chapter Three presents a brief description of the study area and the methodology used for data collection and analysis. The results and discussion on the impacts of PPWMs in the selected towns are presented in Chapter Four. Finally, Chapter Five presents the conclusions and recommendations from the findings of the study.

2. LITERATURE REVIEW

This chapter provides a review of the literature on water as a human right, the water rights entitlements and the challenges experienced in achieving access to water. It also analyses the Integrated Water Resources Management (IWRM) approach as a possible solution to the challenges. Finally, the chapter ends with an in-depth analysis of the prepaid water metering system.

2.1. Human right to water

Water is the essence of life as there is no human activity that does not depend on water (Savenije, 2002). Safe drinking water and sanitation are vital to sustaining life and health, and fundamental to the dignity of all (Guisse, 2005). It is because of this realisation that in November 2002 the United Nations Committee on Economic Social and Cultural Rights (UNCESCR) declared that human right to water which "*entitles everyone to sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic uses*" – General Comment 15. Nonetheless, it was first declared a human right by United Nations Member States in the Mar del Plata Action Plan (1977) asserting that irrespective of the level of development, all people "have the right to have access to drinking water in quantities and of a quality equal to their basic needs" (Smets, 2000; Human Rights Council, 2007). In addition, the Agenda 21 confirmed the declaration, adopted at the United Nations Conference on Environment and Development in 1992 (United Nations Sustainable Development, 1992).

The UNCESCR requires State Parties to formally recognise the rights within their national legislation, to provide laws and regulations to fulfill these essential human rights (UNCESCR, 2003). Nevertheless, many countries have included the human right to water and to a lesser extent the human right to sanitation in their constitutions. These countries include: Bolivia, the Democratic Republic of the Congo, Ecuador, Indonesia, Senegal, South Africa, Uganda and Uruguay (Smets, 2000; De Albuquerque, 2011). Their constitutions ensure citizen's access to a sufficient amount of safe drinking water for personal and domestic uses. Personal and domestic uses are defined as water for drinking, personal sanitation, washing of clothes, food preparation, and personal and household hygiene (Smets, 2000; United Nations Office of the High Commissioner for Human Rights [UNOHCHR], 2010).

Namibia is signatory and ratified international and regional human rights. A National Human Rights Action Plan (NHRAP) for 2015-2019 was developed to tackle human rights problems. The themes for NHRAP range from health, education, housing, land, justice, discrimination; and water and sanitation. The overall vision on the NHRAP is "*the promotion and protection of human rights is the foundation for the delivery of its socio-economic development agenda, with guarantees for equality of treatment of all its citizens*" (Republic of Namibia, 2014). The vision for the right to water and sanitation is "*a Namibia where everyone has access to clean, affordable, acceptable water and suitable sanitation facilities*" (Republic of Namibia, 2014). The specific objectives are aimed at strengthening water and sanitation service delivery; improving research and information on water and sanitation; increasing education and awareness on water and sanitation; strengthening water and sanitation partnerships and coordination; to resource and fund water and sanitation services; and relevant legal and regulatory framework for water and sanitation service provision.

The right to water entitlements will be discussed below. These entitlements include access to a minimum amount of safe drinking water to sustain life and health; access to safe drinking water and sanitation in detention; and participation in water and sanitation related decision-making at the national and community levels (Smets, 2000; Guisse, 2005; Human Rights Council, 2007; UNOHCHR, 2010; De Albuquerque, 2011).

2.1.1 Access to water

According to the World Health Organisation (WHO) and United Nations Children's Emergency Fund (UNICEF) (2012), about 780 million people globally lacked access to clean water in 2010 and by 2015 the number had been reduced to 663 million (United Nations, 2015). Of the global population, 332 million people in Africa use unimproved water sources (WHO & UNICEF, 2015). The WHO/UNICEF Joint Monitoring Programme (JMP) defined basic water as water used for domestic purposes, drinking, cooking and personal hygiene (WHO, 2000).

According to WHO (2000), in order to have a basic access to 20 litres per day, the water source has to be within 1,000 metres of the home and collection time should not exceed 30 minutes. In addition, water must be available in the immediate vicinity of the household, educational institution, workplace or health institution (UNOHCHR, 2010). Access to a regular supply of water within the home also eliminates the need for women and children to spend time and physically exert themselves to collect water from distant sources (WHO & UNICEF, 2015).

In Indonesia, the standard for domestic water is 60 litres/person/day or 10,000 litres/head of family/month whilst for in South Africa 20 litres/per person/day (De Albuquerque & Roaf, 2014). However, the Namibian Water Resources Management Act 11 of 2013 (GRN, 2013) does not explicitly state the quantity of water but it states that everyone should have "*equitable access for all people to safe drinking water is an essential basic human right to support a healthy productive life*" and "*access by all people to a sufficient quantity of safe water within a reasonable distance from their place of abode to maintain life and productive activities*". In Namibia approximately 80 % of all households have access to clean drinking water (59 % in rural and 98% in urban areas), with majority the people have to walk a distance of between one to two kilometres to access the source of drinking water (Namibia Statistics Agency [NSA], 2012 and 2013).

The Namibian institutions responsible for water resources are divided into the following categories for ensuring efficient and effective management thereof:

- Ministry of Agriculture, Water and Forestry (MAWF) Directorate of Resources Management is responsible for the overall water resource inventory, monitoring, control, regulation and management;
- NamWater abstracts water from primary sources (e.g. rivers, aquifers or dams) and supplies bulk water to some end-users directly;
- Local Authorities and Regional Councils in urban areas purchase water from NamWater or supply water from own boreholes for delivery to end users. Water supply to urban areas;
- Commercial farmers, tour operators, mines and nature conservation (parks) are subject to appropriate agreements and licences from MAWF to supplying their own water;
- Directorate of Water Supply and Sanitation Coordination in the MAWF supplies water to rural areas.

2.1.2 Availability of water

According to Gleick (1996), accessibility to drinking water means that the drinking water source must be less than one kilometre from its place of use and it must provide at least 20 litres of water per person per day. According to WHO (2008), the intermediate consumption is 50 litres per day per person, which assures personal hygiene and food hygiene. The WHO, also states that 100 litres of water per person per day are needed in order for an individual to lead a healthy life (Howard & Bartram, 2003).

2.1.3 Safe and acceptable water

The water required for personal or domestic use must be safe, therefore free from micro-organisms, chemical substances and radiological hazards that constitute a threat to a person's health (WHO, 2008). The WHO Guidelines for drinking-water quality provide a basis for the development of national standards that, if properly implemented, will ensure the safety of drinking-water (De Albuquerque, 2011). According to the UNCESCR (2003) and UNOHCHR (2010), the water should be of an acceptable colour, odour, and taste for each personal or domestic use. In addition, all water facilities and services must be culturally appropriate and sensitive to gender, lifestyle and privacy requirements (UNCESCR, 2003).

In Namibia the water quality and bacteriological quality of drinking water have been grouped into four quality classes according to the Namibian Drinking Water Guidelines which are adapted from the WHO Drinking Water Guidelines (Department of Water Affairs [DWA], 1991 and 2000):

- Group A: water of an excellent quality and bacteriologically safe to drink;
- Group B: water of good quality which is suitable for human consumption;
- Group C: water of a low health risk on account of inorganic or bacteriological pollution, which requires immediate remedial action before it is safe to drink;
- Group D: water which has a high health risk and is unsuitable for human consumption.

Table 2.1 shows classification of improved and unimproved drinking water sources as were categorised by WHO/UNICEF JMP as indicators of monitoring MDGs. People who access water from unimproved sources are at risk of drinking contaminated water which may result in waterborne diseases such as cholera and dysentery among others. This situation has affected more than 1.5 billion people annually with the most affected being the poor and the vulnerable groups, such as the elderly, women and children (WHO & UNICEF, 2015).

Table 2.1: Classification of improved and unimproved drinking water sources

Improved sources of drinking water	**Unimproved sources of drinking water**
Piped water (into dwelling, yard or plot)	Unprotected dug well
Public tap/standpipe	Unprotected spring
Tubwell/borehole	Vendor-provided water
Protected dug well	Tanker truck
Protected spring	Surface water (river, stream, dam, lake, pond, canal, irrigation channel)
Rainwater collection	
Bottled water*	

*Bottled water is considered an 'improved' source of drinking water from an "improved" secondary source
Source: WHO & UNICEF, 2012

2.1.4 Affordable water

The human right to water concept states that water facilities and services should be affordable for all. No individual or group should be denied access to safe drinking water because they cannot afford to pay. The United Nations Development Programme (UNDP) suggests that water costs should not exceed three percent of household income (UNOHCHR, 2010). The affordability requirement also underlines that cost recovery should not become a barrier to access to safe drinking water and sanitation, notably by the poor (Guisse, 2005; Human Rights Council, 2007; De Albuquerque, 2011).

In Namibia there is a lack of coordination and/or guidelines between the tariffs charged by NamWater and that what is ultimately charged by the local authorities which are both gazetted by the Government (Republic of Namibia, 2014). This affects a great number of households due to the Namibian unemployment rate (27.4 % in 2014) which are alarmingly high with 56% for 15-19 years while 49% for 20-24 (Namibian Statistics Agency, 2015). The government of Namibia aims at subsidising local authorities and regional councils to strengthen water and sanitation service delivery through social tariffs to people lacking secure tenure, those facing economic barriers, and other vulnerable groups (Republic of Namibia, 2014).

Even though water is considered a basic right, not everyone has access to it. Among the reasons why governments fail to uphold this right is the fact that they do not have the financial resources needed to invest in water provision, especially to the poor. In addition, the water poor infrastructure and managerial loopholes have impeded this from happening.

2.2 Challenges of access to water

2.2.1 Water scarcity

There are many reasons why there is still no universal access to water and one of them is water scarcity. Food and Agriculture Organization (FAO) defines water scarcity as an excess of water demand over available supply of freshwater in a specified domain, under prevailing institutional arrangements and infrastructural conditions (FAO, 2012). Water scarcity is becoming a global problem due to freshwater resources facing increasing demands from population growth, economic activities, and industrialisation and, in some countries, improved standards of living. The pressure on water resources intensifies, leading to tensions, conflicts among users, and excessive pressure on the environment.

FAO's categorisation has three types of water scarcity. According to FAO (2012), physical water scarcity is more defined when there is not enough water to meet all environmental and human demands, with noticeable degradation of the environment, a decline in water resources and inequalities in water allocation. Economic water scarcity is described as a situation caused by a lack of investment in the water sector, and lack of human capacity to satisfy the demand for water. Three types of water scarcity are considered by World Bank (2007): scarcity of the physical resource, organizational scarcity, and scarcity of accountability. Organizational scarcity refers to "getting water to the right place at the right time". Accountability refers to governments accountable to their constituencies and service providers to their users (World Bank, 2007).

According to WHO and UNICEF (2008), Africa faces a situation of economic water scarcity because institutional, financial and human capacities for managing water are also lacking. The situation is exacerbated by competition for public funding between sectors, and heavy public debt burdens in most African countries (African Union, 2009). Studies indicate that increased urbanization and the development of more water-intensive activities have put stress on existing infrastructure (World Bank, 2011).

2.2.2 Poor water infrastructure

The infrastructure deficit is magnified by poor management, through poor maintenance, below-cost-recovery tariffs, and low collection rates (IMF, 2015). Several countries report that the quality of water resources is deteriorating due to contaminants, ranging from fertilizers to mining activities (Fogden, 2009). A good example is Lake Chivero in Zimbabwe. The lake was built in 1952 to supply the city of Harare with water (Makwara & Tavuyanago, 2012). Due to high levels of raw and partially treated domestic and industrial effluent discharged into the lake, leading to poor water quality in the lake. Due to high costs of treating the water and lack of financial resources by the city of Harare, the city's residents are now being supplied with poor water quality (Magadza, 2003; Nhapi, 2004). This situation caused an outbreak of cholera in 2008 resulting in more than 4,000 deaths (Makwara & Tavuyanago, 2012). Furthermore, because there is a limited investment in water infrastructure, not all residents in urban areas have access to water. And in most cities, there is no continuity of supply, and that results in citizens fetching water from contaminated sources.

Water service providers, particularly in developing countries, struggle with financial sustainability, as inefficient operations and low quality of service create a vicious cycle where dissatisfied users refuse to pay water tariffs, limiting the service providers' ability to maintain infrastructure effectively and causing service quality to decline (IMF, 2015). The case study conducted by Blantyre Water Board in Malawi indicated unaccounted for water levels for the utility ranged from 36 % to 47 % as compared to 25 % for developing countries (Kalulu & Hoko, 2010). As for Lusaka, Zambia, unaccounted for water was at 60 % in 1999 and at 50 % in 2003 (Ntengwe, 2004). To compound the problem, aging and corroded pipes lead to high water leakages contributing to high non-revenue water of water utilities. In addition, dilapidated sewer systems are contaminating waterways and drinking water. It has been shown that conventional approaches to urban water management for providing these essential services are costly, often inefficient, and are not integrated (Mohamed *et al*., 2010).

2.2.3 Population growth and urbanisation

In Africa, access to water is one of the major challenges facing the population, especially in sub-Saharan Africa where people spend more than half an hour per round trip to collect water often from unimproved sources (Doss *et al*., 2011). In developing countries, it is estimated that more than 80 % of untreated sewage is discharged into rivers, lakes, and coastal areas, thereby polluting these water bodies. Polluted water leads to approximately 840,000 deaths each year (WHO & UNICEF, 2015). It is also estimated that every minute a new-born baby dies from infections caused by a lack of safe water and an unclean environment (United Nations, 2015). All this is due to the fact that 42 % of African healthcare facilities do not have access to safe water (WHO & UNICEF, 2015).

Water scarcity in sub-Saharan Africa countries is aggravated by the highest prevalence of informal settlements of all regions, estimated at 55 % in 2014 (United Nations, 2015). It is projected that close to 60 % of the Namibian population will live in urban areas by 2030, an indication that rural-urbanization migration is taking place on a vast scale (NSA, 2012). The main drivers of urban growth in the region are: natural increase of population, the inclusion within city boundaries of peri-urban rural settlements and rural to urban migration, mainly moving from rural areas in search of work in industrial, commercial and mining towns. Informal settlers have limited or no access to water, sanitation and electricity. Access to water and sanitation services is unequal: piped water is available primarily to upper-income residents, while the poor rely on untreated wells and surface water (World Bank, 2011). In southern African, countries such as Mozambique and Angola have more than 80 % of the urban population living in informal settlements on the edges of the cities (Leduka, 2010). These people lack access to safe water for basic needs when water should be treated as a human right. Thus, the human right of these poor people is being infringed upon by their governments.

2.3 Integrated Water Resources Management as a possible solution to access to water

The Global Water Partnership (GWP) (2000) defines water governance as the range of political, social, economic and administrative systems that are in place to develop and manage water resources, and the delivery of water services at different levels of society. Thus, Integrated Water Resource Management (IWRM) is aimed: at promoting more equitable access to water resources and the benefits that are derived from water in order to tackle poverty; to ensure that scarce water is used efficiently and for the benefit of the greatest number of people; and to achieve more sustainable utilisation of water, including for a better environment.

The concept of IWRM was introduced as a way of trying to improve water resources management, address the global water problems and working toward a sustainable future for water management given the shortcomings with traditional Water Resources Management (WRM) approaches. The GWP (2000), defined IWRM as a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare benefits in an equitable manner without compromising the sustainability of vital ecosystems.

According to the GWP (2000) the four Dublin Principles are the cornerstone of IWRM:

1. Freshwater is a finite and vulnerable resource essential to sustain life, development and the environment;
2. Water development and management should be based on a participatory approach, involving users, planners and policymakers at all levels;
3. Women play a central part in the provision, management and safeguarding of water;

4. Water has an economic value in all its competing uses and should be recognised as an economic good.

According to Scanlon *et al.* (2004), the Dublin Principle number 4 explicitly reaffirmed the human right to water by stating that: "…it is vital to recognize first the basic right of all human beings to have access to clean water and sanitation at an affordable price". Treating water as an economic good entails allocating water to its highest value and moving towards full cost pricing to encourage rational use and recover the cost. Two schools of thought of water as an economic good have been identified by Van der Zaag and Savenije (2006). The first school maintains that water should be priced at its economic value where the market ensures that the water is allocated to its best uses. The second school interprets the same principle to mean the process of integrated decision-making on the allocation of scarce resources, which does not necessarily involve financial transactions alone.

If one adopts the second interpretation of the principle, this means that implementing IWRM Principle 4 entails recognizing the human right to water and sanitation at affordable prices but not ignoring the economic perspectives as it aims to achieve efficiently and equitable use of water resources. According to Veiga da Cunha (2009), where water is limited, economic tools ought to determine how limited water resources are to be distributed efficiently and equitably. In addition, managing water as an economic good is essential to achieving financial sustainability of water service provision by pricing water at levels that guarantee full cost recovery (Veiga da Cunha, 2009).

Most countries within southern African regions have adopted IWRM plans to try to improve the management of water resources by adopting the concept of promoting efficiency, equity and sustainability of water resources. However, the adoption of IWRM has not been totally beneficial to the management of water in urban areas as many residents still do not have access to drinking water. Below water sector reforms in line with IWRM will be discussed. The different Water Acts governs the use of water in a country, whereby the water belongs to the State in countries such as Namibia, South Africa and Zimbabwe.

2.3.1 Namibia

The Namibia's Water Act No. 54 of 1956 was replaced by the Water Resources Management Act (No.11 of 2013) which classified water resources as a national asset and provides a modern legal framework for managing water resources based on the principles of IWRM. The Act established Basin Management Committees (BCMs) (DWA, 2000; MAWF, 2000; MAWF, 2008; GRN, 2013). The role of a BMCs is to provide scope for addressing various issues affecting water resources in the basin, ranging from efficient water use to monitoring the health of the basin. The purpose of the Water Act is to control the use and conservation of water for domestic, agricultural, urban and industrial purposes (GRN, 2013).

2.3.2 South Africa

In South Africa, Water Act (Act 36 of 1998) provides for the establishment of new water management institutions at local levels. These include Catchment Management Authorities (CMAs) and Water User Associations (WUAs) (Chikozho, 2002). The Act also created compulsory national water quality and supply standards, standard water tariffs, and regulations for water services providers to follow in order to provide a framework for the local government to provide efficient, affordable, economical, and sustainable access to water services (Cohen *et al*., 2010).

2.3.3 Zimbabwe

In Zimbabwe, the Water Act of 1976 was amended and the Water Act of 1998 (Chapter 20:24), established the Zimbabwe National Water Authority (ZINWA). The water management has been decentralized to stakeholder-managed Catchment Councils (CCs) and Sub-Catchment Councils (SCCs). The 1976 Water Act was intended to protect the interests of commercial farmers as a water right were issued in perpetuity on a first user's basis (Makurira, 2003).

All the three new regulations on water in Namibia, South Africa and Zimbabwe emphasize stakeholder participation in water utilization and management in line with the Dublin Principle 3. The idea behind this approach is to enhance greater participation at all levels, thereby increasing the sense of ownership among users and promoting the sustainable and efficient use and environmental protection. Stakeholder participation at all levels (i.e. water affairs government departments, water suppliers, prepaid water meter users, prepaid water meter suppliers) can potentially improve access to water as the marginalised are given a voice in water resources management.

IWRM appears not to have brought the benefits it was thought would bring to different water users, especially the marginalised section of society. However, although most countries within southern Africa have adopted IWRM, there has not been much change in access to water by the poor which can be attributed to IWRM. This made it clear that there is need to look at other ways by which access to water can be increased.

2.4 Privatization of urban water supply

The privatization of social services is a policy that the World Bank, IMF and some water organizations like the World Water Council is promoting in developing countries and leaned on many governments to adopt the same philosophy in the 1980s (Adejumobi, 1999; Rahaman & Neu, 2003). Privatization in the water sector involves transferring some or all of the assets or operations of public water systems into private hands (Gleick *et al*., 2002). These assets include production, distribution, and management of water or water services. The World Bank supports water privatization by Corporate Accountability International (CIA) (2012):

1. Providing financing that becomes a primary catalyst for more funding for water privatization;
2. Serving as an advisor to borrower governments;
3. Funding and disseminating research that promotes private sector solutions; and
4. Running and marketing campaigns promoting privatization

Privatization of water managements services is a major global trend, and is based on the notion that systems of public sector control of scarce resources are likely to be far less efficient than privately run entities (Gleick *et al*., 2002). The poor performance of public sector social services, according to the World Bank, impose high costs on industry and the economy generally, as substitutes have to be developed by private firms to those services (Adejumobi, 1999). In addition, public utilities tend either to make water available for free or at below market cost and therefore fail to provide adequate economic disincentives against overconsumption and virtually guarantees long-term depletion of resources (Canadian Catholic Organization for Development and Peace [CCODP], 2005; Jammal & Jones, 2006; Olleta, 2007). Although, privatization of state-owned enterprises in developing countries are essential for improvement in the operations, the privatization of essential services of water services could lead to serious consequences in the poverty-stricken countries.

Critiques of privatisation (Public Citizen, 2003; Loftus, 2006; Harvey, 2007; von Schnitzler, 2008; Fazel-Ellahi, 2010; Murthy, 2013; Hellberg, 2015) are of the opinion that there is a lack of common principles or guidelines around the subject of water privatization and as a result, there is rapidly growing opposition to privatization proposals from local community groups, unions, human rights organizations, and even public water providers (Gleick *et al.*, 2002). Most of the opposition against water privatization arises from concerns over the economic implications of privatizing water resources, the risks to ecosystems, the power of corporate players, foreign control over a fundamental natural resource, inequities of access to water, and the exclusion of communities from decisions about their own resources (Gleick *et al*., 2002). Several protests against water privatisation have occurred in Bolivia, Paraguay, South Africa, and the Philippines (CAI, 2012). Below the case of Bolivia will be discussed.

The Bolivian government privatised water system of Cochabamba in 1999, the third largest city in Bolivia, partly in response to making structural adjustments to the economy (CAI, 2012). A consortium of companies was granted a 40 year concession by the Bolivian government to run the water system (Gleick *et al*., 2002). The Italian and United States-based private company modified the rate structure, putting in place a tiered rate and rolling in previously unrecovered debt which led to residents receiving increased water bills. Moreover, residents needed to purchase permits to collect rainwater which threatened access to water for the poorest residents.

In 2000, residents organised a protest leading to the government declaring martial law and the Bolivian army killing nine people and over 170 protesters were injured (Gleick *et al*., 2002; CCODP, 2005; CAI, 2012). In the end, the government gave in and canceled its contract with private company Aguas de Tunari. Notably, such cancellation of contracts has also taken place in other countries such as Argentina, China, Colombia, France, Gambia, Germany, Mali, South Africa, Tanzania, Turkey, United State of America, Uzbekistan and Vietnam (CAI, 2012).

2.5 Prepayment in the water sector

Prepayment method is used by service providers of electricity, gas, telecommunication and water to charge their customers before they use the services. There are approximately 20 million prepayment meters installed in the world. A prepayment metering system, according to Kettless (2004) as cited in Makanjuola *et al*. (2015), basically comprises a system master station, a vending machine and prepayment energy meters or dispensers as shown in *Figure 2.1*. Prepaid water metering technology is a water resource management innovation (Kumwenda, 2006). A prepayment system comprises the prepaid dispensing devices, the technology required to load and transfer credit, a database recording customer purchases and metered consumption, and ongoing engagement with customers as shown in *Figure 2.2*. Water meters are used to measure the volume of water consumed by residential and commercial buildings supplied by public water supply systems.

Pre-Paid Water Meters (PPWMs) charges are based on consumption which entails consumers paying before consuming water by purchasing a card, or recharging the card (Georges, n.d; Kumwenda, 2006; Harvey, 2007; Quayson-Dadzie, 2012; Tuovinen, 2013). To draw water a card or token is inserted in the meter box and water is then collected into a portable container. As water is drawn, the balance on the card is adjusted automatically and the remaining credit is displayed.

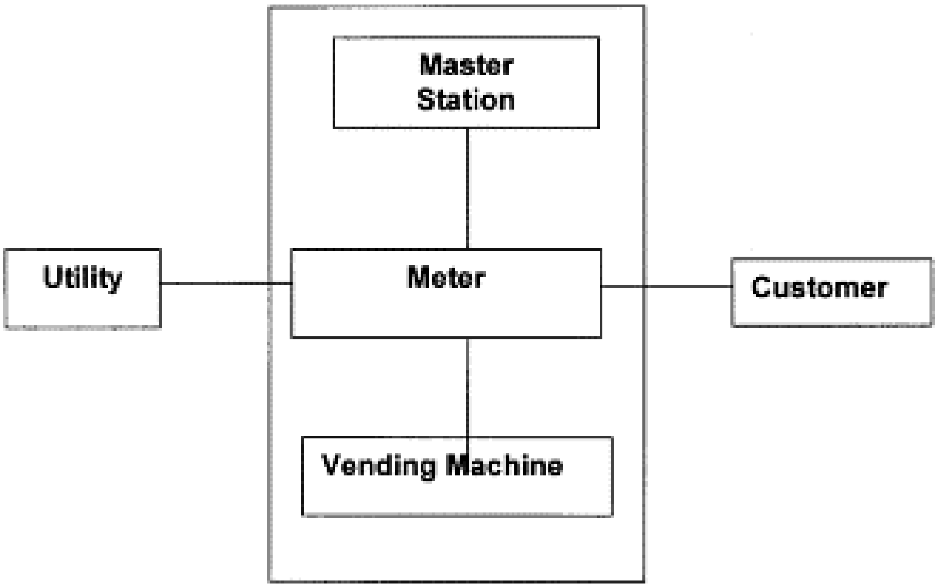

Figure 2.1 Prepaid metering system

Source: Chisanga, 2006

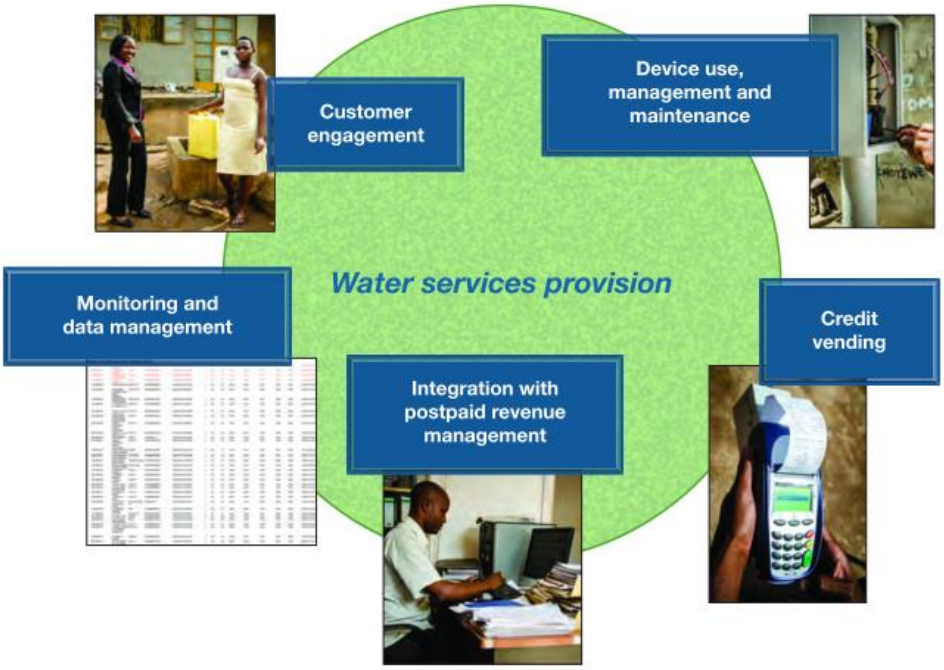

Figure 2.2: Components of a prepaid water metering system

Source: Heymans *et al*., 2014

There are many successful stories of the implementation of prepayment of electricity across many African countries thus encouraging demand for prepaid water (Heymans *et al*., 2014). As an example, Maxwell *et al.* (2015) examined the prepaid metering system of the Electricity Company of Ghana and the study showed that there was a significant increase in the company's revenue collection from the customers. In addition, there was a strong shift by consumers towards energy conserving attitude and behaviour. According to Heymans *et al*. (2014), there are three reasons as to why water prepaid lags behind electricity prepaid as shown in *Box 2.1*. The Bulawayo Progressive Residents Association (BPRA) noted the difference between the prepayment of electricity and water in that electricity has substitutes such as candles, firewood, gas stoves, paraffin and solar that people without money to purchase electricity can use. However, water does not have a substitute *"there is no alternative, there is no choice"* (Savenije, 2002).

Box 2.1: Why prepaid water meters lag behind electricity prepaid meters

Three main issues:

- PPWMs face physical stresses that do not apply to electricity. There are more moving parts, most subjected to fluctuating pressures and flows, and wear, fatigue, and abrasion increase the likelihood of malfunction. Grit, debris, and air affect water metering in ways that are not relevant to electricity. Any moisture can cause malfunctioning in the electronic circuitry. Plus, PPWMs need their own individual energy source, and finite battery life limits what they can do. All of these issues make prepaid water a less reliable technology than prepaid electricity.
- The electricity sector is much less fragmented than the water sector. For more than two decades, manufacturers of prepaid electricity equipment that want to serve particular markets have had to conform to standards and specifications that allow utilities to mix and match components. This has driven competition, with price and quality improvements. Conversely, proprietary systems still dominate the prepaid water market.
- Prepaid water is often seen as controversial. Payment for the supply of electricity is accepted more widely than payment for water, and access to electricity is not regarded a basic human right. There are no substitutes, such as candles or charcoal, for households that run out of water and cannot buy more.

Source: Heymans *et al.*, 2014

2.5.1 Advantages of prepaid water meters

Studies show that prepaid system benefits the municipalities and utility corporations by improving its profits, reducing consumers' bad debts associated with post-paid and thus improved customer relations (Harvey, 2007; Heymans *et al*., 2014). As an example, studies by Bond & Dugard (2008), Plaatjies (2008), and Odeku & Konanani (2014) stated that in South Africa there are three reasons that led to the introduction and implementations of the pre-paid water meters namely:

1. the need to administer free basic water in a cost-effective manner;
2. the need to recover the costs of providing water in order to ensure financial sustainability; and
3. growing concerns over water scarcity which required the conservation of water.

With the prepaid metering system, the safety of the corporation's employees is not compromised as meter readers are exposed to dangers like being mauled by a dog, weather hazards, among others, as well as the perception of intrusion in customers' privacy (Jain, 2011). *Table 2.2* shows a summary of the advantages of PPWMs for both the customers and the local authorities or implementers of PPWMs.

Table 2.2: Advantages of prepaid water meters for local authorities and PPWM users

For local authorities	**For PPWMs users**
Improve revenue as it raises payment levels, improve cash flows and avoids bad debts	No water debts owed to the local authorities
Promotes water conservation and reduce wastage	Raises awareness of water consumption
Improves equity as water is provided to poor customers using standpipes by cutting out intermediaries	Pays for consumed water only
Improved customer service–providing more control in the hands of the consumer.	No disconnections by local authority due to non-payment of water bills
Maximize collection as it helps minimise staff and customers conflicts with misread meter readings and debts control	Leaks are detected by the system and can be addressed earlier
Improves accountability of local authority to the customers	Encourages water conservation as customers avoids leaks and water wastage
Improve customer confidence and willingness to pay for water services	No questionable bills from meter readings errors
Reduces administration costs by reducing billing queries from estimates, human error, and disputed bills can annoy customers which create extra work for utility staff and delay payment	No water disconnections by the local authorities due to non-payments

2.5.2 Disadvantages of prepaid water meters

The implementation of any technology has challenges, and the pre-paid water meter system also has a number of challenges for both the implementers and customers. The significant worry with paid ahead of time metering is that the meter would not convey water unless there is water credit on the card/token/tag. In the event that buyers neglect to add credit to their card or if their wage is to a great degree low, they cannot buy credit and hence have no access to water.

Studies indicate that the implementation of PPWMs entrenches social inequality and poverty in society; as the rich use more water as there are able to pay for it (McClune, 2004). According to Moore (2008), the two biggest barriers to prepaid metering in the North America market have been the high cost of meter as customers have to pay between US$225 - US$400 per installation. In addition, it is viewed as economic discrimination in terms of racial, social or cultural profiling. The poor have to consider their consumptions, hindering their water requirements and productive water use for improving their livelihood strategies. Productive use of water includes uses such as brewing, animal watering, construction and small-scale horticulture (Howard & Bartram, 2003). An aspect of good neighbourliness is lost in cases where PPWMs are introduced this is because water is likely to be treated as an individualized market commodity thereby largely excluding the poor from accessing it (von Schnitzler, 2008; Aubriot, 2013).

Heymans *et al*. (2014) conducted a study in eight African cities (Kampala, Lusaka, Maputo, Maseru, Mogale City, Nakuru, Nairobi, and Windhoek) revealed that there are three types of meters installed in Africa (standpipe, household individual and for large institutional users). The study found that standpipe users perceived water to be cheap (through direct access to utility tariffs) and more self-sufficient. Whilst the individual connections the respondents have more control over their water consumption and expenditure, better management risk avoiding water debts and disconnections due to non-payment.

Heymans *et.al* (2014) stated that prepaid standpipes are not the solution to the low-income households in the challenges facing providing services. The study recognizes that the technology is susceptible to faults (hardware and software) and are expensive to install. They argued that the prepaid water technology should not be seen as violating human rights because of the inconveniences in such as running out of water credit or when they face challenges when unable to purchase water units.

Studies (Harvey, 2007; Heymans *et al*., 2014) criticisms the installation of PPWMs in the mostly low-income household (poor) than affluent households and large institutional users. The low-income households use less water than the affluent households, as an example, the water consumption volume of the affluent households is high as they live in luxury (swimming pool, washing machines, large gardens, water fountains). As for the no income or low-income households were some are in informal settlements are negatively affected as they first need to purchase water in advance.

The cost-recovery potential of prepaid meters is not as straightforward as many of their protagonists assume. Prepaid meters bring their own set of problems: the high cost of installation; the fact that meters can develop faults that deliver free water or can be bypassed or vandalized when monitoring and follow-up action are neglected, which opens the way for high Non-Revenue Water (NRW) losses; technical shortcomings, including inaccurate readings when water pressure is variable; and so on. In addition, the opportunity cost of big investments is high, as the real working life of prepaid meters is only about five to seven years, compared to the estimated 15 to 20 years for conventional meters.

2.5.3 Prepaid water meters case studies

2.5.3.1 South Africa

The Johannesburg City in 2002 launched *Operation Gcin'amanzi* "Operation Conserve Water" in Soweto. The aims were to reduce water losses and demand, rehabilitate the water network, and improve the rate of payment (Harvey, 2007; Odeku & Konanani, 2014). The project was first implemented in Phiri Township in Soweto where the majority of residents survived on government grants and could not afford to spend any money on water particularly within low-income households (Harvey, 2007; Bond & Dugard, 2008). The residents were forced to accept either pre-paid water meters or standpipes as the only options or suffer a complete disconnection of their previous water supply (Bond & Dugard, 2008).

The situation was aggravated by the lack of communication to residents to install the prepaid water meters. This led to the Johannesburg water officials disconnecting power and water to more than 20,000 households per month. As a result, the court case of City of Johannesburg and Others v Mazibuko and Others, (3) South Africa 592 Supreme Court of Appeal of 2009 was submitted. The residents of Phiri instituted an action in court to challenge the City of Johannesburg's Free Basic Water policy in terms of which six kilolitres of water are provided monthly for free to all households (Bond & Dugard, 2008; Odeku & Konanani, 2014). In addition, the court ruling ruled that it was unlawful for the installation of pre-paid water meters in Phiri under *inter alia* the Water Services Act and the City's Water Services By-laws (Harvey, 2007; Bond & Dugard, 2008; Aubriot, 2013; Odeku & Konanani, 2014).

Although privatisation offered the hope that private investors could come into the water sector and increase access to water, this has not been the case. Where water has been privatised access to water has even become compromised for the poor, as the case of Cochabamba has shown. There is, therefore, a continuous search for a solution to the problem of access to water. It is in this context that PPWMs are being introduced.

2.5.3.2 Namibia

Namibia is the driest country in sub-Saharan Africa and depends largely on groundwater. With an average rainfall of about 350 mm per annum. The Constitution of the Republic of Namibia is the primary law for sustainable resource management and equal distribution of water to the people. Specific documents dealing with water management include the: Water and Sanitation Policy of 1993; Namibia Water Corporation Act of 1997; National Water Policy White Paper of 2000.

The MAWF is responsible for rural water supply and to oversee, regulate and permit bulk water supply delivered by NamWater to major users. NamWater is responsible for the supply of water to the bulk users like towns, industries, mines and the Directorate of Rural Water Supply that supply water to rural areas. NamWater was set up in 1997 as a commercialized water corporation under the supervision of the MAWF. Non-revenue water accounts for a low share of NamWater resources, but losses are much higher for most municipalities. Municipalities with non-revenue water of 20 % or higher account for 37 % of municipal water distribution, while in seven towns, non-revenue water exceeds 60 %.

Studies conducted in Namibia by Kurvers, 2003; Kastner *et al*., 2005; Saes, 2012; and Tuovinen, 2013, shows that PPWMs have been introduced with Windhoek being the pioneer. The other towns were the PPWMs are installed are: Aranos, Aroab, Bethanie Gibeon, Gobabis, Gochas, Grunau, Henties Bay, Kamanjab, Karibib, Katima Mulilo Keetmashoop, Khorixas, Mariental, Okahandja, Omaruru, Oshivelo, Otavi, Otjimbingwe, Otjiwarongo, Outapi, Outjo, Rehoboth, Rundu, Stampriet, Swakopmund, Tsumeb, and Usakos. In Windhoek, prepaid water metering has proven to be a successful method of addressing non-payment and ensuring revenue collection. However, the current system poses the significant but addressable risk that those who cannot afford water will not have access to it.

According to African Economic Outlook (2007), regional and local authorities were in arrears to NamWater for their bulk water purchases with an estimate over N$400 million (US$27 million) in 2005. Ngatjiheue (2015) reported that NamWater in its 2014/15 financial year is owed approximately N$300 million (US$20 million). In the 2013/14 annual report, Katima Mulilo, Rehoboth and Rundu Towns were reported to be the biggest debtors. This is due to failure to collect payments from local users. To fight the problem of outstanding arrears on user accounts, in 2003 some towns started installing prepayment water meters.

3. MATERIALS AND METHODS

This chapter describes the: study area, research instruments, data collection procedures, data analysis, and finally, considers sources of error in the data collection methods.

3.1 Description of study area

Namibia is located in the south-western part of Africa and shares borders with Angola in the north, Zambia to the northeast, Botswana to the east, South Africa in the south and the Atlantic Ocean in the west (*Figure 3.1*). The total surface area of Namibia is 824 292 km^2 (Mendelsohn *et al*., 2013). According to the national census of 2011, Namibia's population is about 2.1 million, of which 43 % live in urban areas and 57 % in rural areas (National Planning Commission [NPC], 2012). Namibia is divided into 14 administrative divisions or provisional boundaries called Regions (*Figure 3.1*).

Figure 3.1: Map of Namibia

Source: National Online Project, 2016

The study was conducted in Erongo Region which has an area of 63,539 km^2, a population of 150 809 and a population density of 2.4 people per km^2 (NSA, 2012). The main languages spoken at home as a percent of households are: Oshiwambo 39 %, Afrikaans 20 %, Nama-Damara 19 %, Otjiherero 10 % and 12 % constitutes of other languages (NSA, 2012). Swakopmund is the capital town of Erongo Region. The study areas were Karibib, Swakopmund and Usakos towns (*Figure 3.2*).

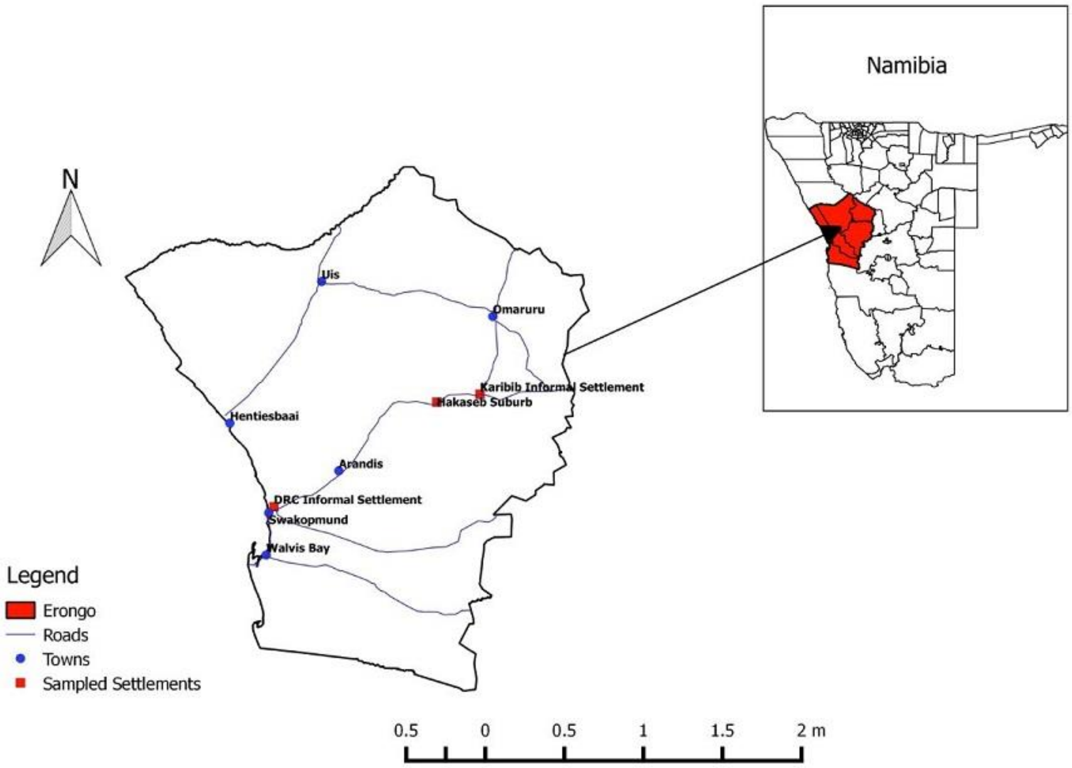

Figure 3.2: Study area map in Erongo Region

Namibia has an average annual summer rainfall of about 285 mm, ranging from less than 100 mm in the west to 600 mm in the northeast (Dirkx *et al*., 2008). The Erongo Region's average annual rainfall is between 15 to 300 mm. The annual average temperature is 19 - 20 ^{o}C with between 3,000 – 3,200 mm per annum as the average annual evaporation in the Region. The average hours of sunshine range between 9-10 hours per day. The Erongo Region has four ephemeral rivers, which are the Khan, Omaruru, Swakop and Ugab River. The towns of Karibib and Usakos are characterised by scanty shrubs and trees are found along the riverbeds. NamWater the national water utility is responsible for the supply of water to the bulk users like towns, industries and mines. Hence, the local authorities provide water and municipal services to the residents.

Erongo Region has six towns that have introduced PPWMs namely: Henties Bay Municipality, Karibib Town Council, Omaruru Town Council, Otjimbingwe Village Council, Swakopmund Municipality and Usakos Town Council. Purposive sampling was used to select the three case study towns in Erongo Region. The towns of Karibib, Swakopmund and Usakos were selected as there have PPWMs installed in their towns and the towns are within Erongo Region. Below further details are provided for the study areas.

3.1.1 Karibib

Karibib is the district capital of the Karibib electoral constituency. It has a population of about 5,000 inhabitants and covers an area of 103.6 km^2 (NSA, 2012). Karibib is a mining town with a gold mine and aragonite marble quarries situated near Karibib. Karibib does not only accommodate miners but also Air Force workers from the Karibib Air Base, which is the headquarters of the Namibian Air Force.

Karibib is situated along the Khan River, which is a water source for the town. Water is supplied by NamWater from the Karibib reservoirs and boreholes by the Karibib Town Council to the residential and industrial customers. However, the mines are supplied directly by NamWater.

3.1.2 Swakopmund

Swakopmund is situated on the coast of Namibia in the Namib Desert and covers 213 km^2 (Robertson *et al*., 2012). The growth of Swakopmund began significantly in 1970 with uranium exploration in the Rössing area and has increased steadily over the years (United Cities and Local Governments, 2014). The town has a population of about 44,700 as of the census of 2011 (NSA, 2012). The municipal council has been in existence for over 105 years while the new local government system has existed since post-independence in 1990 (United Cities and Local Governments, 2014). The major economic sectors of Swakopmund are tourism, fishing, mining and construction.

The climate of Swakopmund is dominated by extreme aridity, cool temperatures, southerly winds and frequent fogs due to the influence of the cold Atlantic water (Klintenberg *et al*., 2007). Although rainfall is extremely rare, with averages less than 20 mm per year, fog occurs at Swakopmund about 125 days each year, usually during the mornings and evenings (Robertson *et al*., 2012). The highest frequencies of fog are between September and December.

Water in Swakopmund is sourced from the Kuiseb River aquifer, Omdel aquifer in the Omaruru River and AREVA desalination plant at Wlotzkasbaken (Erwin, 2016). Increased demand for water is being experienced as a result of the expanding town and increased uranium mining in the surrounding area. The Swakop River groundwater resources are in Group D as they naturally have high salinity which is not suitable for human consumption and irrigation of most vegetables (Ayers, 2011 ; Fallis, 2013). Nevertheless, they support a thin line of woodland vegetation which acts as a linear oasis across the central Namib (Jacobson *et al*., 1995).

3.1.3 Usakos

Usakos, a town of 60.8 km^2 is found in Karibib Constituency and it has a population of about 3600 inhabitants (NSA, 2012). The town was founded in the early 1900's as a workshop and watering station for the trains on the Trans-Kalahari Highway, the main road between the port of Walvis Bay and Johannesburg in South Africa. During the apartheid time, the town was racially segregated with the townships of Hakaseb and Erongosig situated on the town's outskirts. Unlike other Namibian towns, Usakos has not seen substantial development since independence in 1990. The current unemployment rate in Usakos is around 60 % with high poverty rate and alcohol abuse (Ihuhua, 2012). The town center uses a borehole whilst water is purchased in bulk from NamWater and supplied to the town's outskirts.

3.2 Methodology

This study used both qualitative and quantitative research methods. Qualitative research is a method of inquiry employed in many different academic disciplines, traditionally in the social sciences, but also in market research and other contexts (Denzin *et al*., 2005). Qualitative research is useful for studies at the individual level, and to find out, in depth, the ways in which people think or feel. In this study, key informant interviews and Focus Group Discussions (FGDs) were conducted in acquiring qualitative data. Quantitative research gathers data in a numerical form which can be put into categories, or in rank order, or measured in units of measurement (Denzin *et al*., 2005). Quantitative data were collected using a household questionnaire survey.

3.2.1 Research design

Broadhurst *et al.* (2012) defined research design as the structure of enquiring. Parahoo (2014) describes a research design as "a plan that describes how, when and where data are to be collected and analysed". This is done to increase the valid answers to the research question. The study used a case study approach as the municipalities and residents that use PPWMs were the main sources of data in the selected towns. According to Zainall (2007), the case study method enables researchers to closely examine the data within a specific context as it provides in-depth information on individuals. Moreover, Breakwell *et al*. (2004) and Zainall (2007) stated that the case study method has advantages that:

- Provides better insights into the detailed behaviours of the subjects of interest;
- The examination of the data is most often conducted within the context of its use within the situation in which the activity takes place;
- Variations in terms of intrinsic, instrumental and collective approaches to case studies allow for both quantitative and qualitative analyses of the data; and
- The detailed qualitative data helps to explain the complexities of real life situations which may not be captured through survey instruments.

However, case studies have been criticized for their lack of rigor and the tendency for the researcher to have a biased interpretation of the data (Zainal, 2007). In addition, the method's dependence on a single case exploration makes it difficult to reach a general and inclusive conclusion (Tellis, 1997). This research is a case study of the Karibib Town Council, Municipality of Swakopmund and Usakos Town Council.

3.2.2 Sampling

Non-probability sampling is a technique which draws a sample in a way that does not give every member of the population a known chance to be included. Purposive sampling is a non-probability sampling technique, its goal focuses on characteristics of a specific population under investigation (Palys, 2008). Purposive sampling was used to select the three towns under study, Karibib, Swakopmund and Usakos in Erongo Region. In addition, another non-probability sampling, snowball sampling a technique that is appropriate to use in research when the members of a population are difficult to locate (Watt & Van den Berg, 2002). Both purposive and snowball sampling were used to identify key informants and gather sources of other relevant and insightful information. Snowballing sampling technique entailed was used to identify the local authority personnel that deals with the PPWMs, the community leaders, the PPWM suppliers and prepaid water vendors.

Systematic sampling a probability sampling technique relies on arranging the target population according to some ordering scheme and then selecting elements at regular intervals through that ordered list (Watt & Van den Berg, 2002; Teddlie & Yu, 2007). Convenient sampling is a selection of units based on their ease of accessibility (Watt & Van den Berg, 2002). Systematic convenience sampling was used to select households that use PPWMs by skipping every fourth household. Only households willing to participate in the questionnaire survey were interviewed. Therefore, convenient sampling was further used in cases were no households did not participate. Convenient sampling is a selection of units based on their ease of accessibility (Watt & Van den Berg, 2002). The selection of participants in the FGDs was through random sampling from the residents that use PPWMs in Swakopmund and Usakos informal settlements.

3.2.3 Sample size calculation

The *Equation (1)* was used to calculate the sample size at a 93 % confidence interval and a precision level of 0.07. This was also based on cost and time considerations.

$$n = \frac{N}{1+N\,(e^2)}$$

Where n = sample size

N= population size

e = level of precision

The population at the Usab informal settlement in Karibib was not known and only 14 households were interviewed. Swakopmund Democratic Resettlement Community (DRC) informal settlement has an approximation of 10,000 people thus, the sample size was 199 households. As for Usakos the sample size was 119 households of a population estimate of 2,500 people.

Table 3.1 below indicates that the total number of households sampled per town. A total of 321 household questionnaires that were administered with 40 questions per questionnaire. The questionnaires were administered by the interviewer and where necessary, a translator was used to translate to the interviewee during the surveys. Systematic convenience sampling was used to select the households, going to different streets and different areas that use PPWMs, either the domestic in Usakos and communal standpipes in all the three towns.

Table 3.1: Number of sampled households per study site

Study site	Data collection period	Number of sampled households
Karibib informal settlement	17 February 2016	13
Swakopmund DRC informal settlement	13-24 January 2016	199
Usakos Hakaseb suburb	08-14 February 2016	66
Usakos Usab informal settlement		43
	Total	321

3.3 Data collection instruments

A mixed method approach was used to collect both quantitative and qualitative data. This involved household survey, FGDs, key informant interviews and observation. These techniques were used as they provide direct evidence about similarities and differences in the participant's opinions and experiences to reaching conclusions. The data was collected during working hours, after working hours and during weekends.

3.3.1 Household questionnaire

A semi-structured household questionnaire was used to collect qualitative and quantitative data for the study. The design of the questionnaire included both open-ended and closed-ended questions to accommodate the views of the participants in the survey which further enabled the researcher to evaluate the results and provide objective judgment (Driscoll, 2011).

A pilot survey was conducted to pre-test the instrument in order to remove ambiguity, errors and bias in the survey instrument were reduced by first pretesting the questionnaire. The pre-test took place on the 12th January 2016 in Swakopmund DRC informal settlement. The pre-test exercise revealed that the piloted questionnaire had too many questions and this made the respondent lose concentration. The piloted questionnaire was then revised and the following three sections were formulated (*Appendix 1: Household questionnaire*):

1. Section A covered socio-demographic characteristics of the respondents such as the education level, occupation and monthly income of the head of household as well as the size of their household.

2. Section B was designed for standpipe prepaid water meter users only. It enquired about the time away from the household and closest functioning standpipe. In addition, it investigated the time spent at the standpipe waiting to withdraw water.
3. Section C focused the change general prepayment water system for both the individual and standpipe users of PPWMs. Water use changes after the installation of PPWMs, money spent on purchasing of water, the purchasing of water units, alternative water sources, training provided on the use of the meters, benefits and challenges have with the PPWMs.

3.3.2 Focus Group Discussions

Focus Group Discussions (FGDs) are a semi-structured data gathering method in which a purposively selected set of participants gather to discuss issues and concerns based on a list of key themes drawn by the researcher (Kumar, 1987). According to Morgan (1997) focus group projects most often (a) use homogeneous strangers as participants, (b) rely on a relatively structured interview with high moderator involvement (c) have six to ten participants per group, and (d) have a total of three to five groups per project. These FGDs applies the Morgan rule, however, the homogeneous strangers rule was not applied as it included both males and females. In all, FGDs allow for in-depth discussion of issues related to a topic that cannot be acquired from a survey instrument. FGDs are also used to verify information obtained from the survey and also for triangulation purposes.

Qualitative data was collected through FGDs and this was used to supplement the quantitative data. In addition, FGDs were used to gain an in-depth understanding of the community's view on PPWMs. One FGD was conducted in Swakopmund DRC informal settlement and two FGDs in Usakos in Saamstan and Ongulumbashe informal settlements. All the FGDs were heterogeneous as indicated in *Table 3.2*. As for the individual PPWM users in Usakos and standpipe PPWM users in Karibib, FGDs were not conducted due to the unwillingness of community members to attend the FGDs.

Table 3.2: Focus Group Discussions in the Swakopmund and Usakos towns

Study site	Date	Participants Sex	
		Male	**Female**
Democratic Resettlement Community, Swakopmund	13 January 2016	6	6
Saamstan informal settlement , Usakos	13 February 2016	7	4
Ongulumbashe informal settlement, Usakos	13 February 2016	4	6

The thematic questions asked in the FGDs (*Appendix 2: Focus Group Discussion guide*) focused on: stakeholder participation of PPWM users in the introduction of PPWMs; the process of owning a water token, water purchasing place, changes in water use patterns; perceived impacts on your households and community, and positive and negative perceptions of customers toward the use PPWMs.

3.3.3 Key informant interview

Key informant interviews were conducted for the purpose of collecting qualitative information. Interviews were held with a from a wide range of people such as community leaders, officials from the local authorities, or residents who have first-hand knowledge about the community and trends (Carter & Beaulieu, 1992). These community experts, with their particular knowledge and understanding, can provide insight into the nature of problems and give recommendations for solutions (UCLA Center for Health Policy Research, 2004). Key informants interviews were conducted using face-to-face interviews, telephonic interviews and electronically.

Structured-structured questionnaires were used during interviews with the local authorities of all the three towns. Questions asked include why the PPWMs were installed when they were installed, how do customers own water tokens, and what benefits and challenges do they face with PPWMs (*Appendix 3: Interview guide for the local authority personnel*). In addition, interviews were conducted with the Swakopmund DRC informal settlement Committee members, Community leader in Usakos Hakaseb Suburb (*Appendix 4: Interview questions for community leader or committee*), and PPWM's users. Moreover, PPWMs suppliers and prepaid water vendors were interviewed, focusing on how the PPWMs work, challenges faced and communication between customers either local authorities or residents. A list of interviewed personnel's is shown in *Appendix 5*, indicating the name, position of respondent and date of interview were appropriate as some people wanted to remain anonymous.

3.3.4 Observations

Cohen and Crabtree (2006) define observation is a systematic data collection approach were the researchers use all of their senses to examine people in natural settings or naturally occurring situations. Non-participant observations were used were the researcher do not interact with participants but rather simply record their behaviour (Driscoll, 2011).

Field notes were taken on the observations made during the study which includes the following: type of household structure (wood, clay, colligated iron, bricks); water use activities at households (washing of clothes, plant watering) and business areas; the presence of plants watering at the households (lawn, trees, vegetable garden); and type of sanitation facilities at household. Observations at the municipal offices and prepaid vending shops were done to understand how the charging of the PPWM tokens work and the time spent purchasing them. Observations at a standpipe were also done and it was used to get a better understanding of the activities at the standpipe, the state of the PPWMs, type of containers used, who was fetching the water, how much water users took at a time, how they carried water home and time spent at standpipes.

3.4 Ethical considerations

Permission to enter the study area was obtained from the local authorities before conducting the field study. Respondents to the questionnaire and the participants in the FGDs were given an overview of the study and then asked for their consent to participate in the study. It was communicated to them that participation was voluntary and that their involvement would not attract any remuneration. The community was assured that the findings of the study would be disseminated to the community. Ethical considerations are critical so as to observe the rights of people to privacy.

3.5 Limitation of the study

The challenges faced in conducting the study included: not finding people in homes as they either went to work and low willingness to participate in the survey by the residents. The latter had reasons given that a lot of researchers come into their communities conducting research but that no differences were made in the community, especially in Swakopmund informal settlement.

To mitigate this challenges; the survey was also conducted after official working hours on weekdays and over the weekends (between 09h00 am to 20h00 pm). It was important that household heads participated in the survey as they are the ones responsible for making major decisions and overall provision of income to the household.

Whereas, a written proof of the permission to conduct research from the local authorities, the announcement of the local radio by the traditional leader and a letter from the University were the mitigation measures to the low willingness to participate in the survey. As for the local authorities, the financial information was not acquired as there was a lack of data and due to the confidentiality of the information. Therefore, this is why a cost-benefit analysis was not an objective of this study to determine if PPWMs recover costs or not.

The household questionnaires were prepared in English as it is the official language in Namibia. Although this could be a source error it was mitigated by having a translator present during interviews for translation of the questions. This was done because the questionnaires were not self-administered by the interviewee as not everyone would be able to read in English or the local languages (Oshiwambo, Afrikaans, Nama-Damara and Otjiherero).

3.6 Data Analysis

The Statistical Package for Social Science (SPSS) package and Microsoft Excel were used to analyse quantitative data to determine differences and relationships between datasets. Raw data was entered into excel sheet, coded to use in SPPS and then processed. The coding indicated the different possible answers to the questionnaire. The results were presented in forms of graphs and tables. Qualitative data was first transcribed and then categorised into key themes. Themes established from the transcripts were presented as a descriptive narration and direct quotes from the transcripts used in the analysis. The key themes included: water affordability, water accessibly, perceived water use changes, PPWM reliability, and community involvement, perceived challenges of PPWMs and perceived benefits of PPWMs.

4. RESULTS AND DISCUSSION

This chapter presents the findings and discussion of the results obtained from the research. The chapter is thematically organized into four sections: (1) The drivers for the installation of the prepaid water metering system; (2) description of the household characteristics of the respondents, (3) impacts of PPWMs on households; (4) the challenges that households face with the prepaid water meters; and (5) the impacts on the local water authorities.

4.1 Background to the introduction of prepaid water meters in Erongo Region

This section will present a brief history on the reasons why the different local authorities introduced prepaid water metering systems in their towns and the process through which the meters were introduced. The towns which will be looked at are Karibib, Swakopmund and Usakos.

4.1.1 Karibib Town Council

During Namibia's apartheid era, some of Karibib's residents lived in single quarter houses built by the local authorities and employers in Usab suburb. Single quarters are barrack-like rooms which were meant for single men recruited from rural areas to work - in the factories and service industries. The men were prevented from bringing their families with them into towns and from living with them. These living premises comprised of either a room or set of rooms with shared ablution blocks and kitchen facilities. In these areas, the Karibib Town Council (KTC) had installed conventional standpipe taps.

After Namibia's independence in 1990, the men living in the single quarters accommodation brought in their families from the rural areas. This resulted in overcrowding of rooms and high consumption of water by the residents who could not afford to pay for the water services. The overcrowding led to the formation and growth of the Usab informal settlement as people started building shacks close to the single quarters housing area. To provide the much-needed services the KTC installed one communal conventional metered tap where the community members paid a monthly fee to have access to water (Shingenge, 2016).

The community tap was operated by a KTC employee only at certain times of the day, not 24 hours. To access water, community members had to show their proof of payment. However, due to non-payment of water services and water theft by community members the KTC, introduced

PPWMs in Usab informal settlement in 2006. The KTC accountant stated that KTC introduced the PPWMs as a way of improving revenue collection (Gaseb, 2016).

4.1.2 Swakopmund Municipality

Swakopmund water is supplied in bulk by NamWater, which is a parastatal organization. About 70 % of the water supplied to the town is from Omdel dam, 20 % from Swartbank and 10 % from AREVA desalination plant (Erwin, 2016). The Swakopmund Municipality (SM) has two water reservoirs of 40,000 kl and 32,000 kl capacity (Kubirske, 2016). In addition, SM has a treated effluent reservoir of 15,000 L. The treated effluent is sold to private companies and individuals whilst some is stored before it is disposed of. The Municipality treats wastewater to treated effluent standards of WHO guidelines for the safe use of wastewater, excreta and greywater (WHO, 2006) and national standards developed by the Ministry of Agriculture, Water and Forestry. The treated effluent is used to irrigate lawns, sports fields, and gardens in the town.

The Municipality supplies potable water to the residential and industrial customers only excluding the surrounding mines. Along the Swakop River, there are drilled boreholes but the water is too saline for human consumption. Swakopmund, like other towns in Namibia, experiences an acute shortage of affordable housing units. The Swakopmund Democratic Resettlement Community (DRC) informal settlement was established by the Swakopmund Municipality in 2000 when it leased out 1,338 residential erven/stands to people who were staying illegally in shacks on municipal property or in the backyard of other properties.

Since the establishment of DRC informal settlement, there has been a high increase of illegal settlers mainly due to rural-urban migration in search of jobs in the coastal town. This has then led to a division in the area with DRC ‘old’ and DRC ‘illegal squatters’ as the newly migration into the Swakopmund DRC informal settlement. The Municipality plans to formalize DRC informal settlement to approximately 5,000 erven/plots to be serviced with prepaid water and electricity services. According to SM Community Development officer for DRC informal settlement, the population of DRC informal settlement is approximated to 10,000 residents (Mr. Awesab, 2016).

The Swakopmund Municipality has an obligation of providing water to the residents. Since the formation of DRC informal settlement in 2003, DRC informal settlement was served with four conventional water meter taps. The postpaid payment method was used with a fixed fee of N$60.00 per month (US$4) (average exchange rate between January and June 2016). Between

2003 and 2009 the municipality introduced a number of prepaid water metering systems. However, a lot of challenges were faced with the PPWMs. In 2010 to 2011, Water Master (PTY) Ltd, was contracted by the Swakopmund Municipality to buy bulk water from the Municipality and then sell the water on prepayment water metering system in DRC informal settlement using the Conlog prepaid meters. According to Hartman (2011), SM took over the services due to allegations that the private company had poor management, was selling water on credit and poorly maintaining communal dispensing points in DRC informal settlement. Due to mismanagement, the Municipality decided to take over the service.

According to an official that worked for Water Masters (PTY) Ltd, the high levels of Unaccounted for Water (UFW) from the leaking pipes and vandalism of standpipes that resulted in a free flow of water were some reason as to why the private company got into debts (Bloodstaan, 2016). Loss of water was actually a loss in revenue. As a result, the private company faced challenges in recovering costs and went into debt from not paying for the bulk water supplied to it by the Municipality. In addition, the private company faced problems with the Ultima Management Software, which is a Personal Computer (PC) based prepaid water meter vending systems. In January 2011, for example, the Ultima Software was not functioning which resulted in water users failing to recharge their tokens which are needed to access water. One of the reasons why the problems were arising was that the PPWMs and their software were not locally manufactured which made it difficult to address problems.

In mid-2011, SM decided to install the Elster Kent standpipe PPWMs following recommendations from the following towns: Okahandja, Otjiwarongo, Rundu, Tsumeb and Windhoek. The installation was self-funded by the Swakopmund Municipality. This contrasts finding in literature (Heymans *et al*., 2014), which states that local authorities are funded by substantial external support by using commercial or concessionary loans from private banks or international finance agencies. The example of Malawi using World Bank funds is often given (Heymans *et al*., 2014). The Elster Kent meters were still in operation but there have been other types of PPWMs installed in DRC informal settlement namely: Conlog, Lesira At the time of study 27 PPWMs standpipes were installed but four were observed to be nonfunctional. Originally, one standpipe PPWM was expected to serve 40 households. New standpipes at the time of the study were being installed due to the expanding population. Initially, there were three standpipes per demarcated street in the 'old' DRC but there has been new standpipe PPWMs installed due to the growing population.

When the Elster Kent meters were installed all the ‘old’ DRC households got tokens needed to access water for free. As for the ‘illegal’ DRC residents, they had to purchase a customer’s token from the Municipality at a cost of N$230.00 (US$15.30). The total number of registered tokens at the Municipality was 3,884 tokens. Although each household is supposed to have one token, the study found that some households had purchased more than one token. This was one of the themes from the FGDs, participants stated that just in case one token gets lost or stolen there is another one.

The Elster Kent PPWM's system suppliers were procured by the Municipality through the tender process as per Municipalities guidelines. The awarded company, Aqua Services and Engineering, was responsible for the installation of the prepaid meters and the training of the Municipality staff on how to use the software used to manage the system. The Swakopmund Municipality is responsible for selling the tokens, selling of the water units, monitoring, and maintenance of the standpipes meters. Nonetheless, if the municipality cannot address a problem with the PPWMs the supplier is called to assist.

The Municipality plans to install individual PPWMs at the National Mass Housing Development (NMHD) programme under the National Housing Enterprise (NHE) in Swakopmund DRC informal settlement outskirts. Future plans involve linking the customer’s home number to the water meter which can be used as arrears to recover municipal services debts. The Government of the Republic of Namibia (2013), launched the NMHD programme in 2013 aimed at delivering affordable housing and sanitation at a subsided level for low-income earners in both urban and rural areas. The country is challenged by the mushrooming of informal settlement as there is poor access and non-affordable land by the majority of the residents, with 185,000 houses planned to be built in line with Namibia’s Vision 2030 (GRN, 2013).

4.1.3 Usakos Town Council

According to the Usakos Town Council (UTC) Acting Chief Executive Officer (CEO), the main reason why PPWMswere installed in the town was to improve revenue collection, reduce illegal water connections and to reduce water losses. In addition, PPWMs standpipes were introduced in informal settlements as communal conventional taps there was no control of how much each household consume and therefore resulting in dispute within the community members as disconnections were made if customers did not pay for the services.

The accountant at UTC stated that as of 30 June 2015, the Usakos Town Council owed approximately N$380,000.00 (US$25,330.00) to NamWater and UTC was owed approximately N$8 million (US$533,330.00) by about approximately 200 households in unpaid bills. The debts arose mainly due to the unwillingness of residents to pay for municipal services and poverty since most of the residents are pensioners and the unemployed. Some residents who owe the council money for services rendered stated that they had inherited the debts from their parents who previously owned the houses but were now deceased.

The low revenue collection led UTC to apply for Namibian government funds for the rehabilitation of the water reticulation system initiative in the installation of PPWMs in Hakaseb suburb under the Targeted Intervention Program for Employment and Economic Growth (TIPEEG) to the value of N$10 million (US$667,000.00). The South African government provide grants in support of water services as an example the City of Mogale 70 % of the capital cost of the prepayment metering was funded by the government funds (Heymans *et al*., 2014). The TIPEEG is aimed at effectively reducing the high unemployment rate by employing the unskilled youths mainly through expediting implementation of Government programmes in agriculture, tourism, transport, housing and sanitation (NPC, 2011 and GRN, 2013a). The project led to a total of 228 individual PPWMs in Hakaseb suburb and 6 standpipe PPWMs in the informal settlement of Ongulumbashe and Saamstan to be installed in Usakos Town.

4.2 Management structures for prepaid water metering system

The local authorities have departments such as: department of finance; department of public relations and communication; department of community services; department of urban planning and property management; department of environmental health; department of local economic development; and department of infrastructure, water and technical services. The management structure of the prepaid water metering system in all the three towns showed that the technical services and finance departments are responsible for the operations of the PPWMs as shown in *Figure 4.1*.

The technical department is involved in the monitoring and maintenance of either the standpipes or individual PPWMs. The finance department deals with the selling of the customer's tokens, recharging of customers token, water units and the selling of bulk water units to the prepaid water vendors for the case of Swakopmund Municipality. The customers directly interact with the cashiers at the cashier's tellers at the municipal offices. Customers report problems with their PPWMs through the cashiers and the technical department. As for the Swakopmund

Municipality, it is technical department is under Engineering Services of the Works section within the Operations section. The Operations section deals with the day to day running of the Town Engineering Department to ensure that essential services are provided to the public and maintained.

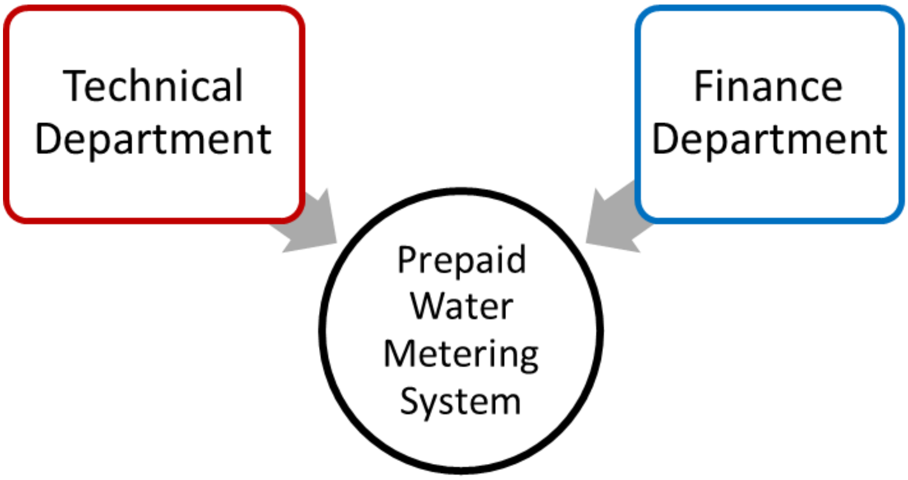

Figure 4.1: Local authorities departments responsible for prepaid water metering system in Erongo Region

4.2.1 Procedures for acquiring customer tokens

A customer's token is used to store water units when a customer purchases water and the units are deducted from the token whilst in use. In all the towns the requirements to purchasing a token is a national identification document and a token price fee. The token prices exclusive of water units are as follows: N$150 (US$10) in Karibib, N$230. (US$15.30) in Swakopmund and N$300 (US$20) in Usakos town. Since the token comes without water units, the customer can decide the amount of money he or she can recharge the token for.

The information about each token which is recorded in the management software includes: the unique identification number, receipt number, date token was purchased, and customer's details including their name, surname and sex. However for individual PPWM users, the erf/plot number and the water meter number is recorded. Every token has a unique serial and an account number assigned. In Swakopmund, tokens can be purchased from the Swakopmund Municipality Head office and registration is administered at the Municipality's Works section where the customer is provided with the token. As for Karibib and Usakos, the purchasing and registration are done at the local authorities offices by the cashiers.

4.3 Types of prepaid water meters used

The study found that there are different types of PPWMs used in the study area. A standpipe PPWM is shared by the community members from different households and they own their credit token. Each time the standpipe users withdraws water, the token has to be pressed against a sensor on the water dispenser as shown *Figure 4.2* (Elster Metering, 2016a).

Figure 4.2: Lesira-Teq standpipe and the token used in in Karibib Usab informal settlement

As for the individual PPWM, a token which is programmed for a specific meter number for each customer. The customers token or tags are used to load water unit credit at the purchasing points using prepaid water metering software system. The customer then presses the token to the dispenser to load the credit into the meter's memory. However, it is different from standpipe users as the customer do not the customers do not utilize the token every time they use water in the house (Saes, 2012; Heymans *et al*., 2014). The standpipe and individual PPWM used in Karibib, Swakopmund and Usakos will be described below and how the PPWMs work. However, prepaid bulk water meters for commercial and institutional customers designed for greater volumes do exist but it is not installed in the towns studied.

4.3.1 Standpipe prepaid water meters

The towns of Swakopmund and Usakos use the same type of PPWMs called the Elster Kent system *Figure 4.3 and Figure 4.4*. Whereas, *Figure 4.2* shows the PPWM type called Efteq installed in Karibib informal settlement.

A. Elster Kent system

The Elster Kent system is manufactured in Johannesburg, South Africa. In Namibia, the Elster Kent PPWMs are supplied by Aqua Services and Engineering (ASE), a private company based in Windhoek. The ASE supplied the following approximate number of standpipes to this town in

Namibia: Aranos 30, Aroab 200, Bethanie 200, Mariental 18, Otjiwarongo 60, Rehoboth 40, Rundu 300, Swakopmund 100, and Tsumeb 200 (Lottering, 2016). The numbers are approximations and may not all be installed. The company has a coastal branch in Walvis Bay which is a town 30km away from Swakopmund. The Elster Kent Communal Water Dispenser (CWD) is powered by a lithium battery which can last up to three years. The meter consists the following hardware components: the electronic module, latching valve, tempar switch and water meter with pulse output (*Figure 4.3* and *Figure 4.4*). According to the ASE Projects Executive manager, the Elster Kent PPWM's components can be replaced once faulty or not working anymore (Lottering, 2016).

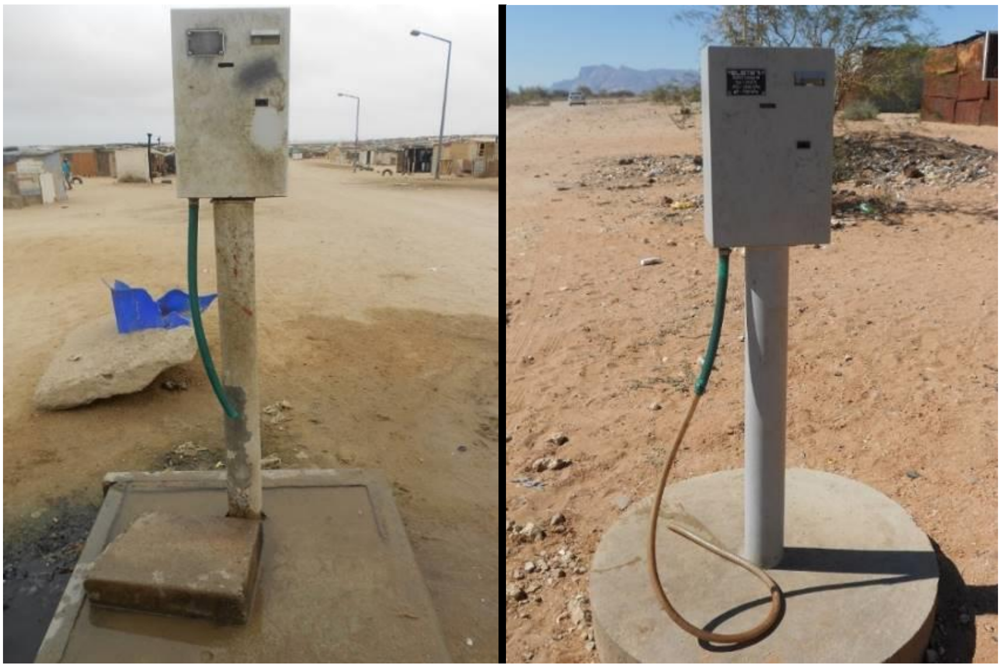

Figure 4.3: Elster Kent standpipe PPWM in Swakopmund and Usakos informal settlements

The meter box consists of a stainless steel above ground which allows the Liquid Crystal Display (LCD) to be positioned approximately 1.2 m above the ground. The meter box lid is secured with security screws which can only be removable with special security spanner. In addition, a tamper switch connected to lid ensures that no water is drawn when tamper mode is activated. The customer’s token stores complete feedback and diagnostic data for the meter, including error codes, monthly consumption volumes and totalizer. According to (Elster Metering, 2016a), the customer’s tokens have a service life of at least 10 years with unlimited read and write cycles. The token is designed to be resistant to extreme environmental conditions shock and temperature (-20˚ C to 70˚ C). The meter’s LCD indicate the monetary credit available on the token. Additional information includes: volume dispensed in litres, meter totalizer in cubic meters, error codes, battery low icon, tamper mode, valve status and no flow status.

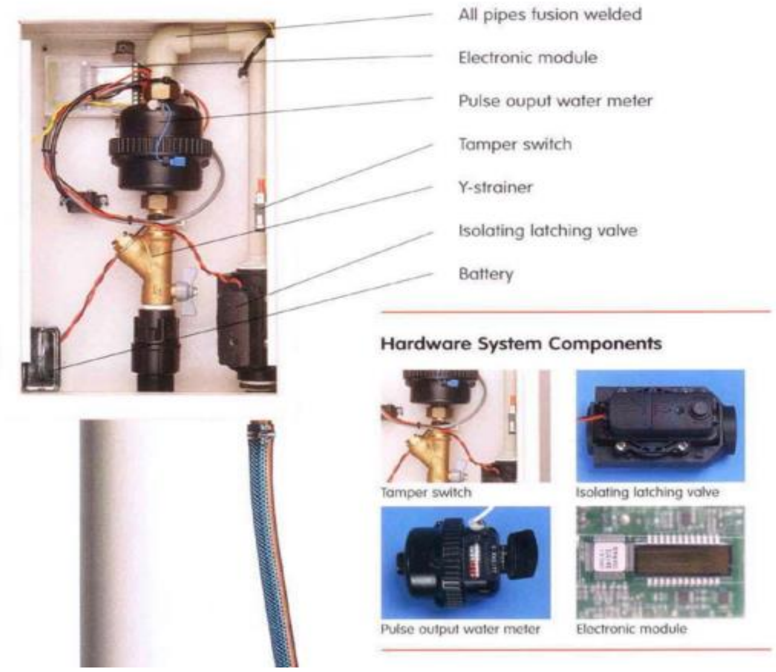

Figure 4.4: Hardware components of the Elster Kent standpipe PPWM

B. Lesira-Teq system

Lesira-Teq (Efteq) PPWMs are also manufactured in South Africa and they are supplied by a Namibian based private company called Thunderstorms Investment CC based in Windhoek. The Efteq standpipe PPWMs are installed in the following towns (Bloodstaan, 2016): Kamanjab, eight in Karibib, Khorixas, Maltahohe, Outapi, Ruacana, Tses. The unit consists of a Class B multi-jet water meter with electronic readout and the system ensures extended battery life. The unit is housed in a robust galvanized or powder coated metal which provides a high level of resistance to physical tamper and magnetic tamper as well (Lesira-Teq, 2016). The meter is designed to serve up to 40 households. The Lesira-Teq meter system uses a Dallas iButton, called a tag or token (Lesira-Teq, 2016).

The token consist of a small stainless steel container containing a microchip (*Figure 4.2*). Credit is loaded onto the user token via Meter Management System (MMS) either at the local authority offices. On insertion of the user tag into the meter, the valve will open and dispense water while deducting credit from the user tag (*Figure 4.2*). After the token is removed from the meter the valve closes. Multiple users can access the meter as the meter itself retains no credit. Each owner recharges his or her token as they can afford.

4.3.2 Individual prepaid water meter

The Elster Kent Domestic Water Dispenser (DWD) is designed for individual households, to control the dispensing of pre-paid quantities of water. The individual Elster Kent PPWMs are installed in the following towns: Otjiwarongo +/-3000, Tsumeb +/-500 and Usakos 233. The Zonke above ground polymer meter box is installed in Usakos as shown in *Figure 4.5*. It also consists of same components as the Elster Kent Communal Water Dispenser. A monthly consumption profile is generated, which in turn is loaded back onto the token. This profile is uploaded to the Cashflow management system the next time the consumer purchases credit. The individual PPWMs box contains (Elster Metering, 2016b):

- A 15mm or 20mm Class "C" polymer semi-positive rotary piston water meter.
- A municipal 3-way ballcock positioned before the meter and a consumer 2-way ballcock position downstream of the water meter.
- Sliding couplings connect the inlet and outlet of the water meter and allow replacement.
- Dual key operated locking mechanism for removal of cover for maintenance.

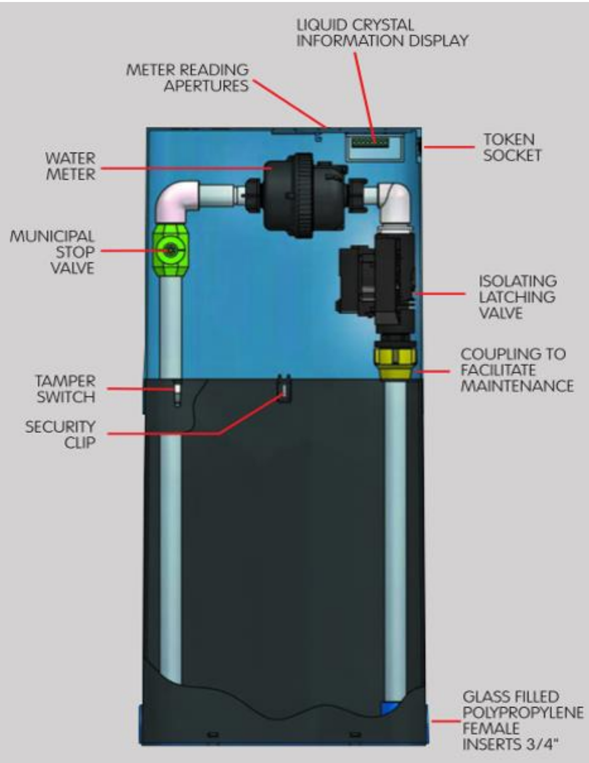

Figure 4.5: The inside of a Zonke domestic PPWM dispenser

Source: Elster Metering (2016)

4.4 Demographic and socio-economic characteristics of respondents

The study carried out a survey to profile the households using the PPWMs and to find out their perceptions towards the PPWMs. The survey was carried out in all the three towns (Karibib, Swakopmund and Usakos) and the findings of the survey are presented below.

4.4.1 Gender

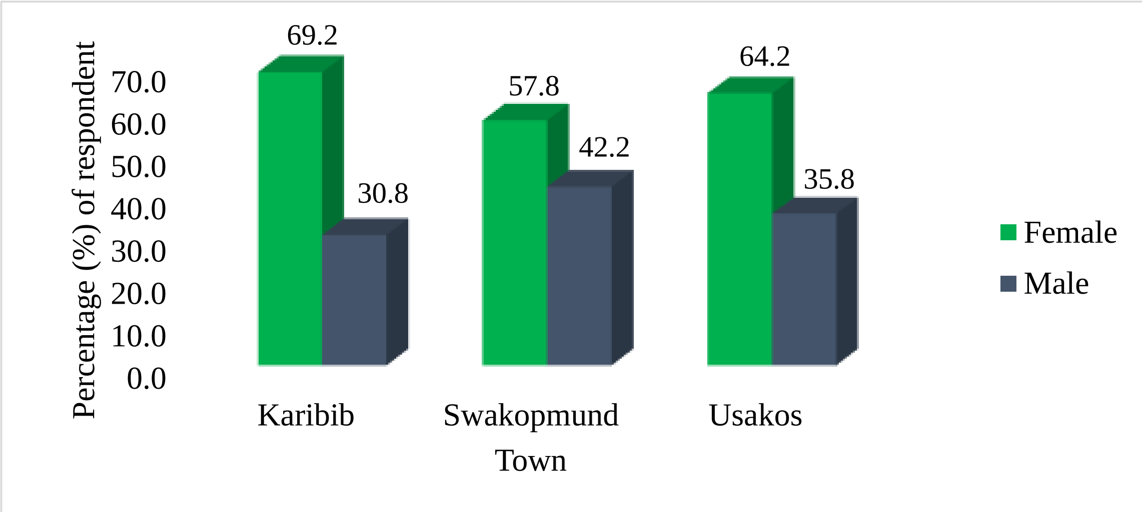

Figure 4.6: Gender distribution of respondents in Karibib, Swakopmund in Usakos towns

The majority of participants in the survey were females (60 %) and males (40 %), distribution across the study area as shown in *Figure 4.6*. It was found that in Karibib about 70 % of the respondents were female; in Swakopmund there was about 58 % female and in Usakos there were 64 % of women responded. However, the 2011 census released that Erongo Region population was 47 % female and 53 % male (NSA, 2012). Of the participants, 60 % were heads of households.

4.4.2 Age distribution

Figure 4.7 shows that the majority of the respondents (about 63 %) were in the age range of 19-39 years. The least number of respondents were in the less than 18 years old category in all towns. Usakos had the highest percentage of respondents older than 60 years (13.8 %) with a higher number of pensioners which make up the town's population.

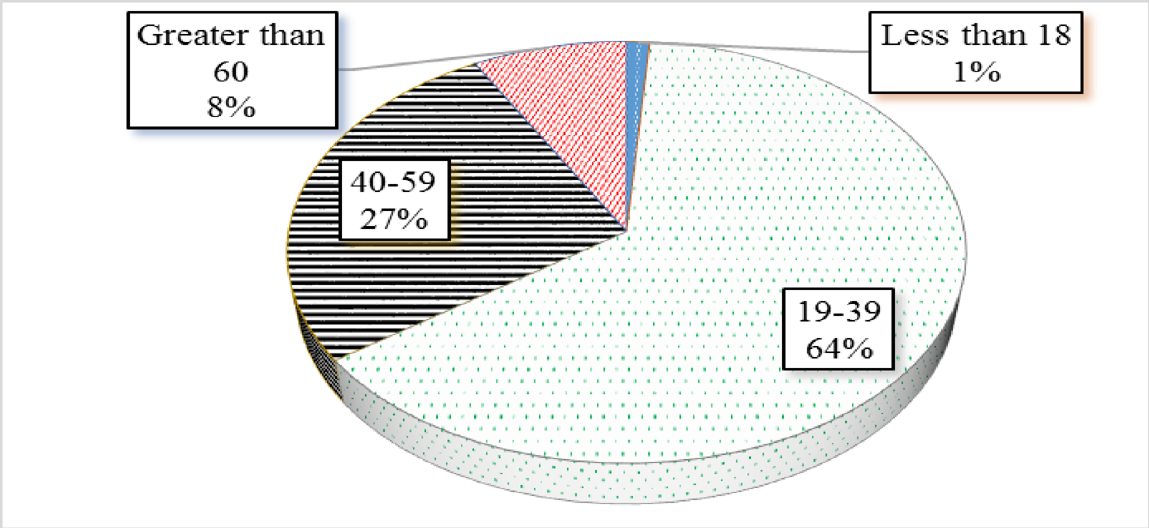

Figure 4.7: Age distribution of respondents

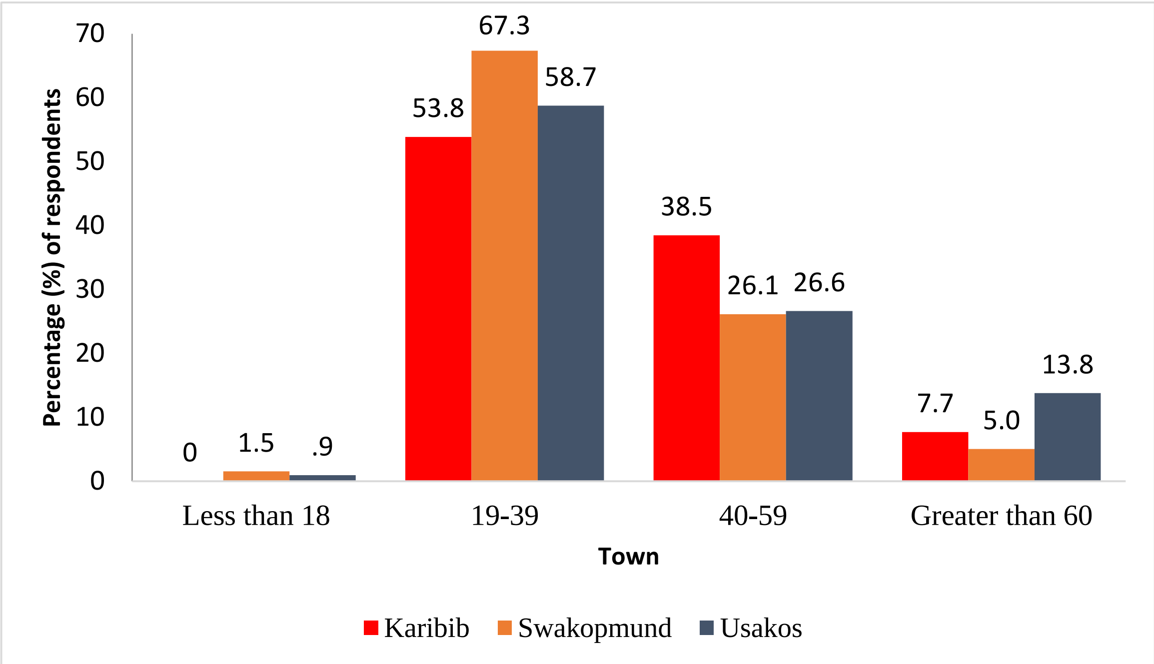

Figure 4.8: Age distribution of respondents in the three sampled towns

The results presented in *Figure 4.8* show that in Karibib, Swakopmund and Usakos towns the age distribution of respondents is between 19-39 years old with 53.8 %, 67.3 % and 58.7 % respectively. Respondents below 18 years old had the lowest percentage in all the towns, this could be due to the fact that the survey took place during school days.

4.4.3 Household size

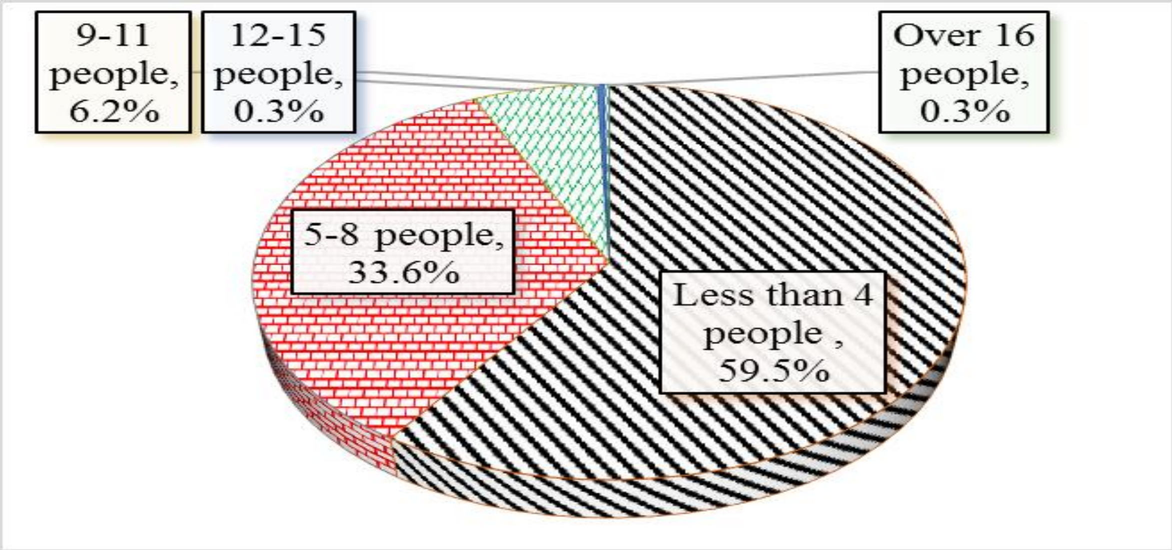

Figure 4.9: Average size of household in the three towns

Figure 4.9 shows that more than 60 % of the sampled households indicated that their household size was less than 4 people.

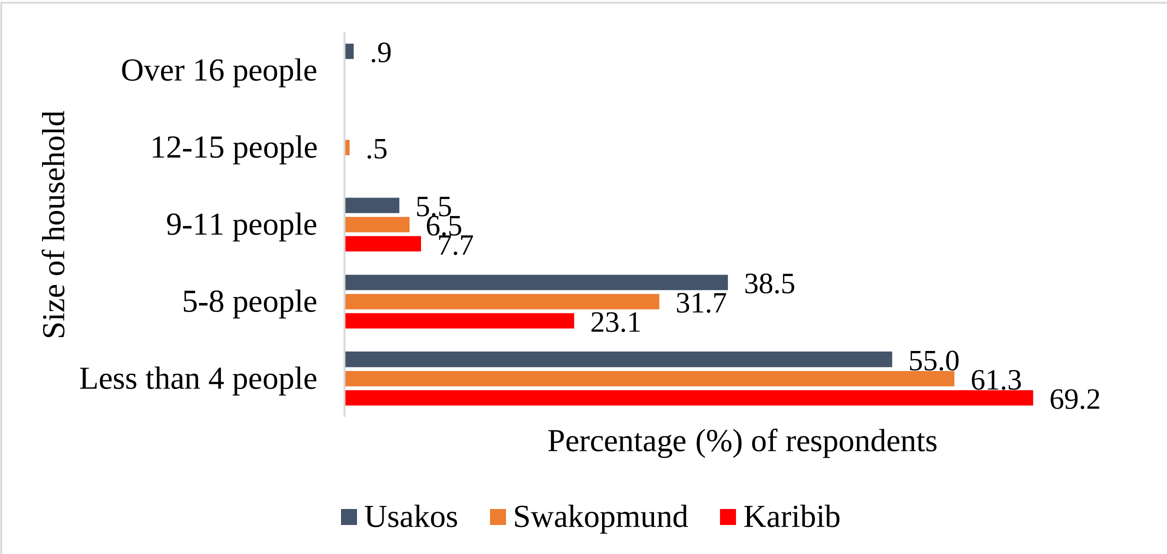

Figure 4.10: Size of households by respondents in the three towns

Figure 4.10 shows the average household sizes in the sampled towns. In all towns, the household size of fewer than 4 people per household had the highest percentage. The size of 12-15 people per household was recorded in Swakopmund and over 16 people per household in Usakos.

4.4.4 Period of stay in study area

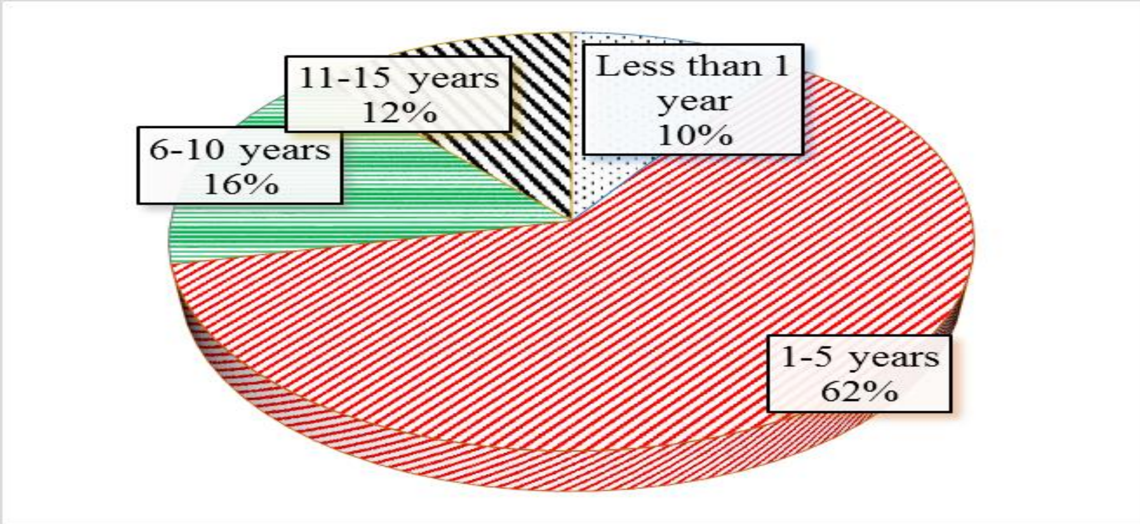

Figure 4.11: Length of stay for respondents in the three towns

For all towns, the majority of the respondents (62 %) indicated that they had lived in the area for between one to five years whilst the rest of the respondents (38 %) had lived in the area for more than five years *Figure 4.11*. It was expected that respondents could have lived in this area for a longer period as the settlements are not newly established except for the DRC 'illegal' settlers. This data could have been affected due to the high population sampled was from Swakopmund from the "illegal" DRC. However, the short length of stay could also be an indication that the settlements, which as mentioned earlier, are largely informal, are continuously experiencing inward migration.

4.4.5 Tenure status of household

Figure 4.12: Tenure status for household

The majority of the respondents about 85 % indicated they owned the houses they lived in (*Figure 4.12*). The remainder stated that they rented shacks in the informal settlements.

4.4.6 Education level of head of household

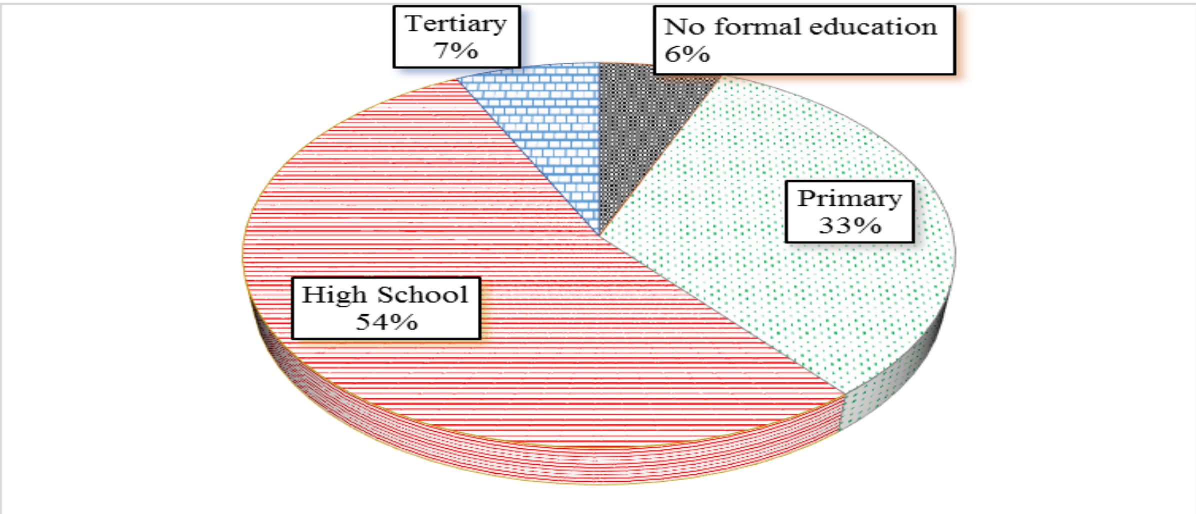

Figure 4.13: Education level of head of household

More than half of the household heads (54 %) said they had reached high school and 33 % gave their highest qualification as primary school education as shown in *Figure 4.13*. With the use of the PPWMs customers' needs to understand basic mathematics as the PPWM's LCD shows the water units/credit in numbers. If customers cannot read or understand what the numbers mean it is a disadvantage to them. The national census revealed that Erongo Region literacy rate was 94.3 %, with no major difference between males (94.2 %) and females (94.5 %) (NSA, 2012).

4.4.7 Occupation

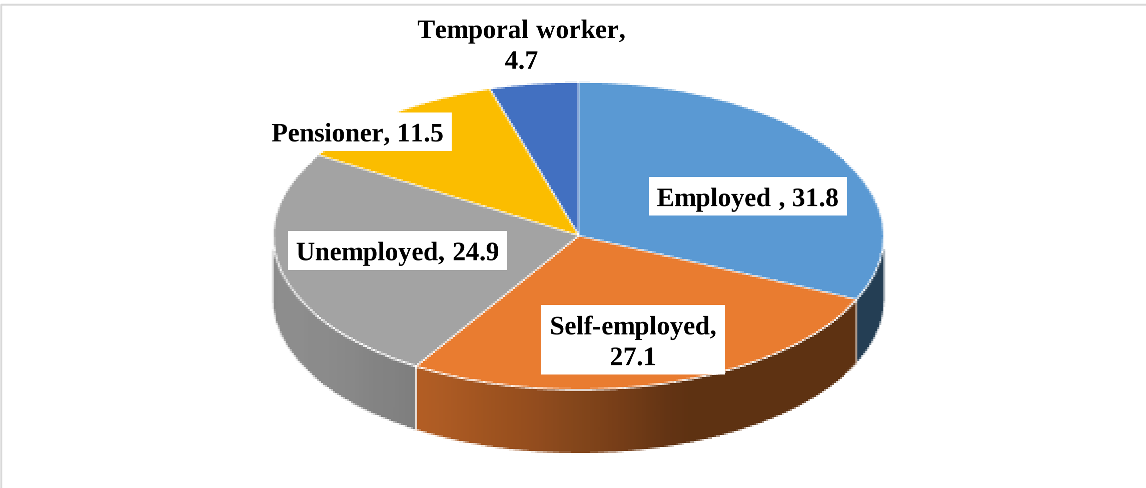

Figure 4.14: Occupation of head of household in the three towns

Head of household who reported that they were unemployed (24.9 %), pensioned (11.5 %) and the rest of the 63.6 % were employed *Figure 4.14*.

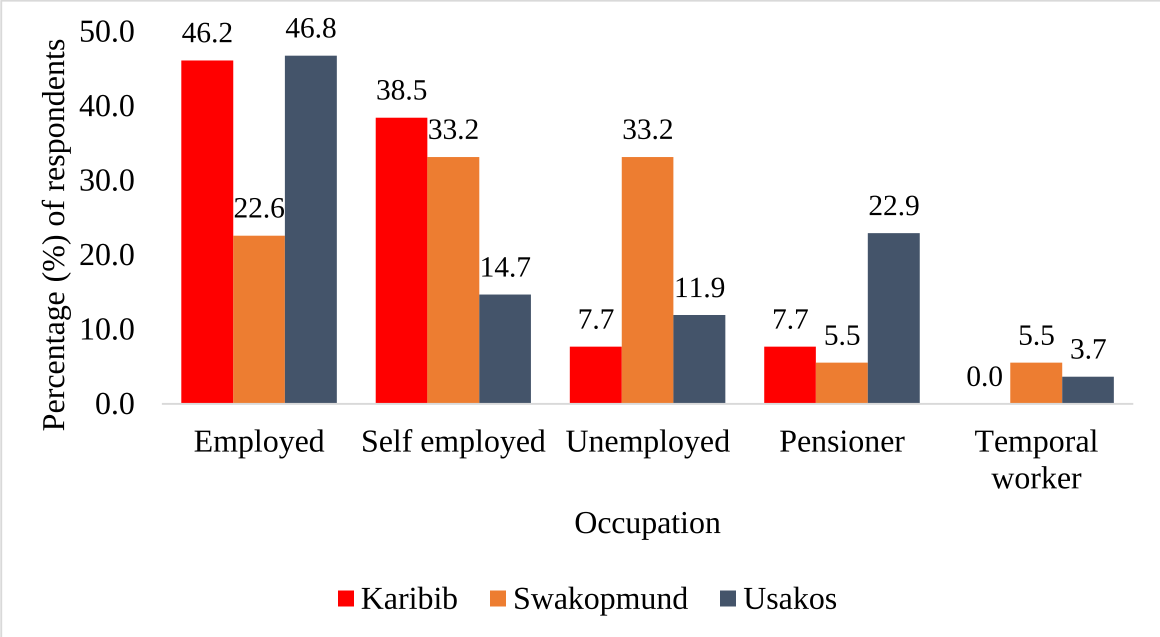

Figure 4.15: Occupation status of head of household

Figure 4.15 shows that in Karibib the respondents of household heads are employed, in Swakopmund an equal percentage of 33.2 % for self-employed and unemployed household heads. In addition, in Usakos the formally employed and pensioners are highest with 46.8 % and 22.9 % respectively. The employed category included those that work in the public and private sectors, whilst self-employed included those that work for themselves such as owning an alcohol retailer, salon and domestic workers. Pensioners are those that are over the age of 60 years old and entailed to a pensioners government grant monthly.

4.4.8 Monthly income

The results in *Figure 4.16* shows that 42.4 % of the household head earn below N$800 (US$53) monthly and 34.6 % earning between N$800-N$2400 (US$53-US$160) monthly and the rest earning more than N$2400 (US$160). The sampled areas are characterized by no income or low-income households.

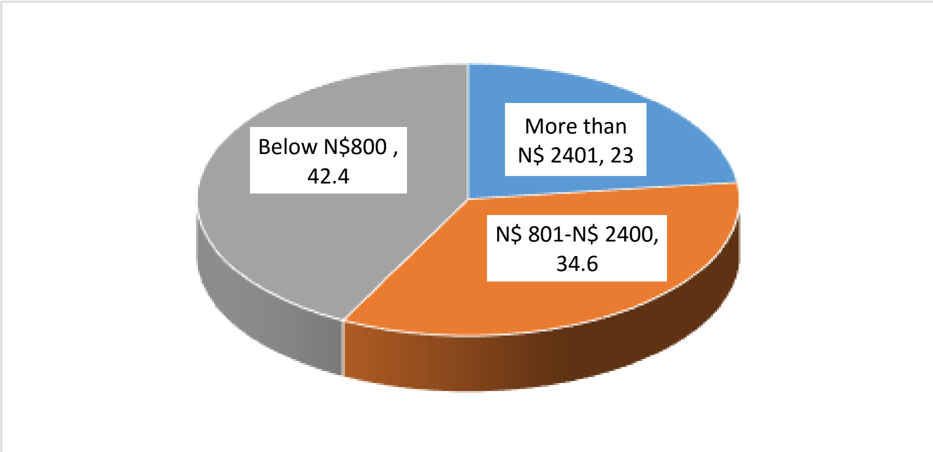

Figure 4.16: Monthly income of household head in the three towns

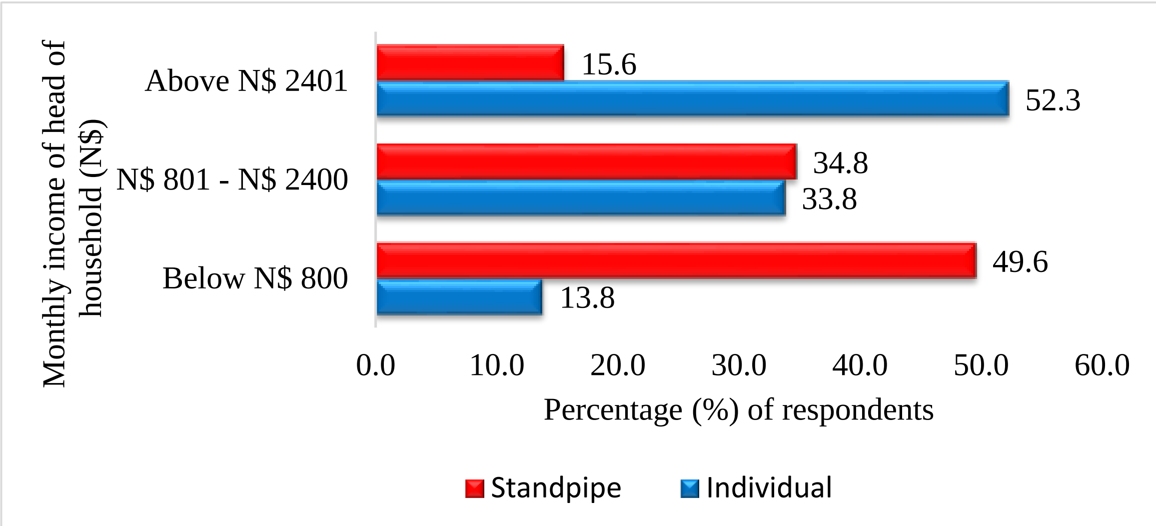

Figure 4.17: Monthly income of household head for PPWM users in three sampled town

The respondents in Karibib indicated that an equal percent of 46.2 % for both below N$800 (US$53) and between N$800-N$2400 (US$53-US$160). Swakopmund respondent's highest income was below N$800 (US$53) with 50 %. The highest income in Usakos was more than N$2401 (US$161) with 37.6 % whilst the lowest was below N$800 (US$53) with 28.4 %. *Figure 4.17* results show that highest household head monthly income for standpipes PPWM users is 49.6 % for below N$800 (US$53) whilst for the individual PPWM users is above N$ 2401 (US$161). This is to justify that the people that live in informal settlements have a lower income of less than N$800 (US$53) majority.

4.4.9 Government grant received

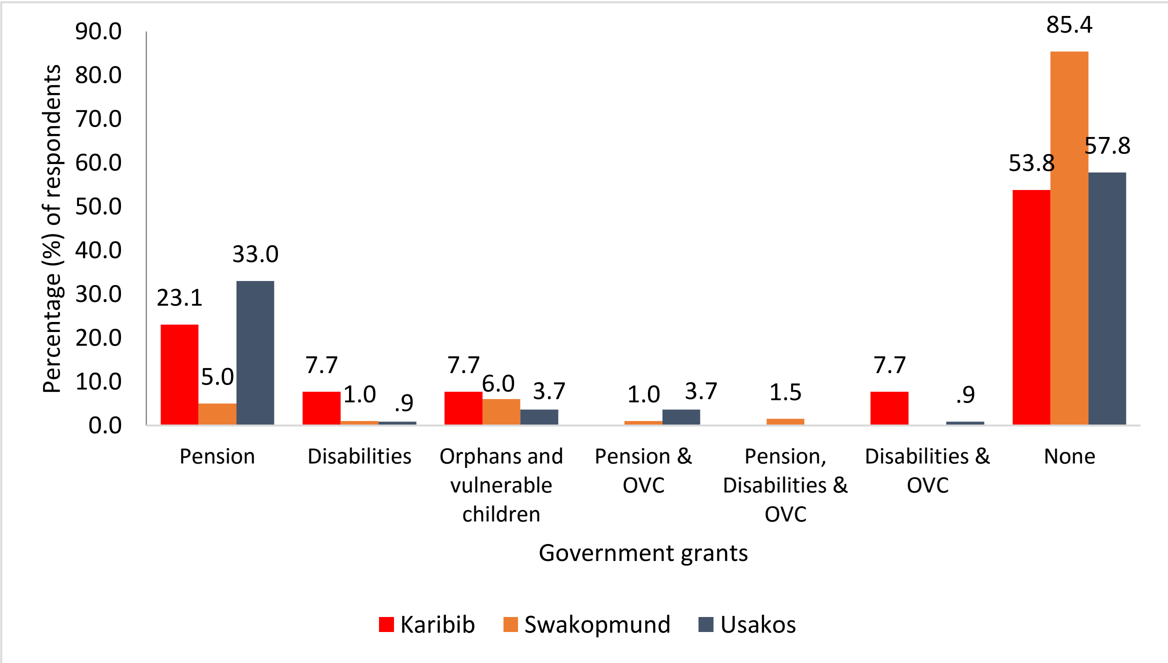

Figure 4.18: Government grants received per household

Figure 4.18 shows that the majority (53.8 %) of households do not receive any government grants. However, Karibib and Usakos had sampled households receiving a pension of 23 % and 33 % respectively. Nationally, Erongo Region had the lowest proportion of people living with disabilities of 2.5 % (NSA, 2012). The Ministry of Poverty Eradication and Social Welfare is mandated under the National Pension Act 10 of 1992 to pay a pension grant to those that attained the age of 60 years and a disability grant to those that reached the age of sixteen years and have been certified as disabled by a State medical officer. Government grants for the unemployed is a source of income for some households mainly the pension and the Orphans and Vulnerable Children (OVC) grant. The pension is N$1,000 (US$67) per pensioner per month and N$250.00 (US$17) per OVC every month.

4.5 Impacts of prepaid water metering system on residents

4.5.1 Water affordability

The local authorities in Namibia are charged differently by NamWater according to their location thus the water tariff adjustments are approved and promulgated in the Government Gazette (GRN, 2013b). Below is the water tariff price of the three towns of both the conventional and prepaid water payment. The study revealed that the water tariff in Karibib and Swakopmund are lower than those of conventional meter users. However, in Usakos, the price of water for both postpaid and prepaid has the same price of N$14.63/m^3 (US$0.98/m^3) of water (*Table 4.1*). This means that the introduction of the PPWMs has not increased or decreased the price of water. According to Heymans *et al*., (2014), generally the customers of prepaid water users are charged the same or less volumetric rate than the conventional water users.

The study conducted by Saes (2012) in Otjiwarongo found water tariff were: N$30/ m^3 standpipe PPWMs users, N$25.64/m^3 individual PPWMs users and conventional meter users pay N$16.00/ m^3. The Otjiwarongo Municipality offers the first 6m^3 of water for free and the 7-15 m^3 at the normal rate for all pensioners (Shikongo, 2016). Saes (2012), stated that the high cost of prepaid water was because the PPWMs cost more than the conventional meters. In addition, the basic charges for water and rental fee for standpipe users in the informal settlement cause the price to be higher.

Table 4.1: The water tariffs in the three towns

Town	**NamWater tariffs (per m^3 of water)**	**Post-paid (per m^3 of water)**	**Pre-paid (per m^3 of water)**
Karibib Town Council	N$11.35	Block tariff system	N$19.90
	(US$0.76)		(US$1.33)
Swakopmund Municipality	N$7.95	Rising block tariff system	N$30.00
	(US$0.53)		(US$2.00)
Usakos Town Council	N$10.50	N$14.63	N$14.63
	(US$0.70)	(US$0.98)	(US$0.98)

Table 4.2 shows that the town of Usakos has the lowest water tariff per m^3 of water which allows the customers to get a water volume of 1,370L of water from N$20.00 (US$1.33). Whilst Swakopmund water tariff is the highest at N$30/ m^3 (US$2/ m^3) per, which means customers pay N$10 (US$0.33) they can only get 300 L of water.

Table 4.2: Water units and amount of water in m^3 that can be purchased

Town	**Purchasing point**	**Minimum amount of money that can purchase**	**Water tariff per m^3**	**Minimum water that can be purchased (m^3)**
Karibib	Karibib Town Council	N\$20.00 (US\$1.33)	N\$19.90 (US\$1.33)	1 m^3 1,000 L
Swakopmund	Swakopmund Municipality	N\$10.00 (US\$0.70)	N\$30.00 (US\$2.00)	0.3 m^3 300 L
	Embwida Pre-Paid Water shop	N\$10.00 (US\$0.70)	N\$30.00 (US\$2.00)	0.3 m^3 300 L
	Hoki Pre-Paid Water Tuck-shop	N\$5.00 (US\$0.33)	N\$30.00 (US\$2.00)	0.1 m^3 100 L
Usakos	Usakos Town Council	N\$20.00 (US\$1.33)	N\$14.63 (US\$0.98)	1.37 m^3 1,370 L

Figure 4.19 indicates that nearly half of the respondents recharge their tokens weekly (41 %). While 35 % recharge month, 18 % recharge daily and only 6 % would recharge more than a month. The results show that, the traveling distance to local authority's offices or vending shops, water consumption and greatly the availability of money. The respondents that purchase water units on a monthly basis stated that they purchase just after they have obtained their monthly salaries.

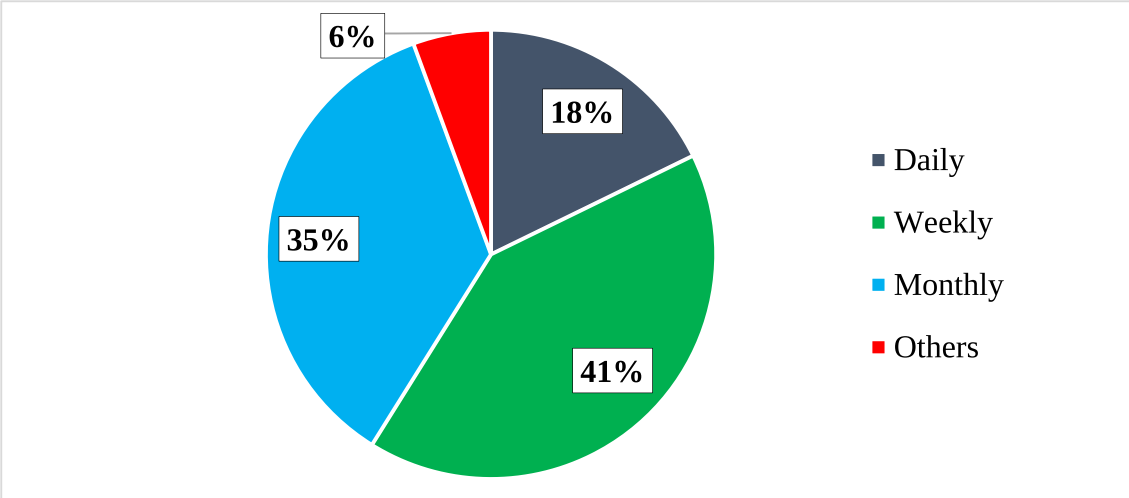

Figure 4.19: Frequency of purchasing water units

Table 4.3 below depicts the monthly mean and mode of money spent on water by respondents when asked how much they spent per month on the prepayment of water. The result shows that respondents in Swakopmund had the highest mean amount of money spent on the water each month of N$118 (US$7.90) and Usakos standpipe PPWM users of N$36 (US$2.40) for the standpipe PPWM users in informal settlements. As for individual PPWM users, the mean amount is N$250 (US$16.70) and mode of N$ 200 (US$13.30).

Table 4.3: Monthly income and water expenditure per month

Town	Monthly income (N$)	Water Expenditure (N$)	Mean cubic per month (m^3)	Water expenditure as a percentage of income (%)
Karibib	800 (US$53.30)	56.00 (US$3.70)	2.81	7
Swakopmund	800 (US$53.30)	118. 00 (US$7.90)	3.93	14.8
Usakos standpipe users	800 (US$53.30)	36.00 (US$2.40)	2.46	4.5
Usakos individual users	3200 (US$213.30)	182.90 (US$12.20)	17.09	5.9

*Mean cubic per month calculated as Mean/Price per cubic of prepaid water

With the monthly income of standpipe PPWM users (US$53.30) and individual PPWM users (US$213.30) were used to calculate water as a percentage of monthly income of households (*Table 4.3*). The water expenditure as a percentage of income for the head of household income was highest for Swakopmund standpipe PPWM (14.8 %), followed by Karibib standpipe PPWM users (7 %) and 5.9 % for individual PPWM users in Usakos. The lowest water expenditure as a percentage of income was calculated for Usakos standpipe PPWM users at less than five percent.

According to United Nations Development Programme (UNDP), suggests that water costs should not exceed three percent of household income (UNOHCHR, 2010). As per the UNDP benchmark, all the surveyed head of household's water users as a percentage of monthly income exceeds three percent. According to Heymans *et al*. (2014), it was found that households in Lusaka, Zambia and Mogale City in South Africa with prepaid house connections tend to spend less on water due to their conscious of their water consumption. In addition, most households using prepaid public standpipes in Kampala, Uganda spend less money and use more because water from standpipes is substantially cheaper than from third-party sellers.

Table 4.4: Money spent on water per month

Descriptive Statistics

PPWM used		N	Range	Minimum	Maximum	Mean	Std. Deviation
Household	Water	65	950	50	1000	182.92	131.526
	Valid N (listwise)	65					
Communal Standpipe	Water	256	790	10	800	105.71	91.491
	Valid N (listwise)	256					

Table 4.4 shows the descriptive statistics where the mean amount of money used for in all informal settlements is N$105.70 (US$7.05) and N$182.90 (US$12.20) for individual PPWMs users. Comparing households using standpipe PPWMs users to individual PPWMs, the study found that households using the standpipe PPWMs pay less for water and use less water as compared to the individual PPWMs households. This can be attributed to the monthly income differences and the household water activities.

As the individual PPWM users have their own piped water connections in their households, with diverse water uses (washing machines, flushing toilet, bathrooms, gardening, car washing), this water user uses high water volumes, therefore, now the need to control their water consumptions as they are paying for the water before usage. Critiques against the introduction of PPWMs is in low-income households as they do not consume a high volume of water but mostly the affluent that live in luxury with high consuming water uses (swimming pool, washing machines, water) and the institutional customers (government facilities and industries).

Table 4.5: Chi-Square Tests of monthly money spent on water and the size of household for the different PPWMs users

Chi-Square Tests

PPWM used		Value	df	Asymptotic Significance (2-sided)
Household	Pearson Chi-Square	5.573	6	0.473
	Likelihood Ratio	6.829	6	0.337
	Linear-by-Linear Association	0.011	1	.918
	N of Valid Cases	65		
Communal Standpipe	Pearson Chi-Square	14.897	6	0.021
	Likelihood Ratio	14.010	6	0.030
	Linear-by-Linear Association	4.935	1	0.026
	N of Valid Cases	256		

A cross tabulation was conducted to analyse the relationship between the monthly income and size of a household of the different PPWMs users. Results presented in *Table 4.5* show that there is no significant difference as p=0.473 in the individual PPWMs users. There is a significant difference between the size of household and the money spent on the water with a p=0.021 which p<0.05. The respondents were asked if they had ever faced a situation whereby they lack money to purchase water. Results show that about half of the respondents in all towns had at some point faced a situation where they lack money to buy water units. The respondents find other alternatives to getting water from other community members as there are no other alternative water sources such as dams (*Figure 4.21*).

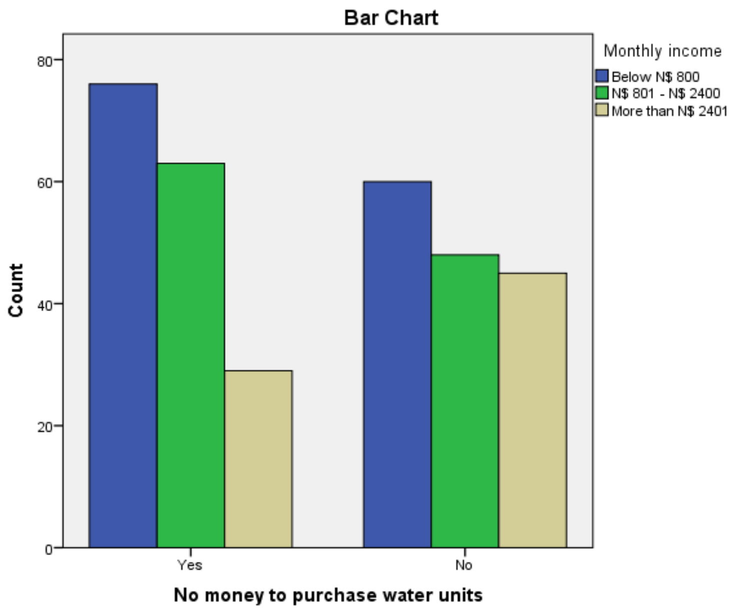

Figure 4.20: Relationship between monthly income and inability to purchase water units

Results of the cross tabulation indicated that X^2=6.682, df=2, p=0.35, therefore there is a significant difference between the money income and respondents running out of water units due to lack of money as p<0.05. From *Figure 4.21*, 68 % of those respondents who run out of water units get their water from neighbors for free and 16 % get water from their neighbors after paying a fee. Some respondents said the cost of water depended on the neighbor, but some charged N$5 (US$0.30) for 25L in Usakos Ongulumbashe informal settlement. This could mean that the respondents are spending more money in buying water from their neighbors.

It was noted from the FGDs and interviews that some residents in the informal settlements do not have their own tokens but depend on their neighbors, this was mostly because they perceive the token to be very expensive. As for the individual water meter users that had debts with the municipalities and they also depended on their neighbors. An example is in Usakos Damara location where two neighbors share water services and a pit latrine.

Some respondents depended on their family members either in the same area or another suburb (*Figure 4.21*). In DRC informal settlement, the respondents got water from family members from nearby residential areas such as Mondesa and Tulipamwe where they use conventional meters. In Usakos, 20 % of the respondents in Saamstan informal settlement got their water from a family in Hakaseb and Erongosig suburbs. Results show that five percent of the respondents store water in their houses but in the case of an unexpected malfunctioning meter. This is mostly for the individual PPWMs users. Respondents of less than five percent stated that when they run out of water units, they had to wait until they had money to recharge their tokens. The respondents in the meantime have to rely on asking for water from their neighbours. A respondent in Swakopmund standpipe PPWM user said: "*No water units means no water*". They therefore just depend on neighbors to get water or community member for help in getting water at least for drinking and cooking. A respondent in Usakos stated that he does not have a token, so he helps out the community do work for them in return for getting money or water.

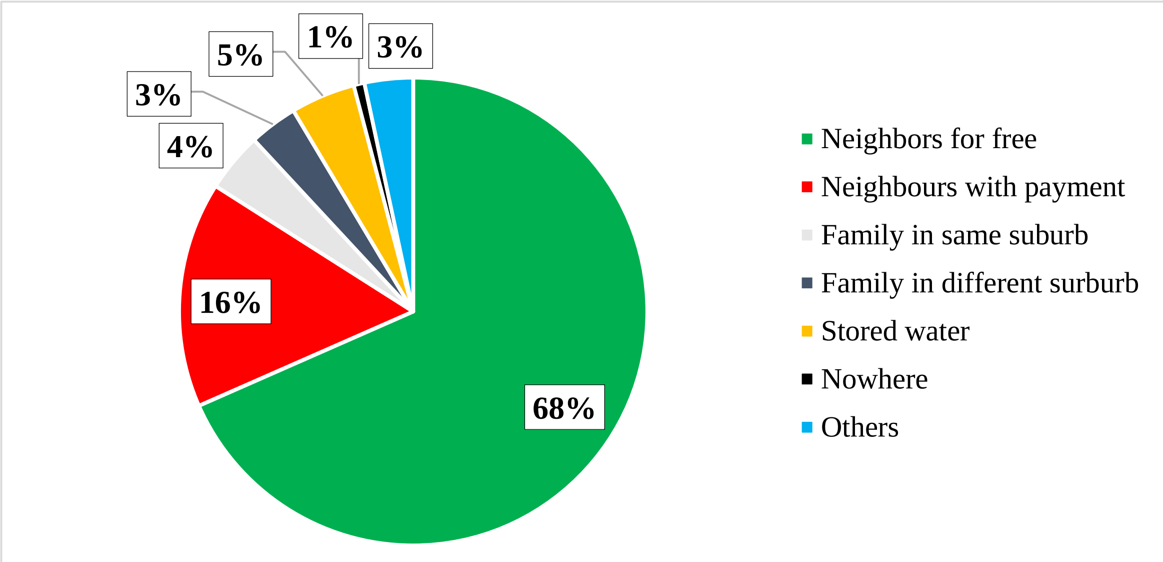

Figure 4.21: Alternative sources of water for respondents in Karibib, Swakopmund and Usakos Town

The study found out that prepayment of water exacerbates the burden and the stigma of poor families that cannot afford to buy water. Less than ten percent of respondents in DRC informal settlement and less than 15 % of respondents in Usakos informal settlement said that they do not own tokens as they were too expensive. These residents said they depended on their neighbours for water by giving a monthly fee to recharge the token to withdraw water from the standpipe for less than N$20 per 100L (US$1.33 per 0.1 m^3). This means that the respondent without a token pays US$13.30/$m^3$ which is not much difference as the UCT sells water for US$0.98/$m^3$. However, other neighbours might be selling water for more than that price.

One of the unemployed respondent in DRC informal settlement helps out the community by traveling to the standpipe to get water for them and in exchange gets water from them for free or however they can pay him. Throughout the interviews, both community leaders and community members commented on the issue of non-affordability. Community members pointed out that there are people in the community who are unemployed or without steady jobs that have trouble buying water. The prepay system for both users does not have any preventive measure to ensure that those who cannot afford water are not denied access.

In the study area, there are no other alternative sources of water apart from tap water in the towns. In South Africa KwaZulu-Natal an outbreak of cholera broke out in 2000 infecting 113,966 people after PPWMs replaced communal standpipes (Harvey, 2007; BPRA, 2015). In the United Kingdom, PPWMs were associated with an increase in dysentery when families self-disconnected after being unable to pay for service (Public Citizen, n.d.). No information on any disease outbreaks was gathered for this study.

4.5.2 Perceived water use changes after the installation of prepaid water meters

This section will focus on the water use changes of PPWMs users as compared to the use of conventional meters to PPWMs. Water use activities that were analyzed are as follows: washing laundry; bathing; watering plants; watering vegetable gardens, flushing toilet; and other activities such as car washes and small business that use water as a product (traditional beer brewery). The different water use changes were categorized as: increased (more water is used), decreased (less water is used), has not changed (no changes or differences noticed) and not applicable (activity was not performed).

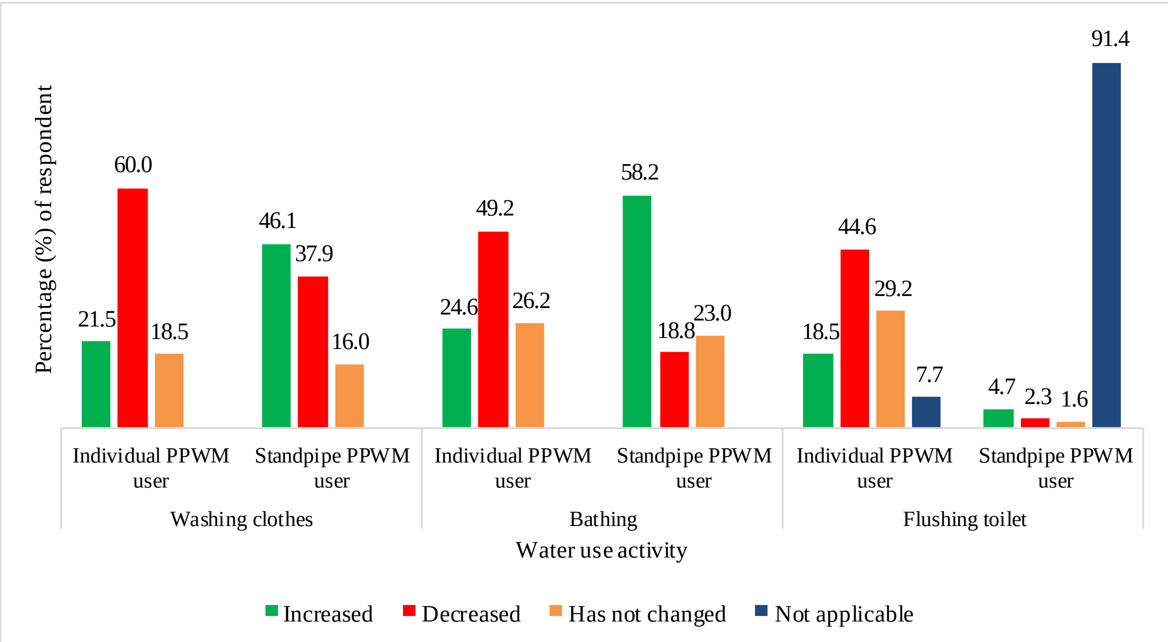

Figure 4.22: Water use changes after the installation of PPWMs (washing clothes, bathing and flushing toilet)

Individual PPWM user's results indicate that respondents perceive their water use activities to have decreased after the installation of PPWMs in washing clothing and bathing activities with 60 % and 49.2 % respectively (*Figure 4.22*). Different to standpipe PPWMs users their water use activities for washing laundry and bathing has been perceived to have increased with 46.1 % and 58.2 % respectively (*Figure 4.22*). According to other studies with the introduction to PPWM's users have control over their own water consumption (Kastner *et al*., 2005; Kumwenda, 2006; Tuovinen, 2013; Heymans *et al*., 2014). However, the results show that it has reduced for the individuals and increased for the standpipe users. This could be that with the standpipe users, the local authorities have expanded the water services in the informal settlement allowing wider spread distribution of water points and more water points increasing the accessibility. As for the individual PPWM users they have had water connections and are in control of their water consumption and can only use water of which they have paid before consumption.

Figure 4.22 indicate that 91.4 % of respondents that use prepaid standpipes do not use water for flushing toilets, they use the unimproved sanitation. Though there was an increase in the water used after the installation of PPWMs (less than five percent for those that use flushing toilets). The informal settlement lack improved sanitation facilities as the community in the informal settlement used self-made pit latrines and open defecate in bushes, shared toilets and bucket system. Open defecation was mostly prominent in Karibib and Usakos as the informal settlement area surrounded by bushes. However, in DRC informal settlement, there are open spaces as there are no trees or shrubs in the area. However, some informal settlers have toilets which can flush and most of them said that they reuse the water from the washing of dishes or clothes to flush their toilets.

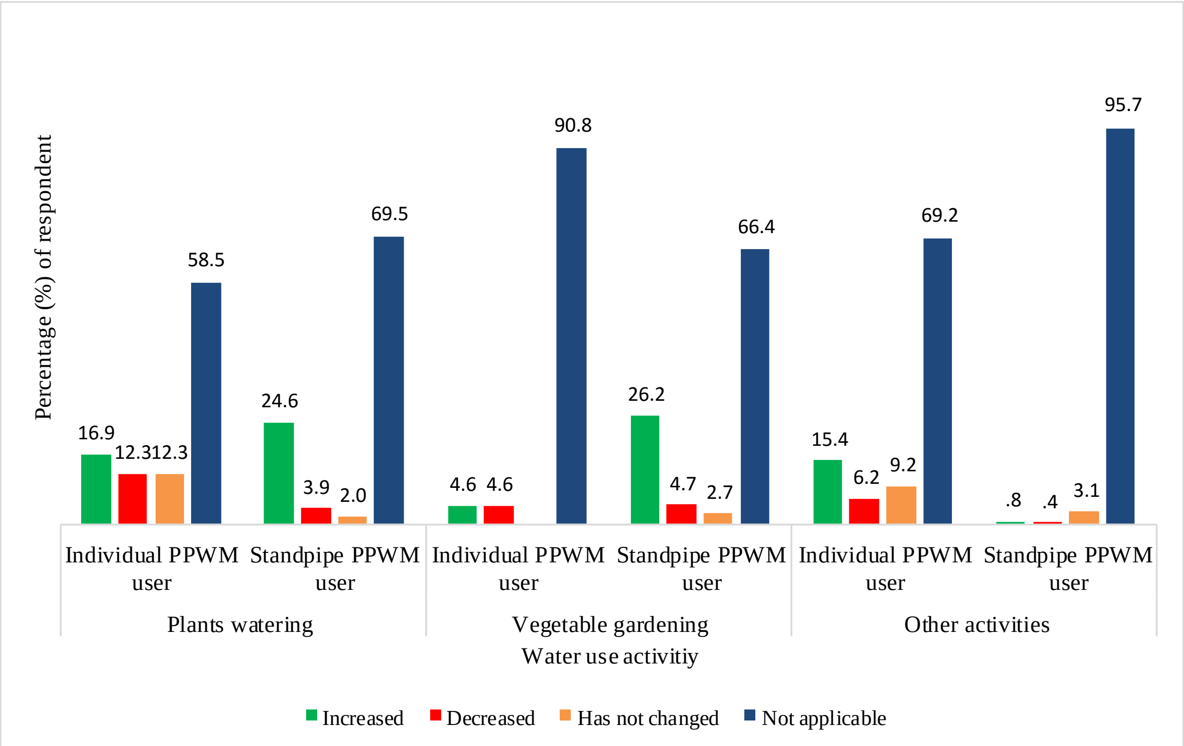

Figure 4.23: Water use changes after the installation of PPWMs (watering plants, vegetable gardening and other water activities)

More than 50 % of each of the PPWMs users did not have plants in the yards or plots. This can be justified by the fact that Erongo Region is the driest. It is a semi-arid environment where the rain can be less than 200 mm annually. Plants watered included: trees, lawns and flowers. Even though the sampled areas are dry, succulent types of plants were noted. The succulents are adapted to the dry environments (*Figure 4.23*). Respondents for both PPWM users perceived that as compared to the conventional meters they now use more water for watering plants with individual PPWM users (16.9 %) and standpipe PPWM users (24.6 %). However, it was noted that the no change and the decrease in watering plants for individual PPWM users were the same all with 12.3 %. The increase with standpipe water users could be related to the fact that water is now easily accessible and affordable which they can use the extra water to water plants.

Vegetable gardens were not highly practiced by individual and standpipes PPWM users with 90.8 % and 66.4 % respectively *Figure 4.23*. The results show that only less than 10 percent of individual PPWMs practice vegetable gardening.

Figure 4.23 show that for standpipe users less than 35% of the respondents practiced gardening and with 26.2 % of them using more water more since the introduction of PPWMs.

Other activities have also increased the water amount used by standpipe users, respondents that have traditional breweries have said that they can now get more water to do their business. This, however, can be either the change in economic development in their areas that their business is growing and not directly not due to the fact that PPWM were installed. Individual PPWM user's respondents stated that activities such as car washing and sprinkling water before raking the yard has decreased after the installation of PPWMs. A respondent in Individual PPWM user in Usakos stated "*I do not wash my car anymore, I just use a wet cloth to dust it. I cannot afford to waste water*". Users are now cautious about the water consumption patterns. The study conducted in Otjiwarongo showed that the water consumption volumes of PPWM users decreased after the installation of PPWMs in their households, the reasons were due to the high water tariff that was introduced with the PPWMs thus reducing the water usage activities (Saes, 2012).

4.5.3 Water accessibility

In all towns on average, the majority of water users walk less than five minutes to the nearest PPWM standpipe (Karibib 70 % and Usakos 95 %). With regards to the time spent fetching water, most of the respondents in Swakopmund about 65 % reported that they spend an average of more than one hour fetching water, while in Karibib it was 50 % of the respondents. Usakos seems to have the most efficient service as the majority of the respondents (about 95 %) stated that they spend less than 15 minutes at the standpipes.

It was expected that the households that have stayed in the informal settlement for a longer time could have standpipes closer to their houses as they could be the ones that initiated where the standpipes could be placed. From the study, the informal settler's water services have improved as water is now more accessible than before as they used only one communal postpaid standpipe. According to oppression against prepaid water, it is expected that PPWMs are not a choice of the poor in need of improved water services, but a choice of corporate water multinationals and bureaucrats far removed from reality (Public Citizen, n.d.).

It was observed, that some standpipes in all towns but mostly in Swakopmund are broken and residents have to walk long distances to find a functional standpipe in the community and queues at those standpipes are longer. In Swakopmund, the population size is bigger as compared to the number of standpipes in the community thus people spend longer times in the queues. In addition, the busiest times that residents spend more time in the queues are early morning, late afternoons and during the weekends. In Karibib and Usakos it was observed that residents do not go and fetch water mid-day as the sun is very hot.

4.5.4 PPWMs' reliability

The study tried to investigate perceptions of households on the reliability of the PPWMs. About 40 % of households with individual PPWMs and about 85 % of households using communal standpipe stated that they faced technical problems in using the PPWMs (*Figure 4.24*). When meters breakdown, residents have to walk longer distances to the next functioning meter. The standpipe PPWMs is a multi-user meter. This is the main reasons as to why they are the ones that mostly fail to work as compared to the individual meters. The PPWMs battery has a life span as discussed early. According to Heymans *et al*., (2014) and Shikongo (2016), their studies revealed that unreliable PPWMs calls for bypassing, vandalism and tampering as the users have paid for the services.

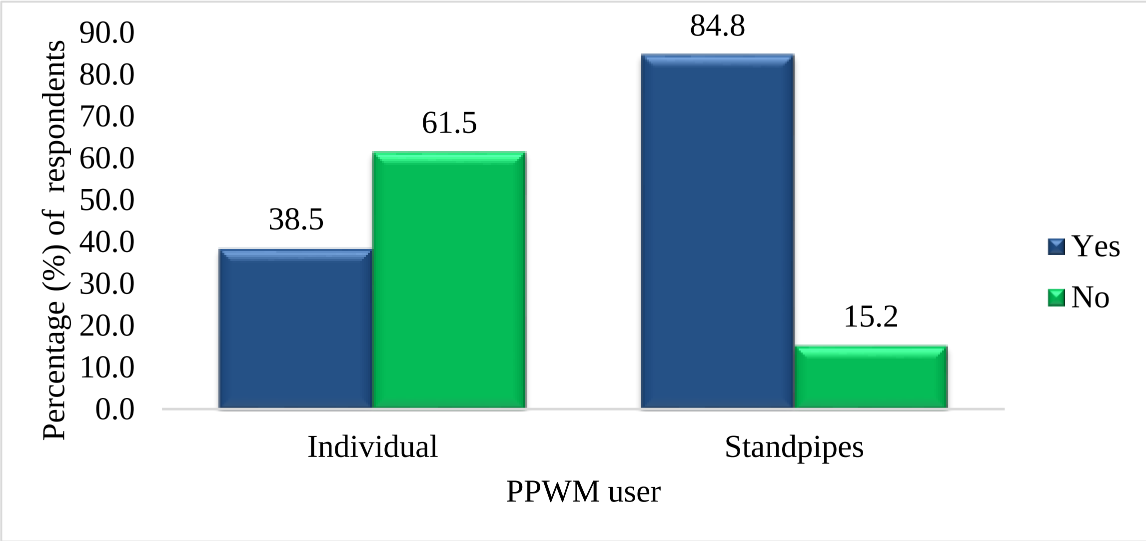

Figure 4.24: Prepaid water meter failing to work

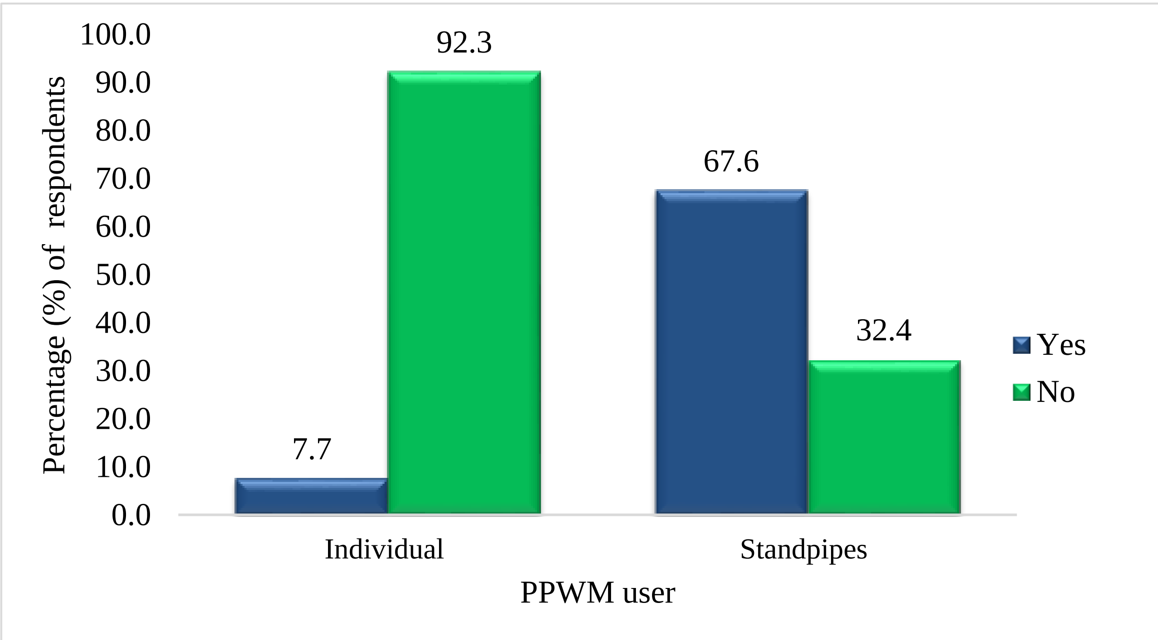

Figure 4.25: Losing water units from the PPWMs by respondents

Individual PPWM users (7.7 %) and standpipe PPWM users (67.6 %) respondents answered that the problems they faced with PPWMs include losing water units from the use of the water meters (*Figure 4.25*). Respondents stated that when they fetch water, even when the flow at times is slower than usual the units would still be decreasing just as fast as if water flow was normal. This was said to be common with the standpipes and mostly reported it happened when the meters are malfunctioning or soon after the meters had been repaired. Such rapid loss of units was also confirmed by sellers of tokens who stated they received such complaints on a regular basis.

It was also suggested that the municipality reimburses customers for the credit lost on their card when a meter malfunction. The PPWM suppliers said that the tokens have a lifespan of one year and after it starts malfunctioning. The local authorities confirmed the allegations however, they said that the tokens are customer's responsibilities to take care and keep them safe from causing them not to be read by the PPWMs.

4.5.5 Training on PPWMs operations

Through questionnaires, FGDs, observation, and interviews with municipalities, community leaders and with residents they expressed that the common training given to residents on how to use PPWMs included how to insert tokens into the unit, when to remove the token from the unit, how to withdraw water and how to read water units from the meter display such training were conducted at the standpipes. As for the municipalities, they showed the respondents how to insert the tokens. This could be due to the lack of stakeholder participation in the introduction process. The Access to information, accountability and stakeholder participation is important in achieving human right to water. The information is supposed to be accessible and understandable to everyone, including, for example, people who speak a minority language or are unable to read (UN Special Rapporteur, 2008).

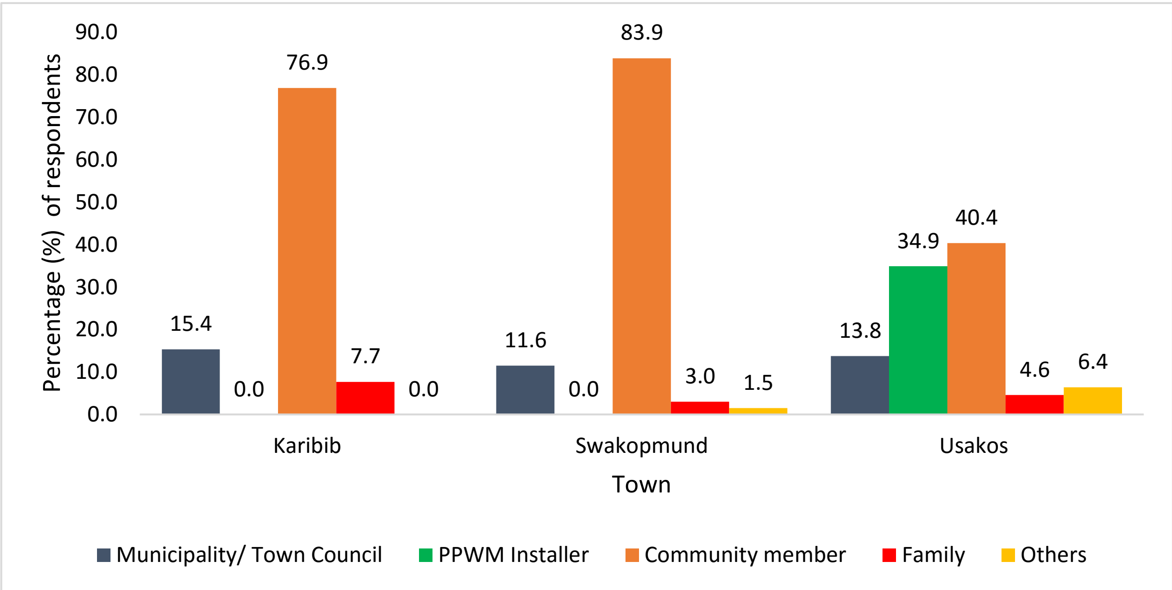

Figure 4.26: Respondents source of training for PPWM operation

4.6 Perceived challenges that respondents face with the prepaid water metering system

Below some of the perceived challenges are further discussed. *Figure 4.27* indicates that 12.3 % of the respondents said PPWMs are inefficient in terms of operation, 10.4 % said they stand for a long time in the queue at standpipes, 8.9 % an individual PPWM users do not understand the two systems of payment for individual PPWM users as.

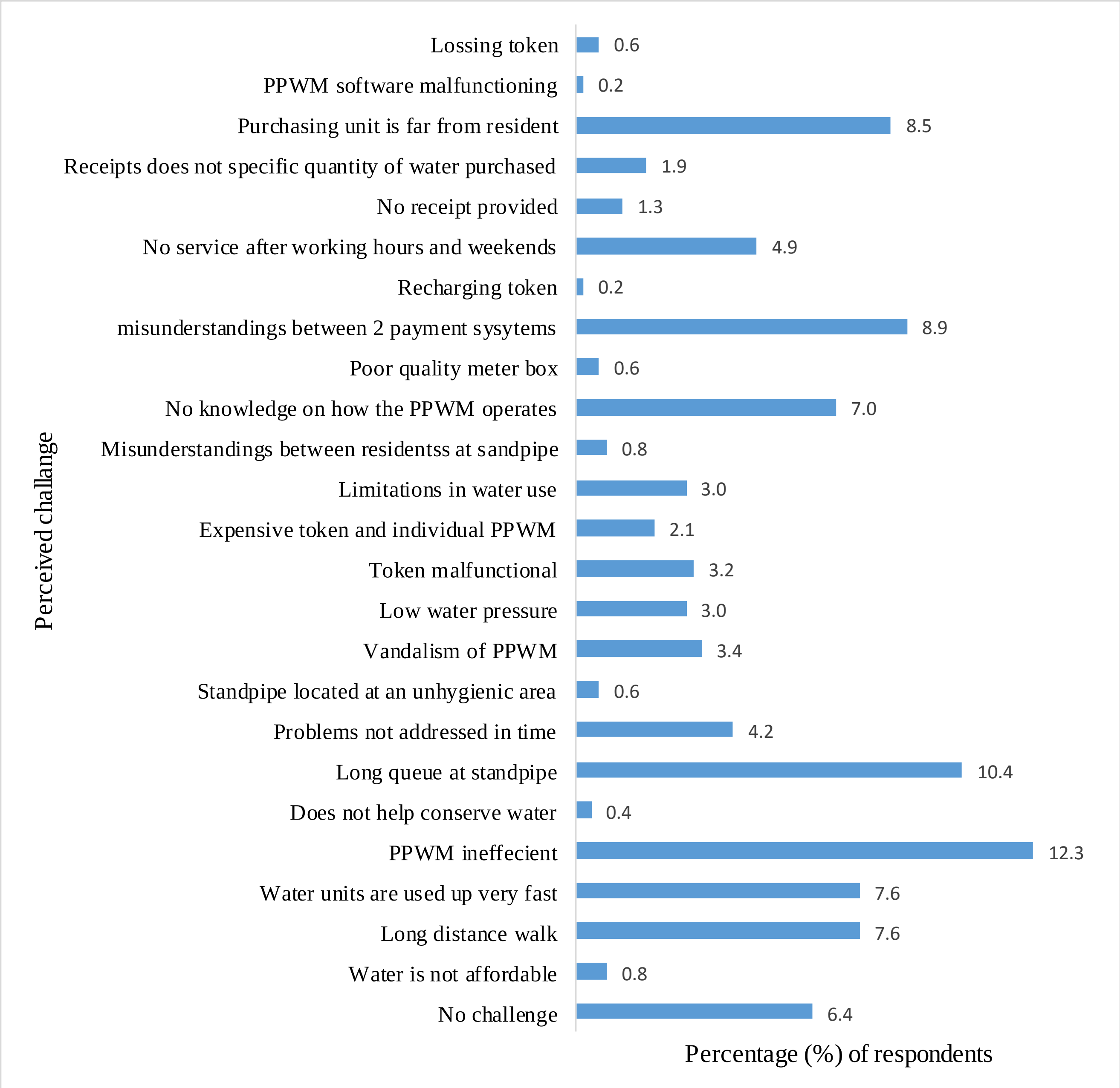

Figure 4.27: Perceived challenges of PPWMs in Karibib, Swakopmund and Usakos Towns

4.6.1 Purchasing water units

In Karibib there are two purchasing stations, both at the offices one of which is at the head office of Karibib Town Council in town and the other one at the Town Council Multipurpose Hall in Usab suburb. The Town's Hall is within a kilometer from the Usab informal settlement while the KTC head office is 2.5 km from the Usab informal settlement. This means that both purchasing stations are within walking distance from Usab. The KTC official operating hours are 08h00-17h00 on weekdays only with no operations during weekends and public holidays.

The Swakopmund Municipality head office situated in town operates on weekdays only during official working hours of 07h30 to 16h30. The head office is situated five kilometers away from DRC informal settlement. However, in DRC informal settlement there are two handheld vending machines that operate all days of the week and on public holidays as well (*Figure 4.28)*. The purchasing places names in DRC informal settlement are Embwida Water Pre-Paid and Hoki Pre-Paid Water Tuck-shop.

Results from the household survey indicated that more than 85 % of respondents purchased water units from Embwida Water Pre-Paid shop and less than five percent purchase from the Swakopmund Municipality head office. The respondents that buy water units in town mostly do so as they work closer to where the tokens are sold. Respondents have a perception that they get more water units when they purchase in town than when they purchase from the kiosks. However, Coordinator Works Assistant at Swakopmund Municipality stated that it was not the case as both the Municipality and vendors in DRC informal settlement sell the water at the same price. As for the Hoki Pre-Paid Water Tuck-shop, less than 15 % of the respondents stated that they purchase from there. It was noted that the participants did not know of any other place to purchase water other than Embwida Water Pre-Paid shop. Reasons for this could be related to the fact that Embwida Water Pre-Paid shop is on the main road into DRC informal settlement as opposed to Hoki Pre-Paid Water Tuck-shop situated far from the main road.

The prepaid water vendors in DRC informal settlement said that they mostly buy bulk water before the weekends, month ends and public holidays. This is due to the fact that the Municipality offices do not open on weekdays and public holidays. The prepaid water vendors purchase bulk water credit from the Swakopmund Municipality head office using the vendor's token. The vendor uses the vendor's token to operate the machine with a password. In Usakos and Karibib consist of a personal computer, a token reader and a printer which are operated by the cashiers.

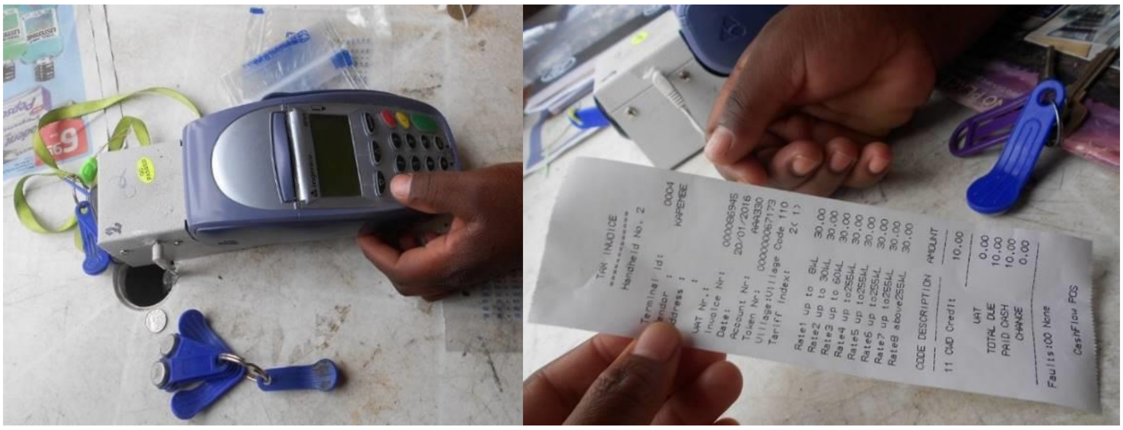

Figure 4.28: Handheld vending machine and a receipt printout for a customer at Embwida Pre-Paid Water shop

The Usakos Town Council head office situated in town only operates between 07h30-14h30 weekdays only and is situated three kilometers away from the Hakaseb suburb. At the time of the study, another branch of the Usakos Town Council's office was being constructed in Hakaseb suburb which is one kilometer away from the suburb which will bring the services closer to the users.

Participants were asked if they had ever experienced problems with the times they could purchase credit from the municipality offices or vending shop. About half of the respondents stated that they found that the time the shops operated very inconvenient while about the other half were of the opinion that the times were convenient (*Figure 4.29*). As the local authorities operate during the official business time (07:30/08:00 a.m.-16:30/17:00 p.m.) customers face challenges when water credit run out should they need to purchase after business hours. From the survey and semi-structured interviews, the PPWM users would have to wait until Mondays to purchase water units when water credits run out during the weekend or on a public holiday.

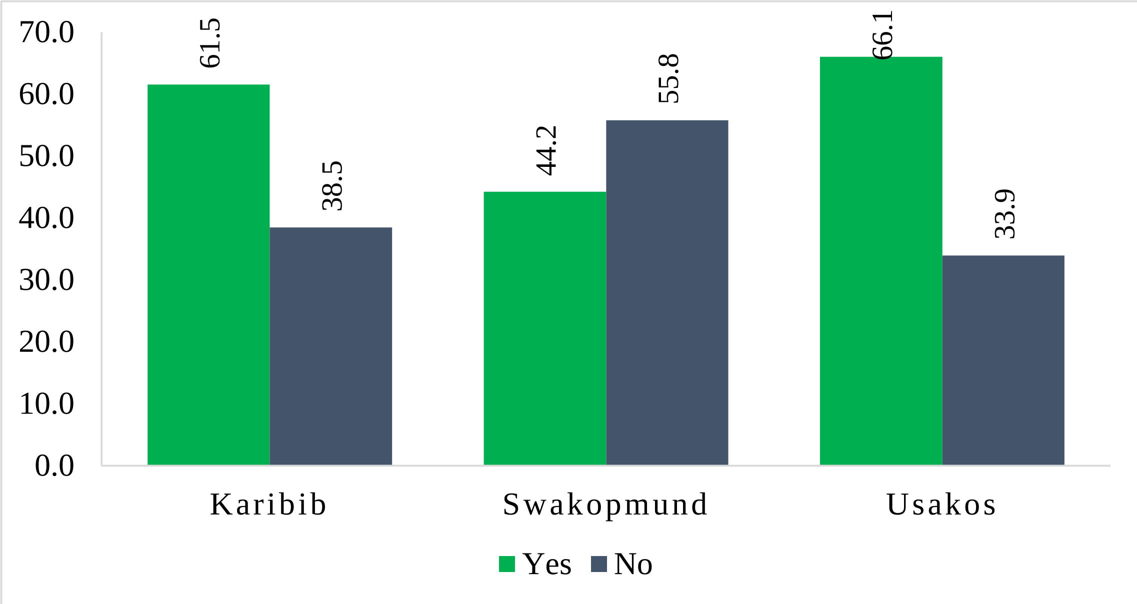

Figure 4.29: Problems with the time of purchasing water units

The participants were asked which times they would prefer to purchase water credit, and the results are depicted in *Figure 4.30* below. The highest percentage of respondents in Karibib and Usakos said they would like services to be available on the weekends as they are currently in place. As for Swakopmund they prefer weekday's morning times to be more convenient as they have to go to work, some respondents said 7 am would be convenient as the vendors open at 8 am.

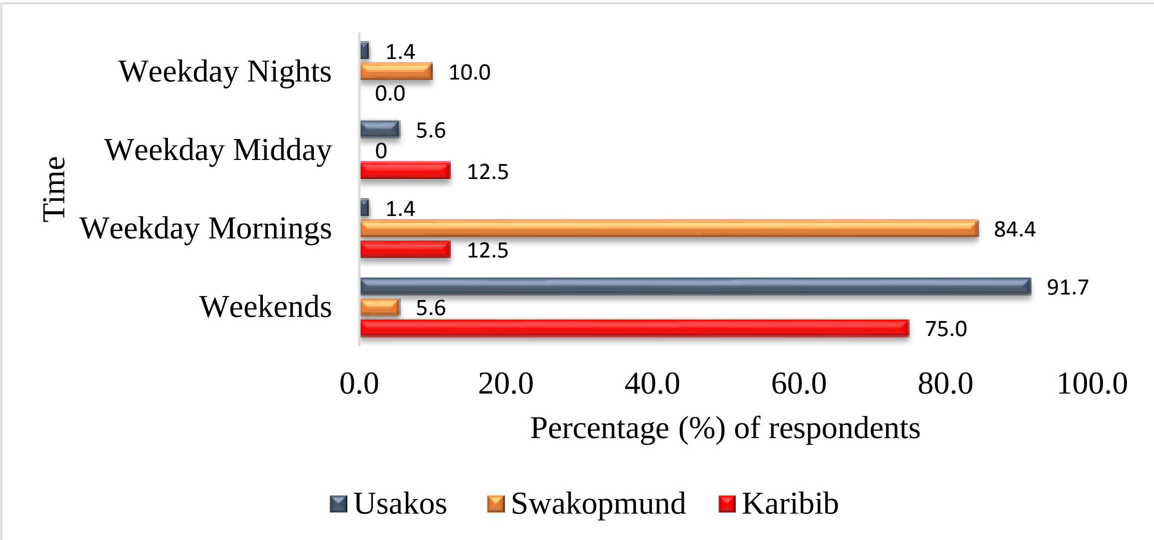

Figure 4.30: Convenient times for purchasing water units

There are no purchasing services in Karibib and Usakos after working hours, weekends and on public holidays. Of the respondents, more than 60 % stated that they had a problem with the times of purchasing. A Chi-square Test revealed that there is no significant difference (X^2=7.694, df=3, p=0.053) between the customers that had a problem with the purchasing times and convenient purchasing times by respondents from the cross tabulation in *Table 4.6*.

Table 4.6: Relation between problem with the times of purchasing water units and convenient time to purchase water units

Relationship between problem with time of purchasing and convenient time of purchasing

% within Problem with the times of purchasing water units		Convenient time to purchase water units			
		Weekends	Weekday Mornings	Weekday Nights	Weekday Midday
Problem with the times of purchasing water units	Yes	45.2 %	46.4 %	5.4 %	3.0 %
	No	50.0 %		50.0 %	
Total		45.3 %	45.9 %	5.9 %	2.9 %

The survey indicated that the majority of customers (41 %) prefer purchasing tokens weekly which the highest preference while about 18 % stated that they preferred to buy the token daily (*Figure 4.19*). The reasons given for this were varied. Some respondents said at times they did not have money to purchase the tokens once off at the end of the month thus they buy them weekly. Whilst others said that they recharged weekly in case their tokens get lost or stolen. If a token is lost the loss would be double as they would have to pay for the replacement token, and they would also not be able to recover the money already spent on recharging the token.

In Karibib challenges experienced with the software are that when a token is inserted it indicates 'Enter the token', token not registered in that town. The Cashier at KTC stated that tokens from Otjimbingwe have been reported to be common in Karibib as it is one of the towns that also use the same type of PPWM Lesira-Teq (Sitwira, 2016). As for Swakopmund Municipality, no analysis has been done due to lack of manpower dealing with the software.

It was observed that DRC informal settlement does not have electricity thus the vendor's vending machine's battery experience low battery causing the vending machine not to function (Nshamba & Martinus, 2016). Hoki tuck-shop uses a solar energy to charge the vending machine. Nonetheless, challenges are faced due to the fog days in Swakopmund (Nshamba, 2016). Losing the vendors token or forgetting token password can make one not to operate the vending machine. At times the purchased water units do not show on the respondents token which brings about misunderstandings between the vendors and the respondents.

4.6.2 Recovering respondents' lost token

The prepaid software's have a function of blocking tokens. Respondents whose tokens are stolen or lost can report the case to the municipality and the token can be blocked so that it cannot be used to purchase water. However, if the token still has water units whoever finds the token can still withdraw water from the standpipe. As per rules, it is only the registered owner of the token that can request for the token to be blocked and token available status of the token as to reduce fraud cases. In cases where the registered owner of the token is not available, a police declaration is needed to state that the person requesting that the token is blocked is authorised to do so.

In Swakopmund, this is service is offered by the Swakopmund Municipality Work's section whilst in the other two towns is at the Town Council's head offices. The survey established that 30.8 % of the households on the PPWMs in Karibib, 81.5 % in Swakopmund and 11 % in Usakos respondents had lost their tokens before. The study established that there are high cases of lost tokens in Swakopmund DRC's informal settlement due to the stolen tokens. This could be attributed to the fact that Swakopmund population is approximately 10,000 people in the informal settlement. In Swakopmund, it was observed that some respondents have bought more than one token per household as a strategy of avoiding the loss of the token which might result in a lack of access to water.

Tokens that are found in the community are handed over to the Embwida or Hoki Pre-Paid Water Shops in DRC informal settlement or the local authority offices. In addition, if someone goes to recharge a block token, the sellers are authorized to confiscate the token. According to the water vendors, it is risky to confiscate the token as respondents do not understand that the token was blocked as some of them would have bought the token in the community. The Municipalities, therefore, prints out a list of found tokens with owner's name and identification number for token collection. The list is displayed at the prepaid water shops and the local authorities' notice boards.

If the token is not found, the respondent has to buy a new token at the token's price exclusive of water units. It was observed that respondents did not know of the process of blocking tokens when they are lost or stolen. In addition, the water vendors in DRC informal settlement said that not all respondents can read or understand the purpose of the list. The Coordinator Works

Assistant highlighted that there have been tokens that are not collected in more than 3 months (Kotze, 2016).

4.6.3 Standpipe prepaid water meter battery

The Kent Elster standpipe has a replaceable battery designed for five to six years life span and is meant to supply to one household. The study found out that the Swakopmund PPWM standpipes batteries are replaced within every six to seven months. Studies revealed that batteries power may fall as little as three months were PPWMs are intensively being used mostly in densely populated areas. In Windhoek, it was found that batteries are proactively replaced after every 18 months (Heymans *et al*., 2014).

The Operation Manager at Swakopmund Municipality stated that this is mostly associated with the fact that the number of households using the standpipe is too high as opposed to the design. According to Water Works superintendent at SM "the standpipes are working overtime". When the PPWMs battery runs flat the PPWM stops operating and to fix this a new battery needs to be replaced. Water users are affected by this as the PPWM completely stops working. Users have to find other alternative standpipes.

4.6.4 Vandalism of PPWMs

In Swakopmund, approximately 94 % of the problems the standpipes face are due to vandalisms from within the community according to the Operations Manager at Swakopmund Municipality. The study found out that no fines or penalties are in place for vandalizing the prepaid standpipes. According to Superintendent Water Works at Swakopmund Municipality, the standpipes' valves are tempered by using a wire or a spoon and when the meter box is smashed, it causes a free flow of water. At times the water pipe is removed from the standpipes by unknown people. Respondent in DRC informal settlement said "*the children remove the water pipes to play with them. Parents need to tell their children not to play with the standpipe*". It was noted in DRC informal settlement that when the standpipe does not have the water pipe, a lot of water is wasted as it does not flow directly into the water containers.

When the token is pressed in and out repeatedly it causes the malfunction on the token port. Furthermore, when the standpipe box is hit, this causes the battery and the meter to trip which either causes free or no flow of water. If the PPWM is tampered with, the dispenser's system shuts down allowing not water to flow (Elster Metering, 2016a and 2016b). However in other cases, a free flow of water is also common, mostly in DRC informal settlement. Towns like Tsumeb and Otjiwarongo use the Kent system and it is reported that the Kent system is easily tampered with (Shikongo, 2016). In Otjiwarongo, it was found that residents tamper with the underground water pipe that supplies water to the PPWM standpipe (Saes, 2012; Shikongo, 2016). Other types of vandalism include the stealing of copper wire that is found in the meters as a case of Tsarax-Aibes informal settlement in Otjiwarongo (Shikongo, 2016).

4.6.5 Token malfunctioning

The study established that the token malfunctioning is a challenge that respondents face with the PPWM system. The PPWMs take the time to read the tokens causing those who are impatient to insert and remove the token multiple times before water starts to flow. The respondents said that this wastes a lot of water and it increases the time spent at the standpipe inconveniencing other people in the queues. It was observed that respondent admitted that they scratch the token magnetic button on the meter box when it fails to read the token as they perceive it to improve its performance.

In Swakopmund, the tokens that are malfunctioning are submitted to the Work's section of the Municipality. It was reported that in some cases the meters would indicate token is corrupted' or 'token tampered with' on Cashflow system. In such cases, the respondents would have to purchase new tokens. In Cashflow software, a respondent's token is registered under the following status: available, lost/stolen, blocked and faulty.

A study conducted in Otjiwarongo (Saes, 2012) and Tsumeb (Shikongo, 2016) also revealed that the standpipe users tokens malfunctions which are time-consuming as the users have to remove and insert the token multiple times. This causes long waiting queues especially after working hours and over the weekends. In Tsumeb informal settlements it was stated that fights break out over the weekends especially if a user has multiple containers to be filled (Shikongo, 2016). However, the fights at standpipes were not noted or mentioned by the respondents in Erongo Region.

4.6.6 Prepaid water meters technical challenges

As discussed why prepaid water lag behind from electricity prepayment, the water meters had water flowing through them which can be affected by technical problems such as debris in water and water pressure. The study noted that the common problems reported were value faults, software problems and battery power being low (Kumwenda, 2006; Saes, 2012; Heymans *et al*., 2014; Shikongo, 2016). The response of where residents report problems related to the PPWMs showed that the highest percentages of users for all the three towns reports to the local authorities Karibib (100 %), Swakopmund (72.4 %) and Usakos (78.9 %) as shown in *Table 4.7*.

In Swakopmund, the results show that a few respondents report to the prepaid water vending shops of less than three percent and six percent to the DRC's Community Committee. From the interviews held with the water vendors and the DRC Community Committee, complaints are then reported to the municipality. It was noted that the respondents do not have any contact numbers of the municipality or to the relevant people they are supposed to report problems to.

In Usakos alone, less than two percent of the respondents reported problems regarding the PPWMs to the PPWM installers. In the town, there are two locals that were trained by the installers on how to address problems with the meters so some residents still consider them as helpful. However, results show that in Swakopmund (19.1 %) and Usakos (19.3 %) the respondents did not know where to go and report problems related to the PPWMs (Table 4.7). The study by Seas (2012) found out that the Otjiwarongo Municipality had written the contact number of the technician on the standpipe PPWM and it was recorded that their call center received about 20 calls of complaints per day (Saes, 2012). The number of complaints or the type of complaints with the PPWMs in the sampled towns was not noted as some respondents said they do not know where to report the problems.

Table 4.7: Where respondents reported problems related to the PPWMs in their town

Where to report problems with PPWMs by respondents	**Town**		
	Karibib	**Swakopmund**	**Usakos**
Municipality/Town Council	100 %	72.4 %	78.9 %
Prepaid water vending shop	-	2.5 %	-
DRC committee	-	6 %	-
PPWMs Installer	-	-	1.8 %
Do not know	-	19.1 %	19.3 %

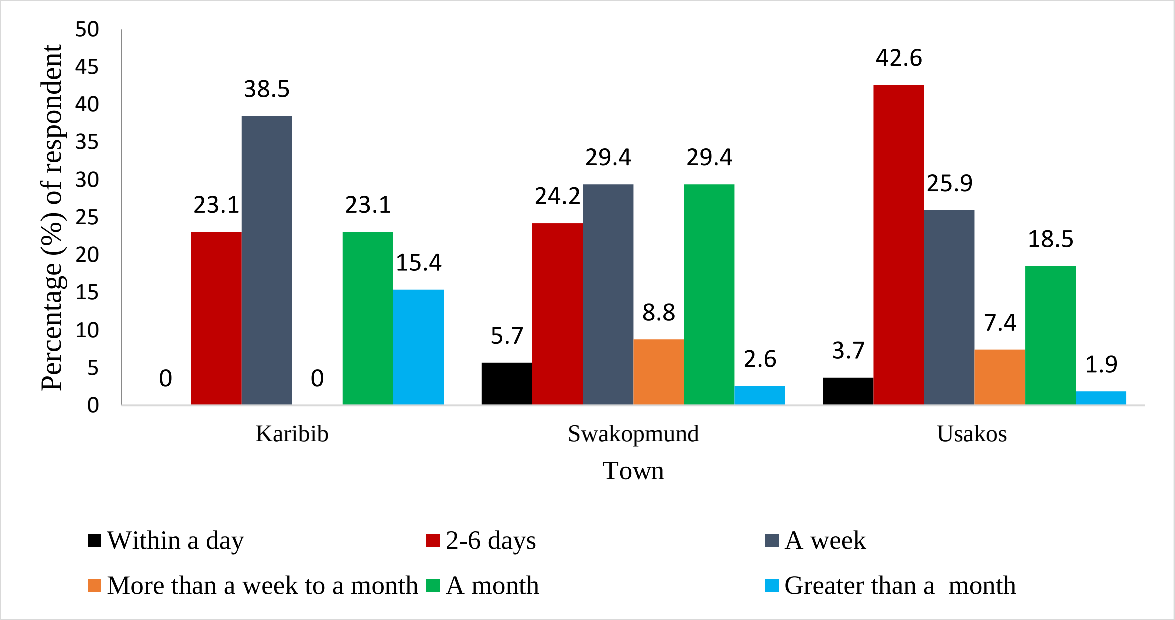

Figure 4.31: How long it takes for the PPWM problems to be addressed

From interviews with the municipality officials, addressing problems pertaining the PPWMs is their responsibilities. The local authorities are the ones in charge of the monitoring and maintenance of the PPWMs. Through interviews with municipality officials, observation, FGDs, and survey with inhabitants they expressed that it can take more than a week on average for technical problems with the PPWM to be addressed. In Tsumeb Municipality, it's technical staff are the ones responsible for the maintenance of the PPWMs (Shikongo, 2016). According to Heymans *et al*., (2014) the performance of the prepaid water metering technology is still inconsistent as meters breaks down and the necessary people to fix the faults or the spares components are not readily available.

The results shown in *Figure 4.31* indicate that in Karibib standpipes PPWM user's respondents said none of the technical problems were addressed within a day and 15.4 % of them are addressed after more than a month. Swakopmund respondent's results showed 29.4 % for both problems being addressed in a week and within a month. In Usakos, problems with the PPWM user's respondents indicated that 42.6 % of the problems are addressed within two to six days. This could be explained by the fact that Usakos town has local technicians in the community which were trained by the PPWM installers.

During the times that the meters are not working, respondents for standpipe users have to walk to the closest functional standpipe. As for the individual users, the respondents have to get water from their neighbours. *Figure 4.21* shows the alternative sources of water that the respondents use in cases when the meters are not in use or have no money of their water tokens. The

Swakopmund Municipality monitors and does maintenance of the standpipes in DRC informal settlement. The SM Superintendent Water Works stated that the routines entail servicing on all meters for every two weeks but at times they face manpower problems (du Plessis, 2016). Where the three local authorities cannot address the problem they then call in the suppliers to help out. In Swakopmund replacing a damaged token port is N$300 (US$20) and standpipe meter battery cost N$800 (US$53.30). According to Heymans *et al*., (2014) they stated that a strong customer focus is essential, the service providers should be effective to respond to customers' needs as they have paid for the water already.

4.6.7 Water emergencies

An individual PPWM user stated: "*Water can just stop when busy bathing with soap all over your body*". Water can finish during events such as weddings and funerals when there are a lot of people gathered at one place, "*The prepaid water meter does not understand emergencies*" stated a respondent. In emergencies such as fire outbreaks in the household, water units can finish and even if they would want to recharge the token, the offices or vendors shops are closed at night. There have been reports of fire outbreaks in DRC informal settlement', from the FGDs and survey, residents alluded to this as PPWM's standpipes may be far from where the fire would have broken out. But the fact that it is the household that has no water stored in the house or water units on their token, the fire can burn out everything. As there is no electricity in the informal settlement they use candles and paraffin lamps.

4.6.8 Debt recovery from individual PPWM users

With regards to debt recovery, Usakos Town Council deducts a certain amount from individual PPWM users who owe money to UTC each time a payment is made. As the customer purchases water units, 20 % of the credit is retained towards the outstanding debt and 80 % is loaded as water credit onto the token. The calculations are done by the cashier as the municipal database has all the information on debts (sewerage, water, refuse, fire levy). The UTC uses two payment system, the Cashflow (prepaid software) and Finstel (postpaid software). This causes confusions within the respondents as they do not understand exactly how they are charged.

4.7 Perceived benefits from the prepaid water metering system

The perceived benefits of the prepaid water metering system for all the three towns will be presented and discussed below.

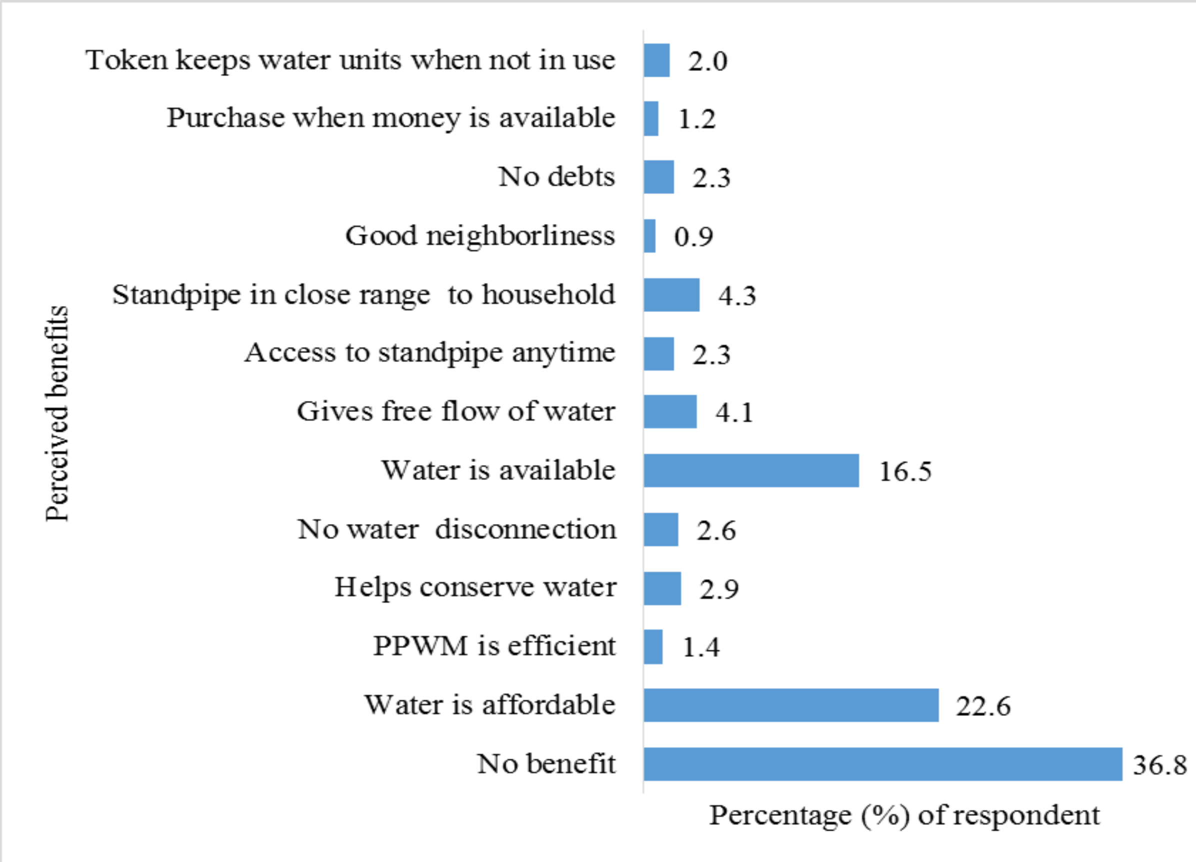

Figure 4.32: Perceived benefits of PPWM by respondents in the three sampled towns

Figure 4.32 indicate that almost a quarter of the respondents do not perceive PPWMs to have any benefits. This is related to the perceived challenges discussed earlier. The individual PPWMs users in Usakos town were the ones that mostly said there were no benefits from the PPWMs. In addition, respondents perceive water to be more affordable (22.6 %) than using the conventional meters. This was prevailing in the FGDs for the prepaid standpipe users. This could be the case, but it was also noted that the respondents did not understand the water tariffs or understand the different figures the PPWMs displayed. However, the respondent's stated that they use less money purchasing water and get more water.

Among those surveyed, they stated that water was now readily available with 16.5% of respondents in support. This is related to the fact that there are no more unexpected disconnections for not paying water (less than three percent) and no debt accumulations (less than three percent) as the system only allows them to use what they have paid for. From the survey and the FGDs, the users of standpipe PPWMs expressed that the meters are much closer to their homes and they can fetch water at any time of the day (less than three percent). This is as opposed to the time they shared community conventional metered standpipes that only operated at certain times of the day in all towns. The respondents stated that the tokens preserved the water units when they have traveled away from home and they could travel with their tokens which are safer from other community members from using it without their permission.

A respondent in Ongulumbashe informal settlement stated: "Now *you can even go fetch water at midnight, no one will stop you*". Heymans et *al*., (2014) stated that there are no limitations from landlords or beyond working hours for the water vendors. However, prepaid standpipes being installed on landlord's property, the landlords tend to personalise the meters by putting ownership to them. This disadvantages the users when on bad terms with the landlord and when they require users to pay them for the use of "their" proclaimed meters.

The standpipe PPWM users were quite open to saying that they benefit when meters become faulty as they get free flow of water that is not metered. When the water freely flows, they do not report the matter urgently but first, make sure that the community collects the water. One respondent in DRC informal settlement stated: "*When the water flows freely, we fold the pipe when everyone has filled their containers and continue withdrawing water the next day*." When asked how long they continue withdrawing water for free he said:" *It is only when someone reports to them, otherwise it can last for long as they do not monitor the standpipes every day so they will not know*".

Good neighbourliness was mentioned by less than one percent of the respondents of prepaid standpipe users. Here the respondents said since the customers token can be used in Windhoek, prepaid standpipes have been found to reduce conflicts among shared payments and disconnections (Kastner *et al*., 2005; Heymans *et al*. 2014). The respondents also stated that prepaid water metering helps as there are no water disconnections if a household has not paid and no debts are accumulated. The respondents were for the prepaid system as they could purchase water within their income levels and do not have to fall in debts. The PPWMs help users to conserve water (less than three percent) as they manage their water consumption. The individual PPWM in Usakos has useful functions, such as the user locking the meter if as an example doing out of town and also warning the user when the credit is low (Lottering, 2016).

4.8 Impacts of prepaid water metering system on local authorities

The local authorities provide water to the residents using the prepaid water metering system and with the different aims of recovery cost in the provision of water services. When a customer purchases water credit, 20 % of the money goes towards the repayment of debts owed to the local authority (Muyeghu & Sylvia, 2016). The study by Shikongo (2016) revealed that PPWM users in Otjiwarongo, 50 % of the credit when purchasing is taken towards debt recovery by the Otjiwarongo Municipality. As for the In Tsumeb Municipality, individual PPWMs are installed in Soweto and Omashaka suburbs as a debt recovery tool as only 30% of the credit is loaded onto customers token whilst the remaining is towards debt recovery (Shikongo, 2016). However, in Tsumeb's Soweto suburb some residents have resisted into paying connection fees whilst others do not purchase water units on their tokens.

When the PPWMs break down, the cost has to be covered by the municipality with the standpipe PPWMs giving free water due to faulty PPWMs. This only means that the non-revenue water is increasing instead of being reduced. The local authorities noted that they spend more money on maintenance of the PPWMs as they are faulty or the batteries power fail (du Plessis, Shingenge and Weskop, 2016). At times when the PPWM's suppliers do not have the spare parts at their office, they have to order from South Africa and this delays the effective addressing on problems with PPWMs (Shingenge, 2016). The technical officer at Usakos Town Council stated that they keep spare parts of the PPWMs at the UTC store room just in case emergencies occur which they have to address on time (Titus, 2016).

The use of standpipes PPWMs as per study shows that there has been an improvement in access to water for the residents in informal settlements as new water supply is equitably distributed as compared to a post-paid metering system where community members shared only one tap. The study conducted in Klipheuwel, South Africa concluded that PPWMs safeguarded the equitable water access by dispensing free basic water to each household every month (Kumwenda, 2006).

The Otjiwarongo Municipality is referred as the town with the success water prepayment system in Namibia as they are recovering debts from the residents. The town has 3000 individual PPWMS and 53 standpipe PPWMs installed (Saes, 2012). The town has also been praised for installing individual PPWMs in households in the informal settlement. The study by Shikongo (2016) revealed that the Otjiwarongo Municipality has engaged the users of the PPWMs before implementation by hosting general meetings and providing awareness regularly and they believed the system could collapse without doing so. "However, the government facilities owe the municipality as they have outstanding fees and there is an increase in community debts.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The following conclusions were derived from the findings, which were based on the objectives of this study:

1. The reasons for the installation of PPWMs is mainly to maximize cost recovery, curb illegal connections and recover debts. This prepayment system is mostly introduced in low-income formal households and in the informal settlements of which the studied towns formed a part. In addition, PPWMs standpipes were introduced in informal settlements as communal conventional taps, however, there was no control of how much water each household withdrew as long as they paid. Therefore, this resulted in disputes among the community members as disconnections were made if customers do not pay for the services;

2. There was no public participation when prepaid meters were introduced in each of the three towns studied as the local authorities did not initiate the customer engagement in its introduction. This lack of participation could be the reason why customers lack knowledge on how the PPWMs operates, this was particularly true for individual PPWMs owners;

3. The respondents have the perception that the use of prepaid meters was not acceptable because of the numerous problems associated with them. These problems included: inconveniences of purchasing water services on a 24-hour basis, tokens were expensive to own and replace once lost, and technical problems with the meters took too long to be addressed;

4. The PPWM had a positive impact on the standpipe users. Respondents perceived that the use of prepaid meters was better than the post-paid conventional meters. This was because access to water has improved and the prices were mostly affordable. However, numerous problems did exist, such as weak PPWM power battery, malfunctions not being addressed on time, token malfunctioning and no water purchasing services after official hours and over the weekends.;

5. Individual PPWM users were negatively impacted by the use of PPWMs in Usakos. This was due to issues concerning inaccessibility to water if municipal bills were not paid, no vending purchasing services on or after hours or over weekends, the high cost of lost token or damaged prepaid meters and the lack of knowledge on how PPWMs operate.

6. Although prepayment water metering for local authorities addresses non-payment and ensures revenue collection, the costs attached to them is often overlooked. To illustrate, customers who cannot afford water are often left with no access to water during that period. This problem was exacerbated by the lack of alternative sources of water in the studied region, leaving people to

depend on their neighbours, family (for free water) or spend their last savings to buy water. This does not only drain their pockets but they run the risk of being overcharged mostly by their neighbours.

5.2 Recommendations

Based on the findings and the conclusions drawn, the following recommendations are made:

1. There is a need for local authorities to conduct consultative meetings or workshops concerning the prepaid water metering system to the customers before installing them. Furthermore, it is still advisable to monitor and evaluate the prepaid water metering system installed;
2. As a result of this, management in the local authorities should consider increasing prepaid water vending points were customers can be able to purchase water during the weekends and after official working hours of the local authorities. These prepaid water vending points need to be located in the community where the PPWMs are installed. In addition, in order to ensure convenience and maximum customer satisfaction, purchasing of water units could be done through mobile or internet platforms;
3. Local authorities need to attend to all technical emergency issues relating to prepaid metering issues promptly. This could be addressed by training local residents in respective communities on how to address problems related to water meters. Mobile numbers of technical teams could be displayed on the PPWM standpipe in informal settlements allowing for any fault or malfunctioning of standpipes to be addressed urgently. The same emergency procedure can be applied to individual households which will allow for emergency units to address the matter in time;
4. The Ministry of Agriculture, Water and Forestry in Namibia needs to regulate the specialisations for PPWMs used in the country. In addition, if possible to introduce a free minimum amount of water to the poor in the urban towns, which can sufficiently sustain life and to ensure that no one is denied their human right to water;
5. The PPWMs should be programmed to deal with emergencies to enable the consumers to acquire extra credit when their water units are finished. This can be applied in cases of fire outbreaks in houses and to people that cannot afford purchasing water units;
6. Apart from training respective individuals within settlements, public education to customers on how the PPWMs operates should also be prioritized. The community development officers should work closely with the technical offices in sharing information with the community. Information should also be shared on the local radio stations or via routine community meetings;

7. Local authorities should keep a log book of all the faults or technical problems that occur with the PPWMs. This information can be shared with the PPWM suppliers in order to help curb or improving the efficiency of prepaid metering services. This will not only encourage the use of this system by increasing the acceptability level of customers, but it will ensure that all their concerns are looked at pertaining to the installation, durability and reliability of prepaid meters; and

8. Local authorities need to keep a record of all the costs and expenditures of the prepayment system. Cost-benefit analysis should be done by those local authorities that use the PPWMs. The prepayment software system could help generate information that can effectively manage the water prepayment system.

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APPENDICES

Appendix 1: Household questionnaire

General Contact Questionnaire For Prepaid Water Meters Users in Karibib, Swakopmund and Usakos Town in Erongo Region, Namibia January – February 2016

My name is Kornelia Ndapewa Iipinge, a student at the University of Zimbabwe studying towards Masters in Integrated Water Resources Management. I am very much interested in hearing your opinions and views with regards to prepaid water meters. I am undertaking this research as part of my academic study. I would highly appreciate it if you spare me few minutes of your time to answer a few questions as it will help me understand prepaid water meters in Karibib/Swakopmund/Usakos. All the information given will be treated with confidentiality and be used for the purpose of the study only. Participation in this research is voluntary and if at any time you feel you no longer want to carry on please be free to withdraw.

Questionnaire No: _______Date: ___________________________

GPS location: _________________________________Time: ______________

Town: _____________________

Residential area/ Suburb: ____

Type of house (brick, clay, shack): _____________________________________

Name of interviewer (s): ____

Instructions: Circle (O) the appropriate letter, Cross(x) in the box and write in the available spaces where applicable.

Section A: Demographic Information

1. Gender of respondent? A=Male B=Female

2. Age of respondent? A= less than 18 B= 19-39 C=40-59 D=Greater than 60

3. Is the respondent the household head? A=Yes B=No

(Household head is the one responsible for making major decisions and overall provision of income to the household)

4. How long have you been staying here?

   A=Less than a year B=1-5 years C= 6-10 years D= 11-15 E=More than 16 years

5. What is the tenure status of this household?

   A= Owner B= Renting C= Company accommodation

   D= Others (specify) ____

6. What is the highest level of education completed for the head of the household?

   A= No formal education B= Primary C=High school D=Tertiary

7. What is the head of household's occupation?

   A= Employee B= Self-employed C= Unemployed D=Pensioner E: Temporal worker

8. What is the average size of your household?

   A= 1-4 people B= 5-8 people C= 9-11 people D= 12-15 people
   E= Over 16 people

9. Does your household receive any of the following government grants?

   A=Pension B=Disabilities C= Orphans and Vulnerable children D=None

10. What is the monthly income of the household head?
    A=Below N$800 B=N$801- N$2400 C: N$2401 and above

11. Does the household have any of the following in a functional condition?

    A= Electricity B= Mobile telephone C= Radio D=None

12. Which Prepaid Water Meter (PPWM) does your household use?

    A= Individual B= Standpipe

13. When was the PPWM standpipe installed? ___________________

Instruction: If standpipe prepaid water meter answer Section B and if Individual go to Section C

Section B: Standpipe Prepayment Water Metering

14. How far away is your closest functioning standpipe?

A=Less than 5 minutes B= 6 mins- 30 mins C= 31 mins to an hour D=Greater than an hour

15. How long does it take to wait in the queue to get water?

A=Less than 15mins B= 15 mins- 30 mins C= 30 mins to an hour D=Greater than an hour

Section C: General Prepayment Water Metering

16. How has your water use changed after the introduction of prepaid water meters in the household?

Use	A=Increased	B=Decreased	C=Has not changed	D=Not applicable
a. Drinking				
b. Cooking				
c. Washing clothes				
d. Bathing				
e. Vegetable gardening				
f. Watering plants & trees				
g. Flushing toilet				
h. For pests and livestock				
i. Others (specify)				

17. On a monthly basis, how much does your household spend on each of the following items?

Items	Amount (N$)
a. Water	
b. Electricity	
c. Others: Groceries & Toiletries, Transport, Rent	

18. How often do you need to purchase water units?

A= Daily B= Weekly C= Monthly D= Other, specify________________

19. Where do you purchase water units? ____

20. Any problems you face when purchasing water? A=Yes B=No

21. If yes, what are the problems____

22. Do you have problems with the times at which you can purchase water unit?

A=Yes B= No

23. If yes, when would it be more convenient to purchase water unit?

A= Weekends B=Weekday Mornings C=Weekday Nights D=Weekday Midday E=Other, specify_________________________

24. Has the following happened to your household?

Statement	A=Yes	B=No
a. Running out of water due to no water credit		
b. A prepaid meter failing to work properly		
c. Losing credit in a prepaid water meter		
d. Lost or stolen token		

25. Does it ever happen to you that there is not enough money left for buying water?

A =Yes B= No.

26. If yes: How long does it take to buy water units?

A=A day B=2-6 days C= A week to a month D= Longer than a month

27. When you do not have water units, where do you get water from?

A=Neighbors for free B=Neighbor with payment C=Family in the same suburb D= Family in different suburb E=Stored water F=Nowhere G=Others

28. How do you rate the following about a prepaid water meter?

Statement	A=Excellent	B=Good	C=Poor	D=Very poor
a. Water services under a prepaid water meter.				
b. Response of the municipality to solve the problems with your prepaid water meter.				
c. Allowing you to access water every day.				
d. Encouraging you not to waste water.				
e. Ensuring that you pay for water.				
f. PPWM solved the problem of the household water supply.				

29. How often do you experience interruptions in water supply?

A=Every day B= Every week C= Every month D=Every year E= Not at all

30. Where do you report problems with a non-functioning water meter or with the token?

A=Do not know B=Council C=Installers of PPWM D =Vendor

31. How long does it take for the issue to be addressed?

A= Within a day B= 2 to 6 days C= A week D=More than a week to a Month E= A month F= Other, specify________________________

32. Do you feel that the prepaid metering system is better than billing system?

A= Yes B=No C=No difference

33. Explain your answer:

____

____

34. Who gave you the training on how to use the PPWM?

A=Municipality B=Community members C=Family members D= PPWM installers

35. What did you learn from the training?

____

36. What do you think are the benefits of the prepaid water meter?

____

____

37. What do you think are the challenges of the prepaid water meter?

____

____

38. Any other contributions you would like to add?

____

____

Thank You Very Much for Your Time and Responses!

Appendix 2: Focus Group Discussion guide

1. How long have you been living there?
2. Do you own the property or rent it?
3. Do you use a prepayment household meter or standpipe meter? (Where do you get water for your daily domestic needs?)
4. In your residential area, would you say there are more people with prepaid meters or post-paid meters? What would you say are the percentages?
5. When were the Prepaid Water Meters (PPWM) introduced?
6. Do you know why the PPWM were introduced?
7. Can you describe how they were introduced: Were you told beforehand when they would be introduced and why?
8. Why do you think PPWM were introduced in your area?
9. Did you pay to have the PPWM installed at your residence?
10. a. Have you received training on how the PPWM operates? If yes, by whom?
11. May you please explain how the PPWM work?
12. How do you recharge the PPWM?
13. Purchasing water units:
    a. Where are the water units purchased?
    b. Which days and times do they sell the 'water units'?
    c. In what amounts are the water units purchased?
    d. What is the lowest value one can buy?
    e. How often do you purchase water units?
    f. Do you experience any problems with buying water units?
14. What is your comment on the recharging of the PPWM?

15. Since the installation of the PPWM, would you say there has been a change in the following:
    a. The amount of water you use?
    b. The amount of money you spend on the water each month?
    c. The supply of water to your residential area?
    d. The frequency of supply disruptions in your area?
16. Are there water uses which you are now able to do, or are no longer to do because of the PPWM?
17. What are the technical problems you encountered with using PPWM system?
18. What are the causes these problems?
19. Whom do you report the problems to?
20. How long do they take to address the problems?
21. What do you think could be done to reduce the problems of the PPWM system?
22. What other sources of water do you use e.g. borehole, river, wells or rainwater harvesting?
23. When you do not have water units,
    a. What are the main reasons why you run out of water?
    b. Where do you get the water from?
    c. How long does it take you to go buy the water units?
24. A. Which system would you opt for, paying for water bills month end or buying water tokens? And why that option?
25. Have you ever received information or awareness on water conservation?

Appendix 3: Interview guide for the local authority personnel

A. Chief Executive Officer:

1. What are the major sources of water supply for the city?
2. Who are the different water users?
3. Approximately what percentage of the town's water supply goes to each of the water users?
4. What is the municipality's coverage of water supply in the town?
5. What is the total water consumption per capita in the town?
6. When were Pre-Paid Water Meters (PPWM) introduced?
7. Why did the municipality introduce prepaid water meters?
8. When installing PPWM, did you target specific areas of the town or you introduced them in all suburbs?
9. What was the reason(s) for the approach? (That is, if you targeted specific areas, what was the rationale, if you introduced throughout, what was the rationale?)
10. Any involvement from government, stakeholders or NGO's? What role did each of the following play in the introduction of PPWM
11. How many PPWM are installed (individual connections and standpipes) and which types of PPWM?
12. Since the installation of the PPWM, what observations has the municipality made in the following areas:

    a. Revenue flows;

    b. Water supply in terms of continuity of supply;

    c. Water supply in terms of coverage

    d. Water supply related faults such as pipe bursts and how these are reported and handled

13. How much does each PPWM cost? Do the residents pay to have the meters installed on their premises?
14. Are the PPWM locally manufactured or you import them (from whom)?
15. What sort of training have the town employees received in terms of operation, servicing and repairing the meters?
16. How many employees of the municipality have received such training?
17. What are your perceptions on the manner in which the residents have accepted/received the PPWM?
18. What are the major issues which have been raised by the residents in relation to the PPWM? What are some of the reasons for the issues you mention?
19. How have you tried to address residents' concerns?
20. How do you compare municipality/town with other towns that have implemented PPWM?
21. What is your response to the concern that PPWM infringes on the rights of residents to access water?
22. Overall, how have PPWM contributed towards the town's objective of increasing access to water at an affordable cost to all residents?

B. Water, Infrastructure and Technical Services Department:

23. May you describe how water tariffs for domestic users are calculated?
24. How much is the per capita supply of water?
25. Approximately percentage of the population is connected to the water supply network?
26. What can you say about continuity of water supply in the city?
27. Which areas have PPWM and which ones do not have? (If some areas do not have PPWM, why?)
28. What were some of the reasons that led to the installation of PPWM?
29. The extent of prepaid water metering connections?

30. Total number of prepaid water metered direct service connection?
31. Total number of prepaid water metered public standpipes?
32. Total number of prepaid water metered households?
33. In terms of operation efficiency, would you in what ways are the PPWM different from the old type of meters?
34. Has the number of meters related complaints went up or down (number of complaints per month)?
35. What are some of the major faults reported about PPWM?
36. How long does it take for PPWM related complaints to be addressed?
37. What are the procedures for reporting meter problems by the residents?
38. How long do you take to address the problems?
39. Is the prepayment water system affected by power cuts?

C. Financial Department

40. Please, may you describe how water tariffs for domestic users are calculated?
41. What is the water tariffs structure? Cost per m^3?
42. Are there differences between price per m^3 paid by conventional users and prepaid users? If yes, what are the differences?
43. How much does a prepaid water meter cost?
44. How much did the town spent on the project of installing PPWM?
45. Of this, how much was financed through the town's own resources and how much was loans or grant?
46. If the town obtained a loan or grant, please state the amount received and the source.
47. How long will the city take to repay the loans or grants?
48. Did individual households have to pay for the installation of the PPWM?
49. Who supplies the prepaid water meters?

50. Purchasing water units:

    a. Where are the water units purchased?
    b. b. In what amounts are the water units purchased?
    c. What is the lowest value one can buy?
    d. Which days and times can water units be purchased?

51. What is the maintenance cost of the prepaid water metering system?

52. What initiatives have been put in place to encourage a willingness to pay for water services?

Appendix 4: Interview questions for community leader or committee

Name of interviewee: ____

Gender of interviewee: ____

Town: ____

Residential area/settlement: _____________________________________

Date of interview: ____

Time of interview: ____

Name of interviewer: ____

Section A: General

1. What is your position in the community?
2. How long have you been in your current position in the community?

Section B: Water Payment

3. What approximate percent of the population use prepaid water meters?
4. When were the Pre-Paid Water Meters (PPWM) introduced in the community?
5. Do you know the motivation for introducing PPWM in the community?
6. What are the differences between prepaid and the old system, and in which way is one better than the other?
7. What are the commonly expressed views about PPWM by members of the community?
8. As a community leader do you think the community is better off with PPWM or with the old system?
9. Does your community have a Water committee? If yes, please describe its roles?

Section C: Maintenance

10. What are the problems which have been experienced with prepaid water metering system by the residents?
11. What are the causes of the problems?

12. Who maintain and monitors the prepaid water metering system?

13. On average how long does it take for a problem to be addressed?

14. What do you think could be done to improve the maintenance of the facilities?

Section D: Participation and Training

15. Were the community members consulted in the introduction of the prepaid water system?

16. Did the community members receive training on the operation of the prepayment water metering system?

17. Do you think your community understands the need to pay for water?

Appendix 5: List of interviewed personnel

1. Awesab, Charles. Community Development Officer. Swakopmund Municipality. 19th January 2016.
2. Bloodstaan, Herbat. Managing Director: Thunderstorm Investment CC. Windhoek. 8th March 2016.
3. du Plessis, D. Superintendent: Water Works. Swakopmund Municipality. Swakopmund. 18th January 2016.
4. Gaseb, Robert. Accountant. Karibib Town Council. 16th February 2016. Karibib.
5. Kotze, Laura. Coordinator Works Assistant: Works Section. Swakopmund Municipality. Swakopmund. 22nd January 2016.
6. Kubirske, Reinhold. Operation Manager: Water and Sewerage. Swakopmund Municipality. Swakopmund. 6th January 2016.
7. Lottering, Barend. Projects Execution Manager. Aqua Services and Engineering. Windhoek. 8th March 2016.
8. Martinus, Maria. Embwida Mini Market Embwida Prepaid Water. Swakopmund. 20th January 2016.
9. Muyeghu, Evaristus. Accountant. Usakos Town Council. Usakos. 11th February 2016.
10. Nshamba, Maria. Hoki Tuck Shop. Swakopmund. 20th January 2016.
11. Reinhold, Hermanus, Acting Chief Executive Officer: Finance and Administration Manager. Usakos Town Council. Usakos.15th February 2016.
12. Shingenge, Elia. Local Economic Development Officer. Karibib Town Council. Karibib. 16th February 2016.
13. Sitwira, Mouren. Cashier. Karibib Town Council. Karibib.16 February 2016.
14. Sylvia. Cashier. Usakos town Council. Usakos. 03rd February 2016.
15. Titus. Acting technical officer, Usakos Town Council. Usakos. 10th February 2016.
16. Uiseb, Ben. Headman of Usakos. Usakos. 08th February 2016.

17. Weskop, Manfriedt. Administrative and Human Resources Officer. Usakos Town Council. 4th February 2016.
18. Erwin, Shiluama. NamWater. Manager: Water Supply Namib Area. 03 May 2016.