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Thesis

Title: **The influence of technical and behaviour factors on prepaid water meter system on revenue collection, a case of Lusaka Water and Sewerage Company, Kafue district.**

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Title

The Influence of Technical and Behaviour factors on Prepaid water meter system on Revenue Collection

Case: Lusaka Water and Sewerage company, Kafue district.

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Summary

The Prepaid water meter technology is growing at a faster rate especially utilities in Africa who desire to handle challenges of debt recovery and non-payment for the services offered by the utility and ultimately improve the collection of revenue. Lusaka Water and Sewerage Company (LWSC) is a state-owned company which oversees provision of water and sewer services to the entire province of Lusaka. The utility was commercialised, to be able to generate revenues to support its operations through user fees as the main source of revenue. However, under the post-paid billing system (fixed and metered), non-payments and debt had increased therefore, the company embarked on Pre-paid Water Meters (PWMs) to improve the revenue collection. The system was implemented in selected residential areas around Lusaka and two districts, namely Chongwe and Kafue, while the rest of the city remained on the Post-payment system. The focal point of this study was Kafue since it had the highest number of PWM consumers. In 2013, the PWMs were installed covering 95% of the total connection of the branch. Some properties which were on fixed charge were captured and 40% of every credit purchase was dedicated to servicing the debt. An improvement in revenue collection was noticed, however collections started dropping since 2015. Some of the challenges revealed were faulty valves, software errors, resulting into meter not shutting once units are depleted, or shutting down completely even with units in the meter, several stuck meters, apparent sales reduction on some properties, intermittent water supply, and customers engaged in meter tampering and vandalism. These factors have adversely affected the operations of the utility. Both technical and behaviour factors help explain the influence of the reduction of revenues collections of the utility.

Based on the challenges afore mentioned, the main objective of this research was to explain the extent to which technical and behaviour factors related to PWM system have influenced the reduction of revenue collection of LWSC in Kafue district. There are many other factors which influence revenue collections, like: tariff, water production capacity. However, the study focused on technical factors which include; valve failures and low pressure in the distribution network while behaviour factors include consumption efficiency and meter tampering. This study is relevant as it informs the decision makers to develop or put in place strategic interventions with a focus on how these factors can be managed to achieve the goal of 100% guarantee of revenue collection. Both equity and planned behaviour theories were used to fully understand how and why the technical and behaviour factors influence revenue.

The study adopted a case study strategy. Both qualitative and quantitative data was collected through primary data using two data instruments interviews and questionnaires. The interviews were semi structured and were administered to representatives from within LWSC who are the experts. While semi closed questionnaires were issued to the water users on PWMs for triangulation. Secondary data was also used for reliability and validity of the research. Purposive sampling and stratified random sampling approach were used in this research. The sample size for questionnaires was not a representative sample size because of time limitations however, the interviews supported the findings. For the interviews, data collected was transcribed and analysed using Atlas. Ti program while for the questionnaires, data was analysed using frequencies of (SPSS) and applied Pearson correlation test and a multiple regression.

According to the main findings; 70% of the valve meters have failed, some customers stopped buying units and become relaxed, some major customers have moved to alternative water source, huge negative balances are abandoned in preference to buying cheap water from neighbours. Reasons found for the failures include; frequent burst pipes, leakages and intermittent water supply. From the findings, these challenges are centred on the dilapidated

water supply infrastructure of the district. Furthermore, inadequacy of technical know-how by prepaid department in the branch, no mechanism to quickly check on the computer to identify the meters dispensing water, lack of materials and poor response to customer complaint are among the reasons of high failure rates of meters . Low water pressure has reduced revenue through valve getting stuck and customers stay for longer hours without consuming especially when burst pipes are being worked on. Lastly, the hours of supply schedule had reduced in some areas. Under behaviour factor, spending and expenditure reduced, however illegalities are high both from internal staff and customers. Illegalities are occurring because of lack of inspection from the utility.

In conclusion, both technical and behaviour factors have strongly influenced the revenue collection. However, technical factors have influence more than behaviour factors. This study recommends LWSC to budget and work on the district water network and intensify physical inspections.

Keywords: Prepaid water meters, Technical factors, Behaviour factors, Revenue collection

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Dedications

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Abbreviations

IHS	Institute for Housing and Urban Development
LWSC	Lusaka Water and Sewerage Company
PWMs	Prepaid Water Meters
NWASCO	Nation Water Supply and Sanitation Council
WMD	Water Management Device
UIU	User Interface unit
PPWMs	Post-paid water meters
SPSS	Statistical Package for the Social Sciences
BRAs	Billing and Revenue Assistants
AMR	Automatic Remote Reading
MFUI	Managing and Financing Urban Infrastructure
WDU	Water Dispensing Unit

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Chapter 1: Introduction

1.1 Background

The significance of drinking water to human kind cannot be over emphasized. Water is essential in environmental and economic sectors for irrigation, food production, industries, health, tourism and ecology. Therefore, proper management of this finite resource is vital (UN, 2002). The idea of water being an "economic good" has been generally accepted among water resource managers since the 1992 Dublin conference on water and environment. The scarcity of this resource gives it demand for consumption purposes by humans, hence the need by service providers to ensure its availability by supplying at a cost which reflects this value to attain efficient usage of the resource and financial viability (Savenije, 2002).

One of the most challenging issue in the delivery of desired level of service in most African utilities is low revenue collection, from both individual customers as well as government agencies like: universities, barracks and hospitals who are the big consumers of water (Kihumba, 2013). Revenue collection, is the total income that the service provider collects or receives from billing consumption, eliminating the ad hoc charges like penalty fees, meter fees and reconnection charges (NWASCO, 2014b). It may also include payments in advance before the service is used, or arrears.

Access to funding from development agencies or governmental transfers is also hard to come by. A greater demand therefore, falls on user finance through the user fees and tariffs to cover the operation and maintenance costs. Additionally, the study conducted in United States confirmed that a greater part of revenue source for water providers was from the water fees and customers were the greater contributor (Boyle, 2014).

Post-paid metering is a general system used for recovering the costs of water in water utilities. It entails billed consumption is only paid after actual consumption. If payment is not made, utilities resort to forceful disconnection, which results in loss of revenue by the service provider (Heymans, Kathy, et al., 2014, Mburu and Sathyamoorthi, 2014).

Furthermore, inability of the utility to recover the service cost, affect significant expenditures for instance: network expansion projects, quality of service improvement and operating and maintenance costs coverage. As a result, the level of service delivery is ultimately affected, coupled with health risks on the health of customers who are forced to seek alternative sources of water which is usually not safe (Cardone and Fonseca, 2003).

Utilities that exhibit ability in terms of revenue collection attracts several financing options (World Bank, 2015). For this reason, innovative measures have been developing gradually to maximise on the collection of the revenue from the customers. One of them being, prepayment water system, which propel customers to pay before use. This technology provides an answer to non-payment challenge and has become famous in health services, electricity services, communication industry (mobile phones) and water sector. A PWM is a device used to regularize the volumetric flow of the service while ensuring payment for the service before consumption. Heymans and Kathy et al (2014) brings out some benefits of using this new technology such as; improvement of revenue collection, water demand management, reduction of billing errors and service quality.

The prepayment technology is growing at a faster rate, and over 20 countries in Africa have adopted this technology together with countries around the world like Colombia, Turkey, Brazil and the United Kingdom. Its advancement started in early 2011 after being given a global certification on the prepayment standards such as interoperability security and vending (Heymans, Kathy, et al., 2014).

However, prepaid water meters are a contentious topic. Others see it as a strategy to improve revenue and cost of doing business- as the meter will automatically close the moment credit paid for by a customer is exhausted. Also avoids debt accumulation and prevents cost of meter billing and disconnection exercise (Lopez, 2013).

Others perceive it as an additional cost on the utility, as maintenance and capital expenditure are high. This leads to punishment of customers who are not well-off especially by not having access to the service. Additionally, meters have a short working life cycle approximately 5 to 7 years as compared to ordinal conventional meters with 15 to 20 years (Heymans, Kathy, et al., 2014).

McDonald (2002 ,p.11) further elaborated that, cost recovery through implementation of prepaid meters has been argued to impact seriously on the low-income consumers. This was correlated to outbreak of cholera in KwaZulu-Natal, South Africa through the analysis conducted, which killed about 200 people. There are no warning steps regarding the cutting of water. Therefore, the only way to avoid disconnections is to top up or buy units in advance. Jack and Smith (2016) argues that prepaid water meter only looks profitable if consumption pattern is overlooked.

To support this argument, a case study in Otjiwarongo Namibia, suggested that the introduction of PWMs on revenue improvement was not as expected due to the reduction in water consumption by the users (Tuovinen, 2014). Water users became conservative and were using water efficiently than before. Similarly, water users in Eldorado Park also became conservative and never left taps running even when they were doing dishes, taking their bath and brushing their teeth, as most households had learned water conservation and were in control of their budget.

Consumption efficiency is defined by Vickers (2001) as a way of minimising the water usage, waste and loss to accomplish a result thus, “doing more with less water and only using water that one need”. Consumption efficiency could be better linked with equity theory which relates fair balance between input and output of the two parties involved. Suppose there are improvements on the quality of service by the utility which results in the rise of water price, the customer would maintain the equity by either paying the increased price or minimise on the consumption of water to still receive the service and still balance and maintain that change in price (Homburg.C, Koschate.N, et al., 2005).

In addition, planned behaviour theory helps explain the change in consumption patterns, which focus on the intention or motivation of people to execute a certain behaviour. It justifies the efforts involved in executing the desired behaviour, and the stronger the motivation to participate in a behaviour, the higher its performance (Beck and Ajzen, 1991). Different motivations results in different intention for a certain behaviour either negative or positive. In service providers, illegal connection, meter tampering and meter by-passes are behaviours motivated at times from inability to pay by the water user in need of access to water.

Prepaid water meter also has influence on the reduction of non-revenue water. Colombia adopted prepaid water metres as a progressive policy which aimed to better collection revenues by reducing the unwillingness to pay for the service rendered, and reduction of water losses via illegal consumption in areas where capacity to pay was low. However, Heymans and Kathy et al (2014) argues that PWM system is not to be viewed as a miracle solution for high non-revenue percentages and low collection of the utility, as it calls for lots of effort in terms of planning (maintenance and network system upgrade), follow ups, monitoring, adequate training for the technicians on the ground to address problems on the meters and implementation of strict regulation.

A study by Al-Fuqaha (2013) supports the argument, as the utility in Jenin and Tulkarem in Palestine invested first in the upgrade of the pipe network which increased the pressure and improved the hours of supply. Introduction of PWMs therefore had positive influence on the payment levels from the residents of Jenin and Tulkarem in Palestine. Customers also felt the price was affordable compared to the 'conventional meters'. In addition, Mogale city in South Africa installed about 1,026 prepaid meters and the water sales quadrupled, because of regular physical checking and, strict penalties against illegal connections, meter by-passes and meter tampering. This enabled revenue improvement through increased sales which tripled than before the interventions, leading to increased number of meters installed to 46000 (Heymans, Kathy, et al., 2014).

On the other hand, in Windhoek, a municipality recorded "call outs" complaints from customers of not being able to get the water once the units were loaded. 20% of the reports were technological problems to do with continuous running of water through the meter due to jammed valve left in open position. Also, meters were found in tampered mode during inspections (Heymans, Kathy, et al., 2014).This contributed to the increase of non-revenue water and reduction of payments, as some water users were enjoying free water as a result of valves not closing automatically once the water credit is exhausted.

Furthermore, according to Heymans and Kathy et al (2014) "from the generic data on costs, tariff and consumption for different customer categories conducted in eight African countries, it was found that a typical service provider in sub-Saharan Africa would make a net revenue loss on all prepaid metering approaches at present tariffs except for large institutional/commercial customers"

1.2 Problem Statement

In Zambia, water resource related issues are stipulated under the water and sanitation Act No. 28 of 1997. Furthermore, commercial utility companies were formed under the enacted water and sanitation act which defined functions of the utilities for providing sustainable services for both water and sanitation under the ministry of local government and housing responsible for the sanitation and water affairs of the nation (Phiri, 2000). Prior to the water and sanitation Act, the water and sanitation services were provided through the local authorities in this case Lusaka City Council under the department of water Affairs. In 1988, this department was detached from the Local Authority to enhance its performance that was deteriorating in terms of service provision. This saw the birth of LWSC, a wholly owned state utility through various local authority in the Province as shareholders. These include Lusaka City, Chongwe, Kafue and Luangwa district councils. In 2002, National Water Supply and Sanitation Council (NWASCO) was established as a regulator to monitor the performance of all utilities in the country (NWASCO, 2014b).

LWSC was formed, to be able to generate revenues to support its operations through user fees as the main source of revenue. However, under the post-paid billing system (fixed and metered), non-payments and debt had increased due to defaulting customers and huge unsettled debt on government properties. Over USD20million was accrued as arrears under the post-paid billing system and statistics indicated that collection ratios ranged from below 35percent on some institutional connection to about 76percent on domestic connections (Heymans, Kathy, et al., 2014).

This rise in non-payers and debt, constrained the company from further expanding service networks, increase production capacity and upgrade deteriorated existing pipes which needed replacement. This adversely affected the company in meeting the service demands of the growing population.

In 2010, LWSC embarked on a turnaround strategy and took up innovative measurement which aimed at improving revenue collection through prepayment system. This system gives a 100 percent guarantee of collection efficiency (NWASCO, 2014b). In support to the advanced technology, NWASCO responded by setting up guidelines on how the management and installation of these meters should be conducted. Proprietary and open system are the type of meters adopted by the company to use on bulk commercial and industrial properties and domestic properties respectively.

The system was implemented in selected residential areas around Lusaka and two districts, namely Chongwe and Kafue, while the rest of the city remained on the Post-payment system.

For this study, we decided to focus on the district of Kafue since it has the highest number of prepaid consumers.

Kafue district is 44km from the south end of Lusaka city with a total population of 227,466 thousand people and a customer base of 10012 (Edams, 2015). The district has its own water treatment plant where the raw water is treated, then transmitted and distributed via pumping to the end users who are connected to the utility network. LWSC is also in charge of the centralized sewerage plant which treats the collected sewage from the district.

According to the company target for the prepaid in the Kafue district is to have 100% of all consumers on prepaid but according to Edams (2015), 95% of the water pipe connections in the district are on prepaid and 5% are still on post-paid connection.

Before the installation of PWMs upgrade of some deteriorated pipes network in certain areas in the district was done (Heymans, Kathy, et al., 2014). This upgrade work has improved the existent low water pressure in many areas of the district.

In 2013, meters were installed. Installation of the PWMs in the district was compulsory and water users had no choice to oppose or remain on either fixed or post-paid meters. Customers were also obliged to pay their arears together with the current water consumption as a 40% of every credit purchase was dedicated to servicing the debt (LWSC, 2015).

After the installation exercise was completed, according to the statistics from the company (LWSC, 2015), the revenue collection increase to about 30% in the first years and thereafter started dropping. Collections for the company has been worsening each year since 2015 (Edams,2015).

Technical and behaviour factors could help to explain the current reduction of revenue collection after the initial increase: In this research, technical factors are classified as those factors which impede or interfere with the accuracy of the performance and operations of a system or its components'(Ashbourn, 2004). While behaviour factors are defined as behaviour changes adopted by water users to satisfy their needs or desire (Solomon, Russell-Bennett, et al., 2012). These usually exert strong influence on revenue collection.

According to previous evaluations on the prepaid water meters conducted by the company (LWSC, 2015). Some of the challenges observed and revealed include among others the following:

Faulty valves – Causing meters not to shut off when units run out. Several properties had faulty meter valves which could not shut hence continuous flow of water causing meters running into negative balance. There could be various reasons to explain the causes, however, the company is conducting investigations.

Software errors - communication challenge of external unit and user interface unit (UIU) on domestic meters especially, leaving the meter to shut off completely even with units or continuously allow water passing without units.

Increase of stuck meters - however, the company lacks spares to replace or repair defective meters or units with problems. From a survey conducted by Heymans and Kathy et al (2014) lack of maintenance and effective inspection on prepaid meters increases water loses and unreliability of the system. Water losses and intermittent supply further reduces the pressure in the distribution network. The entire country experienced heavy load shedding especially in 2015 which led to prolonged power outages which affected supply hours for utilities (NWASCO, 2016).This worsened the intermittent supply by the company.

In support of the factors mentioned above, the water regulators NWASCO confirmed through their reports that the company had reported several metre replacement cases due to high rate of failures of the PWM. According to NWASCO (2017 ,p.8)"there is need to reconsider the prepaid water policy" as it is one of the attributes contributing to the low collections of the utility.

On the other hand, some behavioural factors revealed include;

Apparent reduction in sales on some properties. According to Heymans and Kathy el al (2014) prepaid meters is one system which enable water efficiency. Consumption efficiency is defined as reducing the amount of water wasted by taking certain measures which avoids wastage (Vickers, 2001).This on the other hand means reduction in the amount of water purchases made by the customers.

Lastly, Vandalism – some customers had resorted to tamper with the meters by any means possible, leading to meter malfunctions and consequently valves not closing.

According to Heymans and Kathy et al (2014), prepaid technology comes with its own challenges and should not be viewed as a miracle tool to solve low revenue collection in utilities.

Based on the above and many other challenges, it becomes imperative that a research be conducted to understand the extent technical and behaviour factors have influenced reduction of revenue collection for LWSC under the PWM system. There are many factors which may influence revenue collection under prepaid meter system. However, this study will focus on the afore mentioned.

The technical factors chosen for this research are: valve failures and low water pressures in the distribution pipes, while behaviour factors are: consumption efficiency and meter tampering

1.3 Research Objective

The objective of this research, is to explain the extent to which technical and behaviour factors related to prepaid water meter system have influenced the reduction of revenue collection using the experience of LWSC in Kafue district.

1.4 Main Research Question

To what extent have technical (valve failures and low pressure) and behaviour factors (consumption efficiency and meter tampering) on prepaid water meters influenced reduction of the revenue collection of LWSC in Kafue district?

1.5 Sub Research Questions

1. How are valve failures and low pressure related to prepaid water meters influencing the reduction of revenue collection of LWSC in Kafue district?
2. How are changes in water consumption efficiency and Meter tampering influencing the reduction of revenue of LWSC in Kafue district?
3. What other technical and behaviour factors are influencing the reduction of revenue of LWSC in Kafue district?

1.6 Significance of study

The practical relevance of this study is that, it will provide the utility with deep knowledge and understanding the extent technical and behavioural factors on the prepayment water system are affecting the reduction of revenue collection. This will enable the company to develop or put in place strategic interventions with a focus on how these factors can be managed to achieve the goal of 100% guarantee of revenue collection. Furthermore, it will enable the utility regulator like NWASCO who sets benchmarks and conduct performance assessments to put up strict management regulation for utilities using the PWMs. Also reinforce customer penalty fees against any violations regarding the prepaid water meters as they will have a better understanding how such acts affect the revenue collection, even though their role is to protect and save the consumers interests.

For the significance of academic purpose, owing to the fact that the PWMs is a relatively new topic to the water industry, and there is few literatures available especially relating with revenue collection. This study will highlight some behaviour and technical factors affecting the reduction of revenue on prepaid water meters in developing countries and add to the literature. This will also be a support to the existing literature by Heymans and Kathy el al (2014) which explains that prepaid water meters are not to be miracles to revenue collection problems even though they guarantee 100% collection.

1.7 Scope and Limitations

There are many other key factors such as; tariff, political factors, water production volume and customer base which influence the revenue of utilities. However, this research focuses on the influence of technical and behaviour factor related to PWMs on reduction of revenue collection. The technical factors that will be discussed are valve failures and low pressure in the distribution pipes. Behaviour factors on the other hand will be consumption efficiency and meter tampering. The technology of prepayment system has been installed in other districts and branches within Lusaka provinces. Due to limited time given to do this research, the focus area shall be on the prepaid water meters which were installed by LWSC in Kafue district, as it also gives a significant percentage of the total number of meters installed in the province. However, in a quest to gain a deeper and richer understanding, the literature review will be extended to other African countries who undertook a similar path and their experiences.

Chapter 2: Literature Review / Theory

2.0 Introduction

Prepaid water meters are being utilized in some countries of the world. These include amongst others; Namibia, Philippines, Malawi, South Africa, Swaziland, Mozambique, Colombia, Egypt and Nigeria. South Africa is the largest country where PWMs are applied. Scholars (Heymans, Kathy, et al., 2014, Lopez, 2013, Harvey, 2005, McDonald and Pape, 2002, von Schnitzler, 2008) have said that many utility companies appreciate and adopt the prepayment water system because of the benefit it comes with as compared to the post-paid water system. Therefore, utilities install prepaid meters with the desire that it would handle some of the service problems they face for instance: inefficient finances to fund the growth of the urban population which requires pipe networks expansion, maintenance and rehabilitation of deteriorating pipe networks, poor customer service, high water losses, poor habits of water uses and low levels of payment for the service.

This chapter will look at the identified variables, both independent and dependant, the theories and concepts which support these variables in detail regarding what literature says. Technical and behaviour factors on PWMs are independent variables with valve failure, low pressure ,meter tampering and consumption efficiency as sub variables. Revenue collection is the dependant variable. Planned behaviour and Equity theory are the two theories used as stated in the background.

2.1 Prepaid verses Post-paid water meters

In Africa, over several years the process of billing payment has been done using the post-paid billing system (Mburu and Sathyamoorthi, 2014). However, utilities and municipalities are taking a new direction to prepayment system which comes with benefits such as; increment in payment levels, due to automatic enforcement of closing the meter once units are depleted. Relative to the post-paid meter, the utility engages in enforcement by conducting disconnection. Van Schnitzler (2008) highlights that under the post-paid billing, the provision of services to the customer is dependent on the trust between the service provider and the user, as the payment for the service is made way after consumption is done. This at times is abused by non-payment or late payment by some customers. Utilities in this regard have embraced irrevocable form of socially contract which by duty provides regularized flow of the service while ensuring the customers pay for the service provided. However, by changing the billing system from PPMs to PWMs, pattern of customer's expenditure budget is affected. As it disturbs the usual credit arrangement which enables them pay for the monthly bills. For the utility, PWMs relieves them from transaction cost (disconnection notices, billing, meter reading) and allows the customers to worry about purchases and monitoring consumption unlike the post-paid billing (Heymans, Kathy, et al., 2014). Additionally, on the PWM mode, customers purchase the units and load them themselves. Once the units are almost finishing, the meter shows how much units are remaining. Several prepaid meters have the features which give signal (blink light red) to the customer to show that the units remaining is very low and requires to be recharged. Unlike PPMs which have no such features (Jack and Smith, 2016) instead, the meter reader goes to the premises of the customer and takes a reading based on the increasing consumption and records.

Table 1 shows summary of some advantages and disadvantages of PWMs to both the customer and the service provider (Heymans, Kathy, et al., 2014) .

Table 1:Advantages of Prepaid Water System

	Customer	Water utility
1	The control is in the hands of the customer therefore, budgeting becomes easy as payment is only made on how much one needs and controls the duration before another purchase	The utility receives an upfront payment from the customers. Revenue collection is assured as there is automatic cut off from supply upon exhaustion of units purchased in the prepaid meter, which would compel the user to buy more units
2	Customers can purchase even with small payment, which is far better than paying a huge bill at once and avoids disconnections	The utility saves on printing costs such as reminders and disconnection notices
3	Customers pay for consumption which they can afford and avoid debt accumulation	The utility prevents huge debts especially on government institution such as schools, hospitals and military barracks, which results in bad debt at times.
4	Consumption and abuse of water is less as customers become more careful in the way they use the water at their respective premises.	Non-revenue water is reduced and redistribution of the available water resource, to other areas**,** improve the financial viability of the company**.**
5	There are no penalties such as reconnection fees because its self-disconnection	Reduced staff involvement in enforcing activities necessary for improved revenue collections and eliminating collusions between customers and staff
6	Customers are given a chance to settle debt bit by bit without being pressured.	Debt collection from the owing accounts is increased through monthly automatic deduction
7	Customers enjoy the quality of service the prepaid meters come with	Customer service is improved. The prepayment system demands a reliability in supply and better piped network to avoid malfunctioning of meters.

Table 2:Disadvantages of Prepaid Water System

	Customer	Water utility
1	Demand management is very insensitive to inability to pay, the meter cuts once units are exhausted leading to poor health and disease outbreaks	Customers consume less, resulting in less cash flows for the utility
2	Require monitoring of how much one is using otherwise can cut any time, and gives no time to look for money to top up	The meters develop faults, therefore proper monitoring is required. Easily damaged by air, grit and silt in the network
3	Slow response to complaints, especially on stand posts	Vandalism and illegal connections are high. Maintenance costs are high and add more cost on the utility
4	Lacks information on how to use the new system and consultation before installation is done	More cost on skilled employees to deal with complaints, monitoring consumptions in the system and educated the customers on the use of the system
5	Few vending points, and limited working hours	New technology requires huge capital to set up a complete system

2.2 Prepaid meters and prepayment concept

Prepayment concept is gaining popularity amongst the water providers in the view of seeking means of improving the revenues (plus debts collection) and reduction of water losses. Prepayment system in the water industry is a new technology which initially emerged from south Africa. On the global market, South Africa, Turkish and Chinese are the top leading producers of the prepayment system (Heymans, Kathy, et al., 2014).

Prepayment metering system is a technology which allows customers to pay for the service before consumption and automatically cuts off supply when the credit depletes or in an event of non-payment. The technology is rapidly developing, and meters are installed in middle class but more especially in low areas where payment of bills is uncertain (Von Schnitzler, 2013).

PWMs was viewed as a commercial approach which utilities were implementing for profit purposes above the needs of the citizen. As it attracts no political debates relating to the disconnections of citizen (Privatization, 2004). Through commercialization, and privatization, prepayment system has been introduced by utilities. Von Schnitzler (2008) added that while the prepayment system of meters is usually considered and introduced as effective administrative instruments in the facilitating of services, however, the technology brings out into action relationship between political and social issues. Which lead to the centre of 'reformulation of political subjectivenes'. Commercialization has disturbed the relationship between the local government and the citizen, as disconnections from the basic service by the PWMs is regarded as social hostility.

McDonald and Pape (2002) argues that the prepaid meters were introduced in South Africa as a tool for recovery of cost especially from areas were payment for services was difficult. The need for recovery of cost came about after the neoliberal principle was prompt by globalization.

this principle of recovering costs via prepayment diminishes the citizens from getting access to the basic services, as it relates directly with affordability consequently, impacting on the low-income users negatively.

Lopez (2013) and Von Schnitzler (2013) defines water prepayment system as the liberty of self-disconnection from supply system each time money run out in a meter. The PWM has an electronic device in charge of controlling water quota setting based on the prepayment made and automatically disconnect supply when the credit is exhausted (APF, 2004).Payment is guaranteed without any negotiations (Harvey, 2005).In addition, Johannesburg water describes PWMs as meters which operate similar with the convectional meters. Except that they have a unique digital box together with the keyboard and a port where a token cared is placed for controlling of the bill of water beforehand (Heymans, Kathy, et al., 2014).

There are five common prepayment application which are explained by Heymans and Kathy et al (2014); PWMs are applied on commercial properties, domestic, industries and government institutions such as schools, hospitals amongst others. Lastly, they are also applied on connections such as standpipes or communal taps where residents do not have individual pipe connections but share the facility.

2.2.1 How prepaid water meters work

There are various types and makes of PWMs around but have a similar aim of ensuring consumption of water is read. A complete system of prepayment metering consists of: water dispensing unit (WDU) -which is usually installed at a customer's house (water meter), a vending system, data base and management of the system.

Heymans and Kathy et al (2014) explains how a prepaid water meter functions and the process of loading. Many PWMs used around in cities uses mechanical water meter, linked with an electronic water meter device, where credit is loaded and a valve which controls the water. Whenever the water passes through the meter, a pulse is created just on the probe which is connected to the mechanical meter. Thereby, transforming the formed pulse into credit which is then deducted from the overall loaded credit by the water user. The moment the credit is depleted or a tampering is detected to any of the components of the water meter, the water valve closes.

Furthermore, most prepaid meters consist of rotating pistons together with multijet, however, grit, silt and air usually affect the accuracy of the meter and in most cities in Africa, the meters get damaged by the constant water interruption, deteriorating networks and changes in low pressures supply. Electromagnetic meters together with ultrasonic type are better placed in such areas or cities as the accuracy is quite high and resilient to intermittent supply and low pressure, sand, grit and air. Dallas key pad and button are normally used in credit loading vendor and are programmed such that when the customer purchases credit and loads onto the meter key, the consumption information is also uploaded and analysis can be conducted later. The key pad differs from the numerical token which is one way and requires another data gathering for trucking purposes of the consumption. In addition, the components for these meters are fixed and not mobile which adds to the durability and resilience. A prominent disadvantage is that they are expensive and not advised to be used on domestic properties for cost benefit purposes.

To add support to the security and reliability technique, some prepaid water meters utilizes global system for mobile which enable short message use. Once the units are purchased and recharged, a message would be received to confirm the success and water will flow. In addition, as consumption of water is taking place, a message will be sent indicating, remaining volume and if the customer does not recharge, then the flow would automatically cut (Sangole, Mohini, et al., 2016).

2.2.2 Proprietary and Open System Water Meter Type

Under LWSC, there are two types of PWMs system installed. Proprietary on bulk commercial and industrial properties and Open system on domestic properties. The two types are based on the system transfer specification (STS). Heymans and Kathy et al (2014) explains how these work; STS is an international standard that allows inter- operability of equipment and system supplied by different water manufactures thus prevents a customer from being locked to a supplier. This standard achieves this by specifying the water credit constituted in a token and how it is explained by the water dispensing unit (WDU) at customers' homes. The token transferred to the "WDU" acts as credit unit represented by the STS vend system. A magnetic card or numeric token which is twenty digits in number is then interpreted by water dispensing unit at the premise of the customer. However, the path of information is always one way (from the vending system to the WDU and no return path of information from WDU to the vending system). Therefore, utility find alternative means to determine the quantity of water consumed, the status of the battery also tampering state of the WDU. Normally, an automatic meter reading is utilized to capture such information using short radio wave drive by

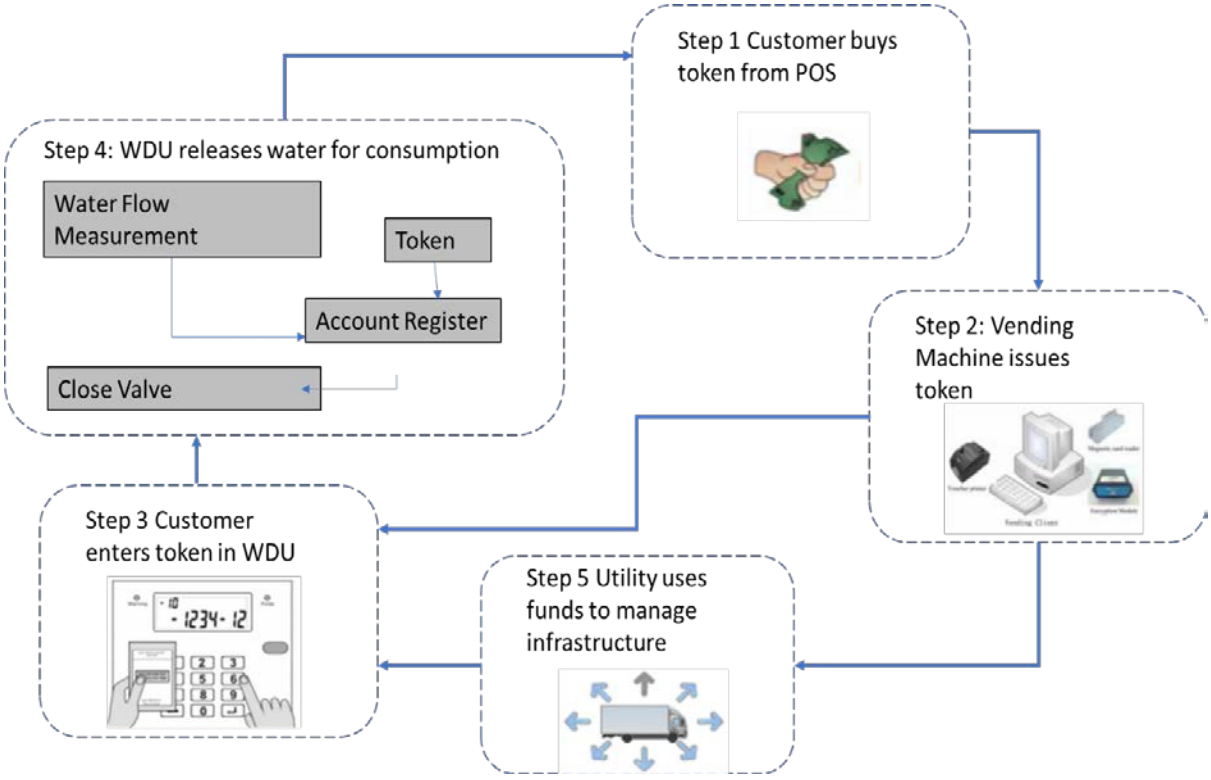
The WDU comprises of three sub units; namely, the user interface unit (UIU) which is used as interface for the customer to input token and check balance; The Water Management Device (WMD) which monitors and controls the usage, lastly the mechanical meter that measures the flow rate. In domestic prepaid meter connections, the UIU communicates with the WMD using short range radio waves within the distance of 150meters. Since its electromagnetic wave, metallic object between two devices would significantly attenuate the signal. The WMD monitors the consumption and subtract the consumption from available credit and once the credit depletes, it sends a digital pulse to shut or close the valve. In addition, the shut off valve utilizes line pressure to close the valve. It requires above 0.2bars to successfully close otherwise the valve remains open.

Furthermore, the arrangement for bulk prepaid meters on commercial, industrial and governmental buildings is similar with a control module, and shut off valve replacing WMD and mechanical meter by magnetic flow meters.

Prepaid metering technologies have now matured with a variety of water dispensing units (including smart metering) now readily available. The issue is the justification for the higher cost of the technology in relation to the expected benefits, Other utilities demand that the prepaid meter system still comes with a mechanical meter so that in an event of non-functioning, the consumption used by the consumer is captured thus improve billing process (Heymans, Kathy, et al., 2014).

Figure 1 below shows the operation of a typical PWM vending system

Figure 1:Prepaid Water Vending System Operation



Source: (Heymans, Kathy, et al., 2014).

2.2.3 Prepaid water meters and Non-revenue water

Non-revenue water (NRW) is defined as the total amount of water which is produced from a water treatment plant or any other source of water, distributed through a water network, subtract the total amount of water authorized through billing of customers (the system input volume minus the authorized billing consumption) (Farley and Trow, 2003). Non-revenue water is broken down into two types of losses: physical loses which are "real loses" through burst pipes, leaking pipes till the customers meter point and overflows of reservoirs. While commercial losses are "apparent losses" through meter errors, unbilled authorized consumption and consumptions which is not authorized (Farley, Wyeth, et al., 2010) . In addition, NRW is one of the indicators used to measure the operation efficiency of a water provider and if managed well, may improve the revenue collection.

Prepaid water meters help in the reduction of loses which emanated from the errors during the capturing of data for tariff and billing. A reduction of NRW for 677 houses was noticed in Mogale, South Africa were PWMs were installed from '29.9m^3 to 11.2m^3' in 2 years' time from the beginning of 2006 (Heymans, Kathy, et al., 2014). Customers become more conscious on the consumption and conservation of water like closing taps and quick notice of leakages. This is because the link between consumption and paying is direct. On the other hand, reduction in consumption may mean increase in redistribution of water to other users resulting in more people paying for the service or increase pressures in pipeline causing burst pipes and leakages especially when the pipe network is old (Heymans, Kathy, et al., 2014).

According to Heymans and Kathy et al (2014), non-revenue water under PWM system arises from the burst pipes due to increased pressures, illegal connections, meter tampering and meter leakages because of delayed maintenance.

One of the most challenging issue pointed out by World Bank (2015) is the failure by water utilities to balance between the volumes of water produced and supplied through distribution

system, to the amount billed to the water users. High non-revenue water impedes the financial viability of the utility through lost volumes of water.

Kumwenda (2006) brings out arguments that under PWMs, water wastage consumption is not reduced for the poor especially, but rather affects the consumption of their important usage (washing, cooking and bathing). In addition, the household level of consumption is already known, therefore, regardless the type of meter customers use, the consumption volume is already known.

2.2.4 Overview of prepaid water meters and revenue in two selected African countries

An overview of experiences with PWMs is based on a study undertaken by Heymans and Kathy et al (2014) on different countries which include among others Kenya and Lesotho. The review was meant to highlight the motives by different utility corporations for selecting prepaid water meters and compare some of the lessons derived from the experience with prepaid water meters. The analysis shows that the common thread among the two countries for introducing prepayment water meters was premised on enhancing service payments from customers (revenue collection) and water demand management.

The researcher deduced that in Kenya, PWMS were first installed in the middle and low income residential area known as Jericho, a former housing estate under the Nairobi city council. Previously under the Nairobi city council, the residents in Jericho did not pay for water services, as the local authority provided the service free of charge. At a time when residents were required to pay for water service provision, it became almost impossible for any resident to comply with the city's water utility firm; the Nairobi City Water and Sanitation Corporation (NCWSC). The situation prompted policy makers (with the involvement of the NCWSC) to seek PWMs to avert the non-payment of service bills by the residents. Thus, in 2009 the NCWSC installed 620 prepaid meters to individual connections, a situation which was not positively received by Jericho residents and as such, most meters were by-passed, leading to low revenue collections.

The main motive for introducing prepaid PWMs by the Water and Sewerage Company of Lesotho (WASCO) in 2004 was because of failure of the post-paid metering system to secure payments from customers who carried arrears resulting in substantial long term debt, a reason like LWSC. The study also revealed that the low staffing levels also contributed to the installation of prepaid water meters in that, WASCO under the post-paid meters could only manage to disconnect a third of customers who were due for disconnections. To cut down on the number of physical disconnections which were not only perceived to be unpleasant for customers but also the lack to effect such disconnections, WASCO opted for PWMs. However, the experience with prepaid water meters had been challenging. The study shows that many PWM installed in Maseru were removed for recording malfunctions arising from inappropriate smart cards, valves that experienced icing up and completely shutting off supply during winter. Non-availability of spares due to the supplier going out of business after the meters were installed was another challenge. Despite the adverse experience with meter, a customer survey conducted by WASCO indicated huge demand for the prepaid water meters. Therefore, WASCO has continued its effort and at the time of the study, WASCO was exploring the smart metering with automatic reading capability, with an option of being used as a pre-or post-paid meter, and with emphasis on data analysis to inform better demand management to bring about customer satisfaction.

2.3 Prepaid Water Meters and Revenue collection/Equity theory

Revenue collection, is defined as the total income that the service provider collects or receives from the billing consumption eliminating the ad hoc charges like penalty fees, meter fees and reconnection charges. Additionally, collection should be proportional to the total billing in a month which may include payments in advance before the service is used, or arrears (NWASCO, 2014b). McDonald and Pape (2002) explains revenue collection as cost recovered from the arrears and billed consumption of the water. Prepaid meters assure 100% recovery of cost billed, plus debt reduction on every water purchase.

Every utility needs a healthy cash flow or revenue for its continuous daily operation and financial health. Padachi defines revenue collection as a balance on the management cash for the daily operation of the business or an organization, thus billing and collection. For this to be achieved, proper management of accounts and collection methods is required. If the utility is not able to collect and recover what they bill, certain important expenditure such as maintenance, is cut off, which increases the future rehabilitation cost, as maintenance costs were neglected (World Bank, 2015). Revenue is like the blood needed for survival of the company, just like blood is required for the survival of a human, provision of desired service to the customers relies on the flow of the revenues (Padachi, 2006).

Due to insufficient revenues, utilities are unable to provide expansions of pipe networks and reliable supply in peri urban and other urban areas which results in un willingness to pay for the service delivered (Cardone and Fonseca, 2003). Berg (2013) indicated that revenue collection is one of the indicators for performance of the utility, however, politicians in some countries do not want to deal with the sensitive topic of non-payment. As they themselves do not pay for the service bills in time, and are not in support of cutting off users for non-payment because it brings about pressure to the politicians and puts the health of the public at risk.

Utilities are embracing the prepaid meter technology as a way of improving the cash flow and increasing the payment levels for the services offered to the customers despite the financial cost of operation and maintenance which comes with it. Utilities believe the benefits over weighs these costs (Heymans, Kathy, et al., 2014).

Privatization (2004) argues that PWMs is an uttermost way of trying to collect full costs from households regardless of the income variations and ability to pay. Its intention is to deal with non-payment and address the unwillingness to pay for the services being provided by the service provider.

However, Lopez (2013) explains that the prepaid waters are targeted in areas where non-payment is a challenge. This helps the customers to control their water usage and prevent getting huge bills they cannot afford every month, as their consumption is legalized. Equity theory best explains this scenario.

Equity theory by Adams 1965, relates perception of fairness of exchange between the parties involved. It states that for a ratio of output and input to be balanced, both parties should feel fairness in the distribution. Either negative or positive treatment will recreate equity. For instance, if the utility company increase the service charges due to improvement of service quality under the prepayment mode, the customers will still maintain the equity of payments by either reducing on their consumption or usage of water or adapt to the new price to balance the change (Homburg.C, Koschate.N, et al., 2005, Bolton and Lemon, 1999). It follows that perception of high satisfaction from the experiences with received service often results in high outcome levels of exchange, which increases the willingness to pay, and continue use of the service. Which improve cash flow for the utility. Customers are the major source of revenue and one way of continuing receiving payments from them, is to balance the equity. Similar, if

the level of service is low, the satisfaction is less and customers respond in exchange with a low payment as a fair balance for such service (Bolton and Lemon, 1999) . Relating this theory with the water prepayment system, which comes with improved quality services, utilities opt for improved collection of revenues from the customer while customers usually balance it with different consumption patterns to maintain the pay.

2.3.1 None payments

The non-payment can be explained into two folds: 'culture non-payment and non-payment'. Von Schnitzler (2013) explains that cultural non-payment can be associated during the anti-apartheid boycott in South Africa areas to make it 'ungovernable'. The boycotts over the payments of the water services provided by the service provider was viewed as political and water users were not willing to pay because, they felt water should not be sold, but free and the charges were exploitative (APF, 2004). However, Savenije (2006) explains the concept of water being an economic good in the sense that, it cannot be replaced by any other alternative but then, the pricing should not be left to the market alone. The price attached to the cost of water should be aimed at achieving the cost of providing the service and pass a message of conservation to the customers.

'Culture non-payment' arises from people not knowing the value of water. Introduction of prepaid meters is a way of re-educating water users on the 'payment culture' (Lopez, 2013). Non-payment on the other hand, explains the non-willingness of the customers to pay for the service received although they are well able to pay for the service. Booysen (2001) explains that non-payment as having customers who rarely make payments, partially and no payment at all. He brings out the two possible factors that causes non-payment: willingness to pay (WTP) and ability to pay (affordability).

APF (2004) argues that prepaid water meters are not the correct instrument for utilities to use to effect revenue collection as some people are unable to afford paying for the water service.

Lopez (2013) also supports this augment in a conducted survey on the prepaid water meters in South Africa Soweto; people are not able to pay for their water bills because they have no income and resources to do so. Out of the 66 households visited ,71 percent confirmed this and mentioned challenges like: lack of job opportunities, high uneducated levels, reliance on informal economy and large number of families per household. People show their 'inability to pay' because prices of the basic needs such as food, cloths and shelter keep increasing therefore, refuse to accept the rise in the water prices (Raje, Dhobe, et al., 2002).

Heymans and Kathy et al (2014) brings out the argument to say the efforts by organization in trying to improve the low collection levels through prepayment water meters would only worsen with minimum improvements in the defects of the service provided .One of the technicians from Mogale city mentioned that the care for customer is a vital factor for PWMs "If you put [PPMs] in and forget about them, you can forget about your money too". however, improving the service is a challenge if the revenue collection is low. This is a dilemma most African countries face.

2.3.2 Debt collection

Harvey (2005**)** explains that installation of prepaid water meters allows the water provider to avoid challenges like debt, disconnections especially in areas associated with non-payment which saves cost of dealing with such challenges. Unlike with the post-paid meters which allows usage of water on credit and pay later, the PWM requires "hard cash" and considered rigid on the payment terms. Heyman and Kathy el al (2014) elaborates that the system gives the user freedom to control what they consume. If there are arrears from the post-paid,

customers can be paying a small agreed percentage towards the debt thereby, avoid debt accumulation even for the future.

Government institutions such as (police and army barracks, prisons, hospitals, schools, and government housing consumers) are main defaulters (Heymans, Kathy, et al., 2014). As they make unreliable payments which accumulate the arears and affect the operation and provision of desired service. Countries like Uganda, Zambia and Malawi resorted to installation of prepaid water meters on such properties and the presidential state house was the first one to have a prepaid water meter in Zambia (Heymans, Kathy, et al., 2014)

However, the residents of Phiri compound, South Africa contended that prepaid is an indirect punishment for defaulters, by self-disconnection whenever the units run out without regarding the circumstance or situation (Von Schnitzler, 2013). People do not have enough income to pay for the water service, and worse asked to settle for the arrears by the service providers. In addition, most families in low income areas could not afford to pay reconnection fees, arrears and service charges, most women felt bad because they had to beg for water whenever they ran out of units and could not manage to buy more.

McDonald and Pape (2002) further elaborate that the harsh disconnections lead to poor health and out breaks such as cholera, as people stayed without water in kwazulu- Natal, South Africa. Lives were lost and because of this incidence, the government then introduced a policy of giving 6000 litres free of water to each household at no cost per month.

2.3.3 Prepaid Water Meter and Tariff

Prepaid water meters may use multiple tariffs with the objective of controlling water demand and being able to provide in the areas where there are shortages.

In developing countries, revenue collection is a challenge as the quality of service provided is low and maintenance of the existing infrastructure is a challenge. However innovative measures such as PWMs are being adopted to improve the delivery of service to the customers.

Pricing water is a way in which water is conserved and properly managed. Having a suitable price plan may avoid misuse of water especially at domestic level where the demand varies. The economic value of water sends a message to customers on which they make informed decisions, thereby affecting proper use of water at both household level and society level (Dinar and Subramanian, 1998).

Tariff setting is often affected by affordability to pay and recommended to be set in accordance with the WHO standards (Al-Ghuraiz and Enshassi, 2005) .When the tariff is too high, people turn to other sources of water which may not be safe for consumption and lead to sickness. On the other hand, under-pricing may result in failure to recover the costs for the utility and reduce incentives for coverage expansions of the service. However, the objective and principles of tariff setting should be considered to: provide an equity distribution of the service, avoid payments for inefficiencies of the service provider, and provide benefits and gains for the service users (NWASCO, 2014a).

Tariffs are set at different rates for different categories of customers and geographical areas for instance, the price may be charged based on the income, the number of people per household, volumetric consumption and the source where the water is originating from. The basic tariff structures applied on prepaid water meters are explained below**;**

- **Uniform rate:** uniform rate is a type of structure where the consumption per unit volume is the same and constant, making the customer to know beforehand how much will be spent per unit.

- **Increasing Block rate:** Usually block rates are divided into blocks, as the consumption increases, the price changes. Normally applied on both prepaid and post-paid meters. On this rate, the higher consumers subsidise the lower consumers who are assumed as poor. The tariff on both prepaid and post-paid water connections is the same except for stand post which are slightly lower (Cardone and Fonseca, 2003). Many countries in the SADC region use the increasing block on the prepaid meters. Others provide some amounts of water free of charge and charge minimal charge on the remaining consumption. For instance, in South Africa, the water users only pay after 6 kilolitres is finished every month on the prepaid water meters and considered as the first rising block (Harvey, 2005). Heymans and Kathy et al (2014) elaborates that in the seven countries that he studied, prepaid water meters use the increasing block tariff.
- **Two-part structure**: 'a fixed charge + user fee for usage of service "based on cross subsidization in five blocks available for different categories of which the first block is set below the cost of service and provides $6m^3$, (Zambia case) for an average of at least 6 people per household each month. The other blocks are set on economic cost to seal the gap between the margin created by the first block. Furthermore, increased price attached to high consumption volume promotes less usage of water especially from abusive tendencies like car washing or careless gardening thereby, boosting provision of sustainable service. However, cross subsidization model operates in areas with metered connection and imposes a challenge on the city as a larger population reside in peri urban with a low metering ratio, therefore impeding the social and cost recovery objective of the tariff setting (Chitonge, 2010).

Some factors that influence Revenue collection in water utilities

- **Billing:** Is defined as the quantity or the volume of water consumed by the water users billed by the utility (Agrawal, 2008). Increase in billing and collection practices increases the revenue collection of a utility and the service delivery of service, as errors in billing leads to incorrect bills delivered to the water users. This may result in unwillingness to pay for such bills there by, lose trust in the billing system of the utility. Utilities face challenges of billing every unit that is treated and produced, therefore results in low billing and low cost recovering. Which further impacts on the operation and maintenance together with the bankability especially if the low billing is because of massive commercial losses (Agrawal, 2008). Billing is more effective if the area coverage is all metered. However, most utilities are not financially viable enough to have a 100%-meter coverage.
- **Increase in supply hours:** This is defined as "the total average number of hours in a day that a utility is able to supply water services to a specific area of the customer"(NWASCO, 2016). If the customers receive a reliable supply, the willingness to pay is high and more customers will be motivated to be connected to a stable supply hence, increase the number of water users. If the production of water is not sufficient such that other users receive less hours of supply, or other areas are not covered at all, the service provider would consider reducing in the physical losses of water and add an additional into the network and improve the supply hours (Farley and Trow, 2003, Farley, Wyeth, et al., 2010)
- **Increase in customer base:** The total number of customers receiving the service and are in the utility data base. In "Manila Metropolitan Waterworks Sewerage" a utility that provides water to about 5.1 million households in the city of Manila witnessed an improvement of about 3 to 5 percent of its usual billing from the time the concession started. This was mainly because, the number of connections to the network increased

and all the properties were metered which translated in revenues and customer service improvement (Agrawal, 2008).

2.4 Factors that Influence Reduction of Revenue on Prepaid Water Meter

Scholars (Heymans, Kathy, et al., 2014, APF, 2004, Lopez, 2013) bring out some of the technical and behaviour factors which influence the revenue of the prepaid water system through the case studies which were conducted in different countries.

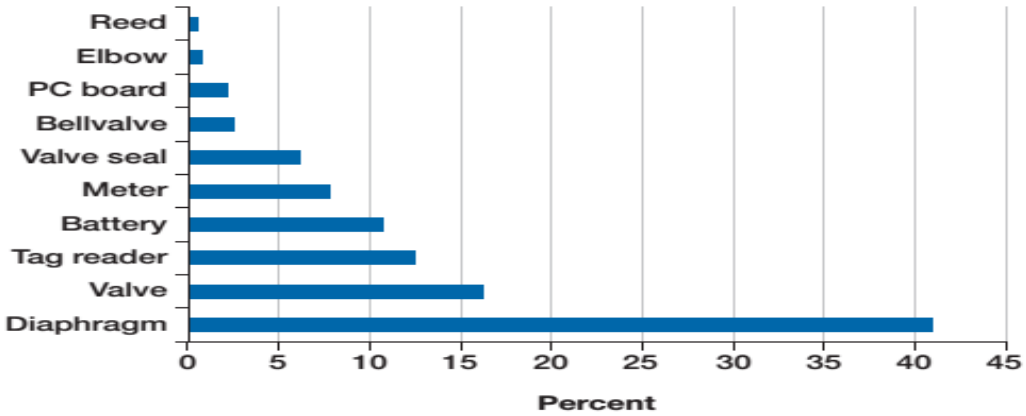
2.4.1 Technical Factors

Factors which cause delay, interfere with the accuracy, operation and performance of a system or a component in time (Ashbourn, 2004). Arregui and Cabrera et al (2005) explains the factors as those which limit the performance of a device or system causing inaccuracies. Additionally, any new technology strives to understand technical factors to be able to adequately describe and test the performance, also calibrate the device or components to deliver a specific performance. The focus is directly on the product of the technology, to be able to monitor interpretation errors and detect manipulation.

- **Valve failures:** These are failures which occur because of errors caused by technology of a system or in the network distribution. Heymans and Kathy el al (2014) highlight that in most cases, valve failures occur because of poor water quality and suspended particles in the distribution networks. These cause meter inaccuracies for instance; some meter valves indicate that they are closed fully meanwhile are open and allow continuous flow of water even after the purchased units in the PWM are depleted. Occasionally, due to component composition, prepaid water meter valves jam on their own for no obvious reason and locks by either shutting off supply, causing token purchase to register or load incorrectly or open the valve and allow continuous flow of water.

  Furthermore, poor quality of water especially with sand and grit, destroys the seals of the meter (diaphragm) and blocks strainers. Blocked strainers further reduce the pressure network (Heymans, Kathy, et al., 2014). Diaphragms are vulnerable to frequent malfunction. The figure 2 shows results on the study of faults on the prepaid meter conducted in Windhoek and was found that different parts needed to be replaced with a large percentage showing diaphragm and valve of the meter.

Figure 2:Percentage of faults on PWMs awaiting replacement over a period of 10 months (2012-2013)



Adopted from (Heymans, Kathy, et al., 2014)

- **Low water pressure in the network:** Some prepaid meters demand a certain pressure (0.2 bar to 1 bar) for the valve to close. If the pressure is less than the set limit, the valve remains open. Furthermore, reliable pressure and continuous flow of the water in the pipe network is vital. 24/7 supply of water should be at least precondition before the installation of PWMs. Supply interruption creates air vacuums in the network which leads to stuck meters, eventually degradation (Heymans, Kathy, et al., 2014) . At times, the meter counters run at a faster rate and depletes the loaded units without suppling any water. Water utilities need to budget for extra funds to cover network upgrade before PWMs are installed.
- **Physical Inspection and strict regulation:** planning and controlling are amongst the functions of management for an organization to achieve its desired objective (Cole, 2004).Formulating groups of actions and ensuring proper monitoring and implementation is key for a successful plan (Heymans, Kathy, et al., 2014).Frequent physical checking of the metres optimizes identifying of anomalies such as water losses through illegal means like; meter by-passing, tampering and illegal connection. If physical monitoring is neglected, water losses are easily unidentified, translating into more revenue lost.

  In Mogela, one of the strategies the municipality came up with, was to put up a strict regulation in form of a penalty fee regarding any illegal and meter tampering. Accompanying this was continuous visible checking on the ground. This reduced cases of tampering and bypasses in the city. In addition, strict analysing of different customer categories trends of consumption was introduced in Mogela city and by monitoring this, customers who consumed a lot of water but paid less or did a meter bypass were easy to identify.
- **Maintenance:** physical caring, replacement of parts and conducting other works to retain or preserve the system in a proper condition. This is a process of keeping an object, machine or equipment in a good condition by taking steps which avoid the breakdown (Bachmann ,2010). Esmaili (2012) brings out two types of maintenance, preventive and corrective maintenance. Preventive maintenance is a planned program to avoid malfunctioning of an asset while corrective maintenance takes corrective measures due to noticed defect. Calais and Matia et al (2013) highlights that preventive maintenance is more effective, reliable and less expensive compared to corrective maintenance which is expensive, unreliable and results in regular failure plus poor service quality resulting into system breakdown.

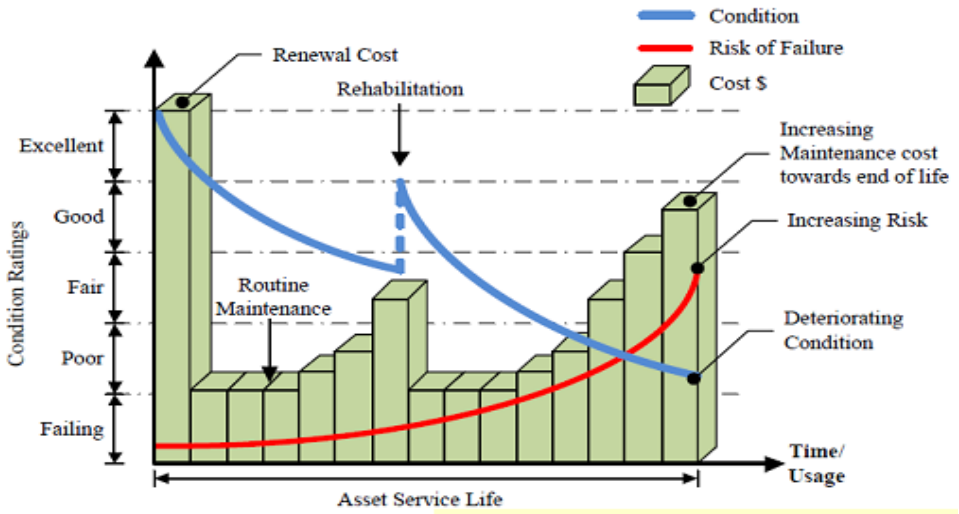
  Maintenance on prepaid water meters' system is necessary to improve the service life of pipe network and the meters. It also reduces physical losses caused from leaking meters. Occurrences of faults and defects becomes more as the asset is in use and aging. To prolong the service life, maintenance is necessary though costly but becomes more if it is neglected and the asset approaches the end of its life-span (Esmaili, 2012).

  Conventional meters are less demanding and inexpensive as compared to prepaid water meters. Recovery of the investment cost is doubted (Heymans, Kathy, et al., 2014). Service providers underrate the maintenance and monitoring requirements for the prepaid water meters. Unlike conventional meters, electronic and software parts are linked together and makes it difficult to manage. In addition, battery failures require repairs and replacement. This is the core part in the management of the prepaid water meter.

If pipe network is not consistently maintained, debris and sand in the pipe networks will choke the meters and stuck it. Meaning, more cost on replacement and revenue loss through faulty valves. The experience of Lesotho with prepaid meters especially in winter confirmed that frequent maintenance is demanded for reliability of a system. In addition, neglected maintenance noted at several sites increased the leakages especially places like barrack police and colleges.

The figure depicts below, that routine maintenance extends the service life but as the asset nears its service life, more breakdowns occur and costs increases.

Figure 3:Lifecycle routine maintenance and costs of an asset



Adapted from AMCL, cited in Lloyd 2010 p. 12

Heymans and Kathy el al (2014) further explains that most managers lack detailed record keeping of the maintenance costs and repair work done on the prepaid water meters. From the survey conducted, it showed that the managers could only provide the statistical numbers of the failures, repairs and items required for maintenance. The author suggests that in-house record keeping and repair and work on the faults, is better rather than engaging suppliers and paying them whenever there are faults.

2.4.2 Behaviour factors and Planned Behaviour theory

Behaviour is a way in which a human being, responds, selects, or acts to satisfy their need and desire (Solomon, Russell-Bennett, et al., 2012). An individual behaves in a certain way towards others, objects and the environment he/she operates in response to a stimulus. Behaviour can be two sided, either good or bad depending on society.

A shift from post-paid to prepaid meter system manifest certain behaviours from consumers which contribute to reduction of revenue collections of utilities. Heymans and Kathy et al (2014) brings out some behaviour which were observed from the cases studied.

- Consumption efficiency: According to Vickers (2001), consumption efficiency is a way in which water wastage and loss is minimised due to “doing more with less water and only using water that one needs”. Heymans and Kathy et al (2014) defines it as a change in water use through reduction in the portable consumption. It is a measure which enables considerable reduction of water consumption with relatively less efforts and high comfort.

Consumption efficiency involves trends of behaviour usage pattern which result in water consumption reduction. Therefore, it links the water required to accomplish a specific task with the actual utilised (Vickers, 2001).

Planned behaviour theory is usually used in explaining behaviour change as it assumes that the water users calculate the benefits and costs before an action is under taken. Normally the different options that are opted are in favour of their net benefit (Solomon, Russell-Bennett, et al., 2012). The theory is focused on the intention an individual in performing a behaviour (Ajzen, 1991). There may be several motivation factors that affect the final behaviour of customers in the purchase and consumption of water for instance income level and affordability. theory states that motivation factors are indicators to how much the customer is willing to attempt to ensure behaviour is performed. In addition, the stronger the intention is or motivation, the more likely the performance of a behaviour which mostly occur when the behaviour is under a volition process.

Customers who consume more are subjected to high use alternations as compared to the lower customers, because of many optional waters use and greater opportunities to minimise their water use (Eskaf, Hughes, et al., 2014). For instance, higher consumers may manage to consume efficiently by simply altering their landscape. Contrast to low consumers who already utilise small volumes of water. Furthermore, customer water use differs according to the income level. For instance, a customer who has a low income might minimise on the consumption more notably as compared to a higher consumer about rate increase. However, the higher consumer may develop new techniques with efficient technology. Ultimately reduce the water consumption which increases redistribution of water in the network

Change from PPM to PWM promotes low water consumptions from the water users which contributes to low revenue billing for water utilities. Water users become conservative and use water more efficiently than before and thereby spend less. For example, in Eldorado park the customers also became conservative and never left taps running even when they were doing dishes, taking their bath and brushing their teeth, as most households had learned water conservation and were in control of their budget. Another case in Otjiwarongo Namibia, suggested that the introduction of PWMs on revenue improvement was not as expected due to the reduction in water consumption by the users (Tuovinen, 2014).

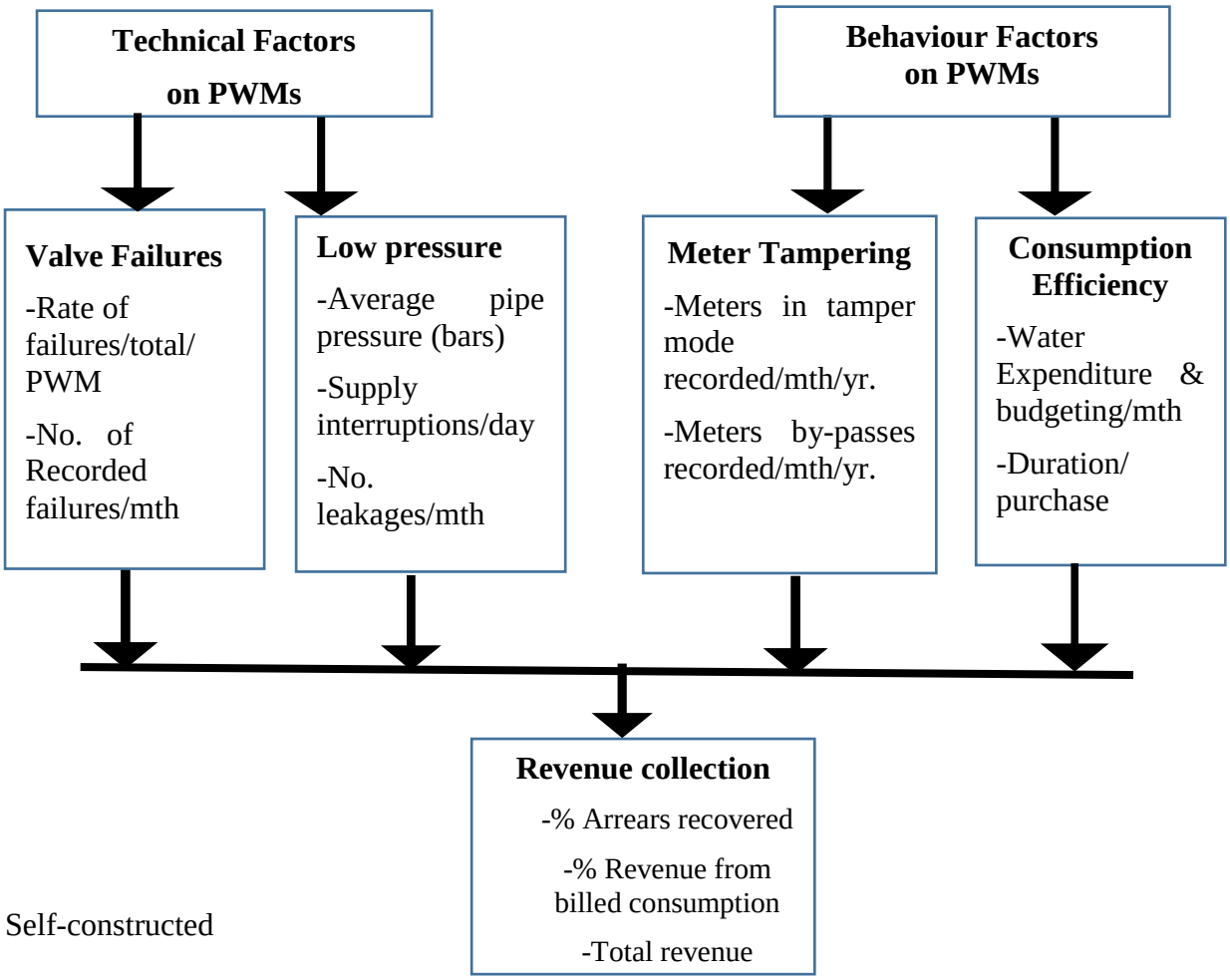
- Meter Tampering: Prepaid water meters are vulnerable to tampering for instance, just puncturing the valve especially those installed on domestic connection (Heymans, Kathy, et al., 2014) . Meter tampering is an act of an illegal exploitation which allows access to a service which is not billed by the service provider (Monedero, Biscarri, et al., 2015).The service provider has no control regarding the consumption as the registration of the consumption of the water user does not reflect as a right billing of a service. These are major water losses in addition to the ones which emanate from meter defaults, meter by-passes and illegal connection. These losses, translated into money, amounts to huge revenue losses to the utility. Meter tampering is an act which slows the flow rate of water or leaves the meter open and freely allow water which is not paid for.
- Illegal connection and meter by-pass: These are other dishonest behaviour where direct connection to the network is done without the knowledge of the service provider who have no control on the billing of the consumption. Illegal connections are sources of low pressure in the distribution system and revenue losses for service providers. While Meter by-passes is where a meter is ignored and connection done before the meter (Monedero, Biscarri, et al., 2015).

According to Heymans and Kathy et al (2014) from the studies conducted, concluded that lack of continuous monitoring and delayed response rate to customer complaints regarding meter failures, was a genesis for vandalism and meter by-passes**.**

2.4 Conceptual Framework

The conceptual framework shown below displays the variables which are derived from the literature (Heymans, Kathy, et al., 2014, Ajzen, 1991, Bolton and Lemon, 1999), concept of prepayment water system and constructed from the main research question. These include, technical and behaviour factors under PWMs, which are independent variables and revenue collection as dependent variable. Under technical factors, two sub variables have been selected for this research, valve failures and low water pressure in the distribution network. On the other hand, the two-sub variable identified under behaviour factors include: meter tampering and consumption efficiency. The four sub variables ultimately influence the revenue collection of the utility. The focal point of this study is to examine the relationship between technical and behaviour factors on revenue collection. Planned behaviour theory and equity theory are the two theories used in this research. Equity theory helps to explain fairness of exchange between the parties involved while planned behaviour theory describes the behaviour change as it assumes that the water users calculate the benefits and costs before an action is under taken.

Figure 4:Conceptual framework



Self-constructed

Chapter 3: Research Design and Methods

3.0 Introduction

This chapter focuses on the operationalization of the indicators, the variables and concepts from the conceptual framework. It also brings out the research strategy which will be used, the sample unit size, the methods for collecting data, reliability and validity and data analysis methods.

3.1 Operationalization

3.1.1 Definition of Variables and Indicators

Operationalisation is defined as the "transition from theory to empirical research"(Van Thiel, 2014). In this process, the concepts used in theory are changed into being, which is observable or measurable in real life.

There are three steps required in the process of operationalisation: defining the concepts used in the research, operationalise the variables in to measurable indicators and attach a score or value to the variable (Van Thiel, 2014)

3.1.1.1 Equity theory

Is a theory by Adams 1965 that relates perception of fairness of exchange between the parties involved, it states that for a ratio of output and input to be balanced, both parties should feel fairness in the distribution. Whether the treatment is negative or positive, equity is recreated. In the case of LWSC, the theory helps explain the balance created between the organisation's aim to improve revenue through prepayment system which comes with improved quality of service, with the customers who still maintain the equity of payments by either reducing on their usage of water or adapt to the new price to balance the change (Homburg.C, Koschate.N, et al., 2005, Bolton and Lemon, 1999)

3.1.1.2 Planned Behaviour theory

Planned behaviour theory is usually used to assume that customers calculate the benefits and costs before an action is under taken. Normally the different options that are opted for are in favour of their net benefit (Solomon, Russell-Bennett, et al., 2012). According to Ajzen (1991) explanation, the theory is focused on the intention that drives an individual in performing a behaviour. There may be several motivation factors that affect the final behaviour of customers in the purchase and consumption of water for instance income level and affordability. The theory states that motivation factors are indicators to how much the customer is willing to attempt to ensure a behaviour is performed. In addition, the stronger the intention is or motivation, the more likely the performance of a behaviour. This theory helps this study to understand the behaviour factors which result from the prepayment system.

3.1.1.3 Prepayment water metering

Prepayment metering system is a technology which allows customers to pay for the water service before consumption, and automatically cuts off supply once credit depletes or in an event of non-payment (Von Schnitzler, 2013) .The author simply means "pay before use"

3.1.1.4 Revenue collection

Revenue collection has been defined by so many authors, however, this research adopts the definition by McDonald and Pape (2001), who explains revenue collection as cost recovered from the arrears and billed consumptions of the water. It excludes ad hoc charges like penalty fees, meter fees and reconnection fees.

3.1.1.5 Technical factors

These are factors which cause delay, interference with the accuracy, operation and performance of a system or its components (Ashbourn, 2004**).** The author describes the factors as limitation to operation and performance of a system. Nonetheless, the research centres on two, valve failures and distribution low pressure pipe.

3.1.1.5.1 Valve Failures

Heymans and Kathy et al (2014) describes these failures which occur because of errors caused by technology of a system or in the network distribution. These failures cause the meter not to either open fully or close. (highlight that in most cases, valves failures occur because of poor water quality and suspended particles in the distribution networks).

3.1.1.5.2 Low pressure pipe

Heymans and Kathy et al (2014) describes distribution low water pressure pipe as unsteady pressure which is usually less than the set pressure (0.2 bar or 1 bar) for the opening and closing of the prepaid water meter valve. Interruption in water supply and leakages are some of the causes of low pressure in the water distribution network.

3.1.1.6 Behaviour factors

Behaviour is a way in which a human being, responds, selects or acts to satisfy their need and desire (Solomon, Russell-Bennett, et al., 2012). An individual behaves in a certain way towards others, objects and the environment he/she operates in, in response to a stimulus (Solomon, Bamossy, et al., 2006). Behaviour can be two sided, either good or bad depending on society. While behaviour factors are defined as behaviour changes adopted by water users to satisfy their needs or desire (Solomon, Russell-Bennett, et al., 2012). These usually exert strong influence on revenue collection.

3.1.1.6.1 Consumption efficiency

Consumption efficiency: According to Vickers (2001) consumption efficiency is a way in which water wastage and loss is minimised due to “doing more with less water and only using water that one needs. Consumption efficiency involves trends of behaviour usage pattern which result in water consumption reduction. Therefore, it links the water required to accomplish a specific task with the actual utilised (Vickers, 2001).

3.1.1.6.1 Meter tampering.

Meter tampering is an act of an illegal exploitation which allows access to a service which is not billed by the service provider (Monedero, Biscarri, et al., 2015). The author explains that the service provider has no control regarding the consumption as the registration of the consumption of the water user does not reflect as a right billing of a service

The concepts, theories together with the variables and measurable indicators used in this research are shown in the operationalization table 3 below.

Table 3:Operationalization of Variables and Indicators

Theory/Concept	Variables	Sub-Variables	Indicators	Method used In data collection
Prepayment water system	Prepaid water meters - Technical factors	Valve failures	-Frequency valve failures/total meters connected - Number of recorded valve. Failures/month	-Interviews -Questionnaires -Secondary data
Planned behaviour theory		Low pressure in distribution line	- Average pipe pressure (bars -Water interruptions/day -Pipe leakages recorded /month	- Interviews -Questionnaires
Equity Theory	Prepaid water meters - Behaviour factors	Consumption efficiency	-Water Expenditure/month -Budgeting/month -Duration/next purchase	- Questionnaires -Interviews
		Meter Tampering	- Meter tampering recorded/month -Meter-by-passes recorded	- Interviews -Questionnaires -Secondary data
	Revenue collection		-Arrears recovered -Revenue from billed consumption -Total revenue/year	-Secondary data

3.2 Research strategy

Considering the objective of this research which is: to explain the extent technical and behaviour factors related to prepaid water meters influence the reduction of revenue collection of LWSC in Kafue district. This research had adopted, an explanatory type of research because we wanted to explain the extent of "cause and effect "relationships between technical and behaviour factors (independent variable) related to prepaid meters on revenue collection (dependant).

The study had employed a case study strategy. It included taking a holistic approach, implying that all the data was to be collected on everything to do with the topic of the research (Van Thiel, 2014). Case study can be used for inductive and deductive type of research and mainly take interviews as data technique for collecting or analysis.

Case study is a strategy which allows one or more cases of a subject to be studied in either a real life set up or day to day case (Van Thiel, 2014).The strategy is limited to a small sample size and includes many unknown variables that can explain a phenomenon. Additionally, it goes more in depth to fully explain, explore and describe a phenomenon in very great details, within the distinctive context of the research in question. This brings out a rich qualitative understanding (Flyvbjerg, 2006).

Furthermore, a case study makes different types of comparison which can be a single case or multiple case. A single case is a scenario where the comparison finding is within one case study while, a multiple case is one which involves comparison of various cases usually two or more. Nonetheless, (Van Thiel, 2014) contends that a researcher can as well choose one or more cases felt to be illustrative and acts as an example of the study topic in a single case study. This study had adopted a single case study. There are three types of case studies namely; Co-variation-used to explain effects of why X_1 leads to a change in X_2 within a context. Congruence analysis-used when comparing competing theories. Lastly, Causal process tracing-focuses on processes and not causal relationship (Van Thiel, 2014).

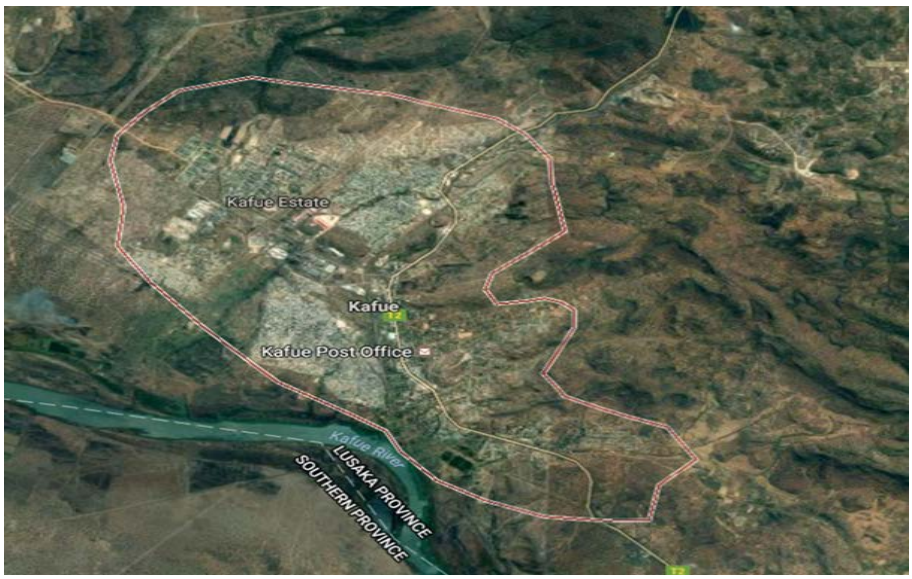
This strategy was selected because, it allowed in depth data generation to explain how technical and behaviour factors relating to prepaid water meters influence reduction of revenue collection in LWSC. There were many possible unknown variables under technical and behaviour factors that could explain reduction of reduction in the district, beside the mentioned. Therefore, using this strategy, allowed a rich and wealth data to be unpacked within the context of the district and the interaction of these variables. In addition, it allowed flexibility to discover data during the process of data gathering, unlike in survey.

3.3 Data Collection Methods and Sampling

3.3.1 Area of study

The area of study was Kafue district, one of the districts in Lusaka province where LWSC oversees provision of water and sewerage services. LWSC has divided the district into zones, namely: Central zone-which includes town area properties, Western zone, Northern zone and Southern zone and South-East. All these zones form Kafue branch operational area in the district. LWSC has a customer base of 10,002 and of these, 8,000 connections are on prepaid water meter (Edams,2015). The district is divided into two income categories, medium and low income. Fig 5 below is showing area map of Kafue where the data was collected.

Figure 5:Kafue map



Source: Google Maps

3.3.2 Unit of Analysis

The unit of analysis in this research included; LWSC, as it oversees the service provision to, commercial and domestic properties in the district. However, for triangulation reasons, customers on PWMs were included as well.

3.3.3. Secondary data

This research was backed with secondary data through desk research. This increased reliability and validity of the research. LWSC data base and Unpublished report from Prepaid collections and purchase exception reports were reviewed as data sources to understand the trends, and helped in answering some question of the research.

3.3.4 Primary data

Two data instruments were applied, interviews and questionnaires. The interviews were semi structured and were administered to representatives from within LWSC Kafue who are the experts. While semi closed questionnaires were issued to the water users on PWMs. A copy of both interviews and questionnaire is in Annex 1.

3.4 Sample Size and Selection

Purposive sampling and stratified random sampling approach were used in this research. Purposive sampling was used for the semi structured interviews while stratified random sampling were used for the questionnaires.

Interviews -Purposive sampling is a non-probability type of sampling where selection is done in relation with the knowledge relevance, or based on theoretical knowledge regarding to the topic. It is qualitative in nature. It allows sample selection which gives findings within the context. Furthermore, it deals with a relatively small size, as the objective is to select or pick only people who are informative (Van Thiel, 2014) . Based on these reasons, this research had adopted this type of sampling.

Kafue branch consist of 20 employees. Two are under senior management ,6 are middle management and 12 are under operations. From the total number of employees, 12 respondents were to be interviewed. Furthermore, respondents were to be chosen according to the variations

in the level of positions in the company. This increased representativeness and reliability of the results. Also, to understand in detail the views of commercial customers, 5 customers were to be interviewed giving a total of 17 respondents. The list of the respondents is seen in table 4

Table 4:List of respondents

Position	Department	Level of position	No
LWSC Employees			
Branch Manager	Commercial	Senior Management	1
Senior Engineer	Engineering	Senior Management	1
Branch Engineer	Engineering	Middle Management	1
Superintendent	Engineering	Middle Management	1
Credit controller	Commercial	Middle Management	1
Billing and Revenue officer	Commercial	Middle Management	1
Customer service officer	Customer service	Middle Management	1
Foreman	Engineering	Operation	1
Plumber	Engineering	Operation	2
Billing and Assistant	Commercial	Operation	2
LWSC Commercial customers			5
Total sample			**17**

Questionnaires - The sample size was based on a population estimation of 8000 households connected on PWMs (Edams,2015). Then, applying a confidence level of 95% and an interval level of 5, we came up with 367 households which is a representative sample. Kafue district is divided into five zones classified as middle and low-income level categories. A stratified random sampling approach was used to include the two income categories of water users from the five zones.

The following steps were taken; Firstly, the area was selected, thereafter, from the map certain number of streets were selected to issue the questionnaire. Selection would start on one point of the street, then after five houses, picked another house. The same procedure was repeated for the other zones. Doing this procedure, a total of 30 questionnaires were issued to 30 households. Nonetheless, this sample size is much less than the calculated representative sample size. This was because of time limitations caused by the fact that field work was to be done within a month.

The total adopted sample size for this research before field work was 42 respondents

Adapted sample size after field work

When field work started, some changes were made to the initial sample size due to some challenges that were faced during the field work. For the interviews, it was difficult to interview commercial customers, most of those approached refused as they were afraid and thought it

was politics related even after clarifications. People refused giving information for fear of being implicated. Because of this, only one commercial customer was interviewed. Furthermore, only one person from senior management was available. Four employees from operation were interviewed instead of five as finding them before they went for field work was a challenge. In total, 11 respondents were interviewed. The list of respondents after field work is seen in table 5

Table 5:List of respondents for interviews after field work

Position	Department	Level of position	No
Semi structured Interviews			
LWSC Employees			
Senior Engineer	Engineering	Senior Management	1
Branch Engineer	Engineering	Middle Management	1
Superintendent	Engineering	Middle Management	1
Credit controller	Commercial	Middle Management	1
Billing and Revenue officer	Commercial	Middle Management	1
Customer service officer	Customer service	Middle Management	1
Foreman	Engineering	Operation	1
Plumber	Engineering	Operation	1
Billing and Assistant	Commercial	Operation	2
LWSC customers(Commercial)			1
Total sample			**11**

For questionnaires, 30 households were issued of which, 5 were customers who had small business just right at their homes such as brick construction and grocery stores. The response rate was 100 percent.

However, these changes did not have any impact on the research as all the key respondents were represented. The total adopted sample size after the field for this research was 41 respondents.

3.5 Reliability and Validity

3.5.1 Reliability

According to Van Thiel (2014), reliability involves accuracy and consistency in the way variables in a research are measured. Results reflect a more representative picture if the level of accuracy and consistency is high. Accuracy in an explanatory type of research implies that the explanation provided is most certain correct and no deformation has happened. Furthermore, reliability means the accuracy regarding the measurement instruments selected for a research. Consistency on the other hand includes repetitive -getting the same answers under the same condition measuring the same study. Providing assurance that the result found in a research is correct, is harder to achieve.

To increase reliability in this research, all the methodology steps were documented. Also, being transparency regarding any changes that may have taken place during the collection of data. Using semi structured interviews and questionnaires enabled the measuring instruments used to be sound thereby, increase reliability.

3.5.2 Validity

Van Thiel (2014) brings out two types of validity, internal and external validity. Internal validity point to whether the research has measured what it intended to measure. While external validity brings out the extent a research can be generalised. To achieve validity, the research had constructed semi structured interviews based on the concepts from literature which are operationalised**.** Also, different sources of data and sourcing data through triangulation was used, both primary qualitative/quantitative and secondary quantitative data.

3.6 Data Analysis

For the semi structured interviews, data collected was transcribed and analysed using Atlas. Ti program. To be able to use Atlas. Ti program, a topic list was created based on the research questions and indicators reflecting in the operationalised theoretical frame work. Thereafter, data was coded using codes from the topic list and new constructed codes. The data was then labelled using the generated code list. For better analysis of the gathered data, relevant codes were grouped into categories in a logical way. The grouping consisted of attributes with shared characteristics in a significant form. Lastly analysis of data using Co-occurrence analysis and summary frequencies was conducted. Query analysis was also carried out. These tools helped in coming up with patterns and focusing on the patterns, for easy identification of the relations and findings.

For the questionnaires, data collected from the field was first inspected, prepared and edited through variables based on the conceptual frame work. The data was analysed using frequencies of Statistical Package for Social sciences (SPSS). But also applied Pearson correlation test and a multiple regression. Pearson correlation was conducted to tell statistically how strong the association between technical factors and revenue collection, also behaviour factors and revenue collection of the utility. The relationship between the variables can either be positive or negative (Van Thiel, 2014). A positive or negative value co-efficient greater or equal to 0.5 was accepted for this research as “stronger correlation”.

Furthermore, correlation test only displays the relationship between two variables, therefore, to find out the influence of technical and behaviour factors on revenue reduction under PWMs, a multiple regression analysis was carried out. The test displays whether the changes in one variable is influenced by changes in the other variable while controlling for effects of irrelevant variables statistically. Additionally, it shows not only the “significant effects “but also intensity of the explanation of their value (specifies the percentage of explained variance R^2) (Van Thiel, 2014).

On the other hand, secondary data was used to support the primary data collected and analysis was done using Microsoft excel.

Chapter 4: Research Findings

4.0 Introduction

The previous chapter outlined the methodology and the research instruments used to collect the data. Hence, this chapter builds on the previous chapter by presenting the research findings through the analysis of the data collected to address the research objective of this study. This chapter begins with a short summary of the study case description thereafter, is given a brief description on the respondents' characteristics from both interviews and questionnaires. Field findings are then displayed using the frequency tables and later discussed in line with literature. Secondary data is also used to support the findings.

4.1 Description of the case

This research is established on a case study of LWSC, a water and sewerage provider in Kafue district. The main objective of this research, is to explain the extent to which technical and behaviour factors related to prepaid water meter system have influenced the reduction of revenue collection. According to Edams (2015), 95% of the water pipe connections in the district are on prepaid and 5% are still on post-paid connection. The water service provider is wholly owned by the government though operated as a private company from the time of commercialization. PWMs were introduced to improve the revenue of LWSC, however, the performance of these meters from 2015 till now has been deteriorating and revenues have been decreasing. Both technical and behaviour factors are said to contribute to the decrease in the revenue collections and adversely affect other operations and maintenance of the company.

4.1.1 Description of respondent characteristics from the interviews

A total of 11 respondents were interviewed, of which 10 were from LWSC and 1 respondent was a commercial customer. The education qualification of the respondent is generally high, where the highest qualified holds a master degree and the least holds a craft certificate. Furthermore, all LWSC respondents have been working with the utility for more than 4years.

4.1.2 Description of respondent characteristics from the questionnaires

On the other hand,30 questionnaires were issued to help in understanding the customers perspective regarding behaviour and technical factors on the prepaid water system. 56% of the respondents were men as heads of the house while 43% were female. Heads of the house in Zambia oversee bill payments such as paying for water service and others. The average number of people per household was 6. Additionally, most of the respondents have had PWMs for 3 to 4 years. This is enough duration to express opinion on the experiences with the PWMs.

4.2 Research findings and Analysis

The data findings are presented according to the sub research question.

1. How are valve failures and low pressure related to prepaid water meters influencing the reduction of revenue collection of LWSC in Kafue district?
2. How are changes in water consumption efficiency and Meter tampering influencing the reduction of revenue of LWSC in Kafue district?
3. What other technical and behaviour factors are influencing the reduction of revenue of LWSC in Kafue district?

1.How are valve failures and low pressure related to prepaid water meters influencing the reduction of revenue collection of LWSC in Kafue district?

4.2.1 Technical factors

Under this segment, valve failures and low pressure in the distribution network will be discussed to provide answers for the first sub-question indicated above. The results will be discussed starting with the interview findings then followed by questionnaire findings

According to the interviews, the following questions were inquired based on the indicators presented in chapter3. Failure rate of the valves, common failures of the valve meters and why these failures are occurring, measures put in place to reduce these failures and how valve failures are influencing revenue collection. Also, for low pressure, the following were asked; Average pressures in the distribution lines and pressure management, supply hours under PWM and reliability, pipe leakages and control measures of the leakages, how low-pressure influence revenue.

4.2.1.1 Valve failures from interviews

From the interviews, a summary of responses on valve failures is depicted below in table 6

Table 6:Summary of the respondents on valve failures

No	Question	Summary of responses	Frequency
1	Failure rate of the valves to the total meters.	70% of the PWMs have valve challenges [2]. The rate is very high.	9
		50% of the complaints that come to customer service office, must do with the prepaid meter failures.	2
		The number is increasing and failures are happening every now and then [3]	10
2	Common failures of the valve meters and why these failures are occurring	Meter giving negative balance, getting stuck and under recording	10
		Lack of man power and availability of materials to handle complaint and quickly respond to faults	9
		Debris are found in the network and choke the meters	10
		-Employee lack technical know-how, caused by lack of training	7

		Delink between Kafue branch and PWM department in Lusaka.	2
3	Measures put in place to reduce these failures	AMR is done once a month, though it is not very effective	5
		-Replacing PWMs with PPMs	10
		-Routine inspection, though rarely conducted	4
4	How valve failures influence revenue collection	Most customers become relaxed, they stop buying units or buy less water because water keeps coming out [1]	10
		It brings queries between landlords and LWSC to say why meter are not shutting, so the fault goes to LWSC and payments are affected [2]	5
		Disconnected customers do not settle huge arrears sitting on account. Buy cheap water from neighbours [3]	7
		Some major customers have moved to alternative water sources like private boreholes	5
		More time is wasted on repairing valve faults while neglecting other operations like leakages	7

Table 6 shows the results of valve failures from the interviews. The following will be discussed in detail following the sequence and considering the indicators; failure rate, common failures and why the failures are occurring and how the valve failures are influencing revenue.

Failure rate of the valves to the total meters.

From table 6, question 1, as can be seen, 70 percent of the total meters that were installed when the meters were introduced have challenges with the valves. This means that only 30 percent of the meter are working normally. 9/11 Respondents indicated that the failure rate of the valve on PWMs is high. The findings indicated that even new meters are also failing, what has been happening is that a meter may be installed today, then a few days the valve stops closing. Respondent 2 stated, *"I can say 70% of those that were installed do go in negative they don't shut when the water finishes in the meters"*. Furthermore, 2/11 Respondents said that most of the complaints customer service handle, are related with the PWM failures. However, Respondent 3 argued that customers only report mostly when the valve is stuck in close position and have no access to water

From figure 6 and 7 regarding to the questionnaires on valve failures, we can see that 60% of the respondents strongly disagreed and disagreed with the statement that water cut once loaded units are finished. Also, 70% of the respondents strongly agreed and agreed that their meters go into negative when units are depleted. Indicating that the meter keeps dispensing water even after zero which is the set point for the valve to shut.

Figure 6:Water cut once loaded units are finished

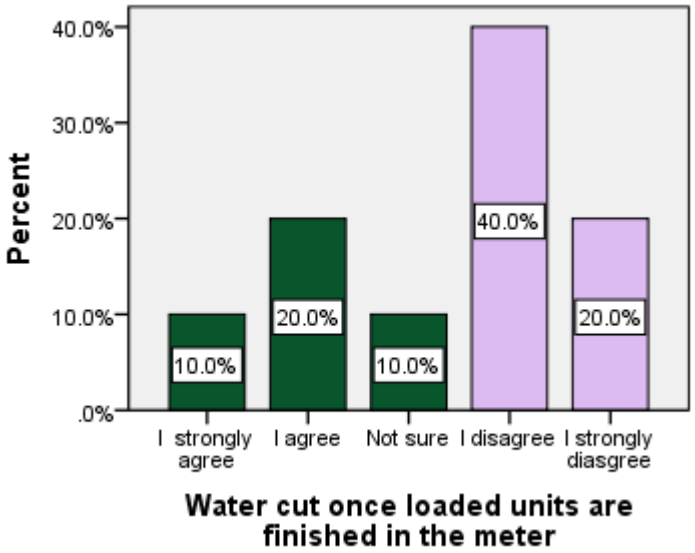
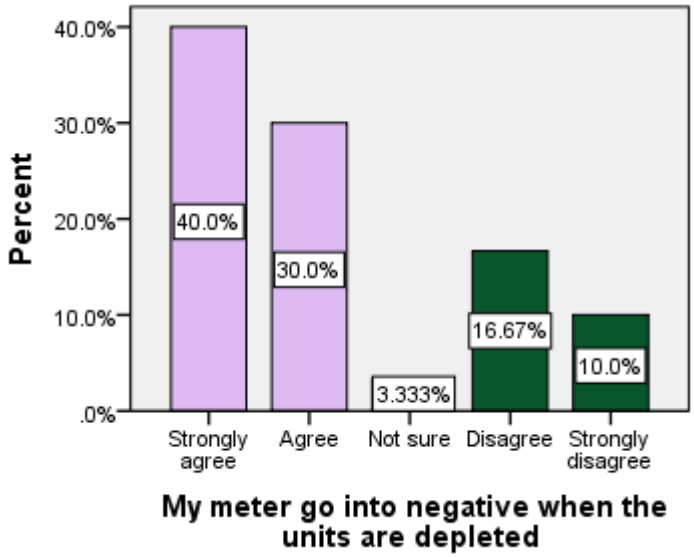


Figure 7:My meter goes into negative when the units are depleted



From the results discussed from both interviews and questionnaires, we can see a match that the rate of valve failures is high on PWMs. As most of the meter valves fail to shut whenever loaded credit is depleted. Contrary to what literature stated in chapter 2, that PWMs automatic cut off from supply upon exhaustion of units purchased in the meter (Von Schnitzler, 2013). Nonetheless, Heymans and Kathy el al (2014) stated that PWM is a new technology and comes with its own challenges. Also from secondary data, according to table 7 showing the number of valve failures captured by AMR for five months can confirm this.

Table 7:Number of valve failures captures by AMR

	Month	Meter read	Closed valve	Faulty valve	Uncaptured meters
1	December 2016	4413	563	465	2573
2	February 2017	5550	884	418	1991
3	March 2017	1373	653	494	2308
4	May 2017	4617	569	500	2352
5	June 2017	1261	490	557	2573

Source: (collection and purchase exceptional reports)

Common failures of the valve meters and why these failures are occurring

As can be seen from table 6 question 2, 10/11 respondents, mentioned common failures of the valve being meters not shutting at zero when credit exhaust hence gives customers negative balance and meters getting stuck (under record or not shutting). From the findings, some of the vital reasons why the meter failures are happening in the district includes;

In line with why the valve failures are occurring, 9/11 of the respondents said man power is not enough to handle all the valve complaints and conduct inspections. Respondent 3 mentioned that the utility has only four billing and revenue assistants comparing to the ratio of more than 8000 meters. The same team is required to conduct meter reading and meter checks on post-paid meters, and attend to leakages and other faults on the meters. Respondent 6 added that response to customers has not been good because of less man power. Considering the rates at which these valves are failing, the utility fails to integrate all the works together.

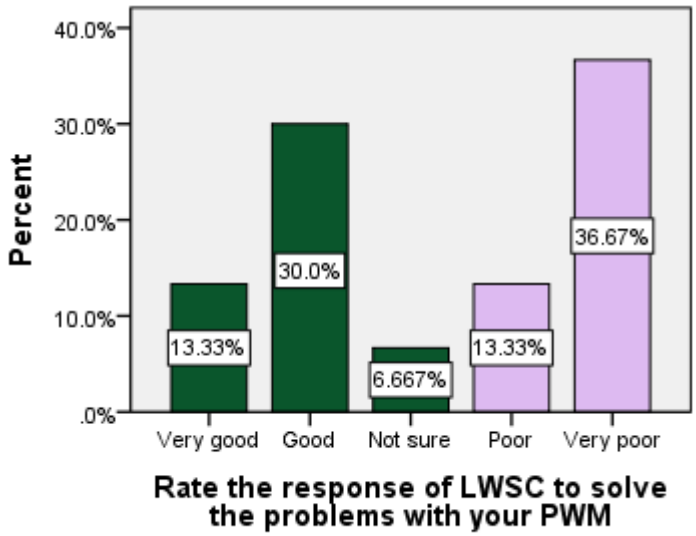
"*but if we can have a quick response team to quickly respond, the rates of meter failures can reduce and things can be ok*" Respondent 3. According to Heymans and Kathy et al (2014) from chapter 2, Most utilities place their focus mostly on maximising the revenue collection and arrears with regarding the extra maintenance and significance of equipped technical staff required in responding quickly to PWM faults. Respondent 2 also indicated that spares were currently very scarce.

However, 7/11 Respondents stated that the department which handles the PWMs in the branch lacks the technical knowledge. Findings review that plumbers who carry out maintenance on PWMs have had no proper training in Kafue. Respondent 1 stated that except one or two occasions where the prepaid water department team from Lusaka took them through, but was not given much information. The findings imply that plumbers discover how to resolve most complaints in the field themselves.

In addition, Respondent 4 said that LWSC lacks an internal workshop which would be able to repair and appreciate and work on the challenges that surrounds the meter. This is in line with respondent [10]; "*…, why are the meters failing today, one it's our technical know-how of how to handle this meter, it's a bit lower than the technology itself. We do not have labor to fully understand it, digest its operations and find out why it is failing in certain aspects. I think that is a biggest failure around it internally. I think it is all centered on whether we were ready to handle this technology in terms of manpower and technology? I don't think we were, but if you ask me, it is the best technology yes*".

From the questionnaire on valve failures from figure 8, the results seen supports the findings from interviews which says that 70% of the total meters installed have challenges with the valve and LWSC has challenges in handling the complaints and inspection. 50% of respondents indicated very poor and poor response from LWSC while 43% answered that it was good. An explanation for this paradox could be that among the 43% of the respondents, some could be experiencing problems with the PWMs but lack of repairs from the utility may be opportune for such users.

Figure 8:Rate the response of LWSC to solve the problems with your PWMs



Findings from both interviews and questions shows that LWSC response time to resolve the complaints relating to the PWMs is not good. Though only 50% indicated that the response is poor, it could be explained by the fact that some customers are happy and take advantage of the lack of repair so that they keep enjoying free water. Literature in chapter 2 stated, that

utilities often are required to respond quickly to customer complaints on PWMs as compared to PPMs. As customers expect a good service because they already pay for the service in advance. In addition, prepaid water meters can improve revenue but may also worsen with inefficient response time to resolve faults (Heymans, Kathy, et al., 2014) .

According to equity theory stated in chapter 2, the service quality received by customers follows that perception of high satisfaction from the experiences with received service often results in high outcome levels of exchange. Therefore, increases the willingness to pay, and continue use of the service. This improve cash flow for the utility. Customers are the major source of revenue and one way of continuing receiving payments from them, is to balance the equity. Similar, if the level of service is low, the satisfaction is less and customers responds in exchange with a low payment as a fair balance for such service (Bolton and Lemon, 1999)

However, findings from interviews indicated that this is so because of less man power and technical know- how regarding the operations and maintenance of the PWMs. From the findings, it shows that the technology capacity of the employees is low. PWMs demands more cost on skilled employees to deal with complaints, monitoring consumptions in the system and educate the customers on the use of the system (Heymans, Kathy, et al., 2014)

How valve failures influence revenue collection:

As seen from table 6 question 4, the findings show that 10/11 Respondents indicated that customers tend to relax, they stop buying units or buy less because water keeps coming out. Customers buy water for as little as k20 or k30 and stay for three months without making purchase. Respondent 5 added; *"You find that like those stuck meters or valve failure you find some people have only purchased once. We installed meters in 2013 so you will find maybe they just purchase once in a year or not at all because it's a stuck meter and, it allows water when its stuck so they don't see the need to come and pay or buy any water units. It has really affected the company"*. However, according to Respondent 3, the branch use AMR, to capture and extract reports which show valve faults, and other faults of the meter, then make follow ups of inspection but this is not very effective, sometimes some properties are not captured hence ignored during inspection. "Moreover, she added that the drive by is expected to be conducted twice in a month but commercial department does it only once and not consistent. Respondent 8 added that, it is a challenge for them to be aware of such faults unless the property is visited physically, otherwise, customers keep on enjoying free water. This confirms with Heyman and Kathy el al (2014) frequent physical checking of the metres optimizes identifying of anomalies of water losses. If physical monitoring is neglected, water loses are easily identified, translating into more revenue being lost.

However, an interview with Respondent from senior management reviewed that some customers are clever and when they discover that their meter is dispensing water they keep quiet, while it takes a month before a drive by is done. Meaning the whole month customers would have been using free water and even after data is captured it takes weeks to a month for the branch to start resolving and acting on the faults. This is loss to the company and has a bearing on the collection of revenue for the company.

From the same table 6: question 4, 7/11 Respondents mentioned that the utility tends to disconnect properties with huge negative balances. However, most customers do not go forth to clear these arrears. In such instances, some customers turn to buy water from neighbours at a cheaper price hence, debt is stagnant. In line with respondent 3;" *customers do not come forth to pay the arrears sitting on that account, if the arrear is like k1,000, they would rather*

buy water for k50 from the neighbours and not settle that debt sitting on the account. And the meter will be inactive and no revenue will come from there"

However, literature stated in chapter 2 that installation of prepaid water meters allows the water provider to avoid challenges like debt, disconnections especially in areas associated with non-payment which saves cost of dealing with such challenges (Harvey, 2005).

Furthermore, 5/11 Respondents also indicated that when engaging customers on board to clear the negative balance is always a challenge as customers fully blame the utility for meters not closing when they are expected to be automated. Findings review that it brings queries which usually take a long time to resolve and recover the money. Meanwhile, some clients take advantage of such situations. In addition, Respondent 2 added;" *When the valve is allowing the water to pass when the units are finished, you find that with these rented houses you find that the tenant will use the water and move out of the house. Then it brings a query between the landlord and LWSC to say why was your meter not shutting so the fault comes to LWSC and payments are affected"* He further stated that that there is no mechanism system where the utility can quickly check on the computer to identify which meter is dispensing water or faulty, unless they just conduct a drive by or physical check-up.

Furthermore, some major customers have moved to alternative water sources like private boreholes and 5/11 respondent confirmed it. In line with respondent 6 **"***Customers are sinking boreholes, we have lost this school here, Naboye, National Chemicals of Zambia have their own Treatment so customers are sinking boreholes because the water table here in Kafue is just too near. These are big customers we are losing out* "However, Respondent 5 noted that LWSC are to blame because they do not engage customers well and take long to resolve the faults.

Respondent 7 who own a lodge said he mostly uses LWSC sewer services now than water as he has a borehole. He added, he only uses LWSC water for drinking purposes. On the other hand, findings reviewed that most properties rely on LWSC as a water source.

Also, from secondary data, table 8 shows the number of properties without purchase since installation of PWM and those that have not purchased water in 90 days for January 2017 to June 2017. It confirms the findings from the interviews that the utility is losing revenue because some customers are buying less water and some stay for months without any purchase. Customers are consuming free water.

Table 8:Number of properties without purchase since installation of PWMs and those that have not purchased water in 90days from January 2017 to June 2017

no	Month	No purchase since install	No purchase in 90days
1	January	30	1154
2	February	45	1265
3	March	16	1389
4	April	16	1574
5	May	13	1468
6	June	12	1631

Source: (collection and purchase exceptional reports)

4.3.1.2 Low pressure

From the interviews, a summary of responses on low water pressure in the distribution network is depicted in table 9

Table 9:Summary of responses on low pressure in the distribution network

	Questions	Summary of responses	Frequencies
1	Average pressure in distribution lines and pressure management	-Some parts of the district have low pressure while others have good pressure. But during dry season, they are very bad. PWMs set pressure is 0.3bars [10]	6
		-Frequent burst pipes have affected pressures	10
		-Pressure management is done by throttling of main valve. The network does not have district meters. Non-revenue is high	5
2	The supply hours under PWM and reliability	-Supply depends on how much water is in the reservoir and power supply by ZESCO	6
		-Supply is intermittent	11
3	Pipe leakages and control measures of the leakages	-Number of leakages is high	11
		-Repair as they are reported or noticed. However, repair materials are not available, takes time to seal leakages especially distribution line	5
4	How low pressure influencing LWSC revenue	-Valve gets stuck Customers tends not to consume especially when burst pipes are being worked on.	7
		-Less supply hours	10

Average pressure in distribution lines and pressure management

As seen from table 9: question 1 according to 6/11 Respondents, the pressures vary. Most areas on the upper stream experience low pressures while on the downstream have good

pressure. However, in dry season the pressure becomes very challenging. The country has 6months as rain season and the rest of the months are dry season.

Respondent 2 added; *"there is low pressure but it is not always the case, but some areas, people don't receive good water pressure yes."*

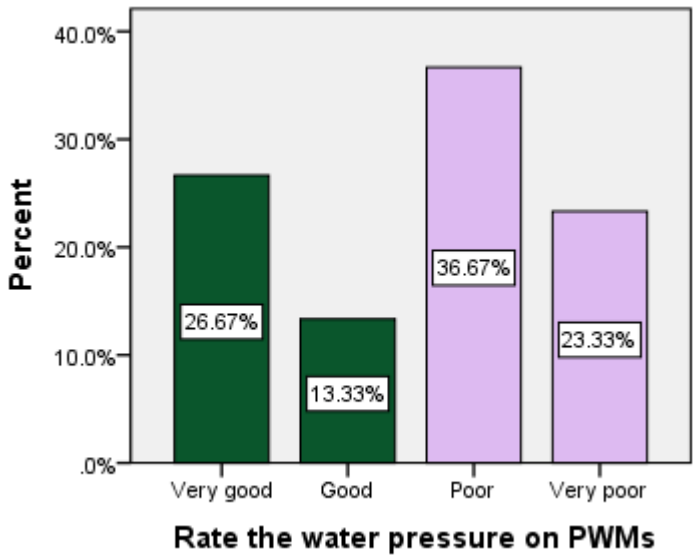
Respondent from senior management argued that the set pressure for the PWMs they are currently using is 0.3 bars and comparing this to their average pressure in the distribution line, he said it was ok. However, the pressures are usually affected by the frequent isolations of the network due to works on pipe bursts. The finding of the set pressure was expected as literature in chapter 2 stated, some prepaid meters demand a certain pressure (0.2 bar to 1 bar) for the valve to close. If the pressure is less than the set limit, the valve remains open (Heymans, Kathy, et al., 2014).

Findings from all the employees interviewed agreed that burst pipes had contributed to the low pressures in the district due to old networks.

When the respondents were asked how they manage their pressure in the network 5/11 from engineering section review that they throttle the main valve by reducing or increasing the turn. Though, findings indicated that the district does not have measuring systems in the network to indicate areas where pressures are more or less. Also, where the utility is losing more water so that they intensify in such areas. Respondent 4 indicated that Non-revenue water is high, at 70% though the way it is calculated is questionable.

From the questionnaires on low pressure in the distribution network figure 9, shows responses of customers to a statement, rate the pressure on PWMs. 60% of the respondents indicated that pressure is very poor and poor while 40% suggested that the pressure was very good and good. The majority who indicated that they experience low pressure could be residing from the upper stream of the district as indicated from the interviews.

Figure 9:Rate the water pressure on PWMs



Findings from both interviews and questionnaire reviewed that pressure varies per district area, however, most of the customers experience low pressures according to the results from questionnaires. Findings also indicted that frequent burst pipes because of old pipe network contribute to the pressures in the distribution line.

These findings are in line with Heymans, Kathy et al (2014), Non-revenue water under PWM system arises from the burst pipes due to increased pressures and meter leakages because of delayed maintenance. One of the most challenging issues pointed out by World bank (2015) and Heymans and Kathy el al (2014) is the failure by water utilities to balance between the volumes of water produced and supplied through distribution system, to the amount billed to the water users. High non-revenue water impedes the financial viability of the utility through lost volumes of water.

The supply hours under PWM and reliability

From table 9: question 2, all responses stated that supply is not stable in the district and because of this, the rate of stuck meters and meter failures have increased. The general supply system is by gravity. From 05hrs to 12hrs, water is supplied to the customers, then closes to build the water levels in the reservoirs. Thereafter, open supply again from 15hrs to 22hrs.Athough, one of the Respondents noted that supply hours depends on how much water the utility has in the reservoirs. Sometimes supply is more and other times less hours. However, supply hours vary per district area. Respondent 10 also added that the utility depends on ZESCO for power supply which is not 24hours supply throughout. Therefore, the distribution network is not pressurised. "*It is a bit a tricky because we experience power failure at the plant almost like once in two days the whole year*" Respondent 10 said

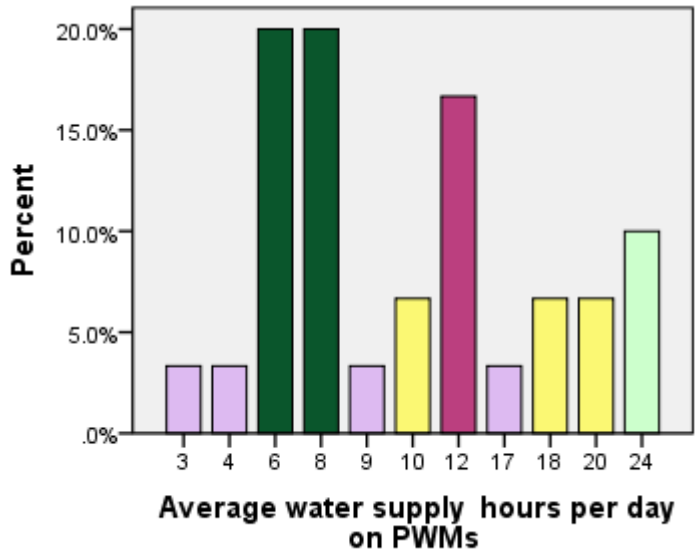
From the findings, old network with worn out pipes, causes burst pipes almost every week which take time to be worked on adversely impacting on supply hours. Respondent 8 added; "*The supply I should say is not as stable as expected because of the network. Kafue network is very bad and I think that is what has contributed to the failures of prepaid meters"*.

Respondent 4 argued saying, lack of materials from their store prolong the repairs of the leakages. They drive to Lusaka to source for materials where the main store is, nonetheless, repair materials are not readily available. Respondent 5 indicated that leakages that stay for a long time, even a year without being worked on are those on big pipes for example 24inch. He reviewed that there are no pipes available to do replacement, as bigger portion needs replacement and not just sections. Water utilities need to budget for extra to cover network upgrade before PWMs are installed to enjoy the benefits of the new technology according to Heymans and Kathy et al (2014).

Furthermore, findings reviewed that intermittent supply at time cause air locks in the pipes. This causes meters to drive even when there is no supply and at times, jam the valve due to the presence of grit in the pipes.

Responses from customers were also obtained from the questionnaires on low water pressure, figure 10 depicts the average supply hours per day. The results show that 40% of the customers receive 6 to 8 hours of water supply, which represents a bigger percentage while 6% receive 3 to 4 hours which is the lowest. This finding demonstrates that only 10% of the customers receive 24 hours supply.

Figure 10:Average supply hours per day



From both interviews and questionnaires, findings suggest that supply hours are not uniform in all the district areas. Supply hours vary in district areas therefore, it is intermittent. Heymans and Kathy et al (2014) suggest that PWMs must be on "twenty-four/seven" water supply due to the presence of air and sand which easy get sucked into the pipes after a no supply period. Supply interruption creates air vacuums in the network which leads to stuck meters, eventually degradation.

Pipe leakages and control measures of the leakages

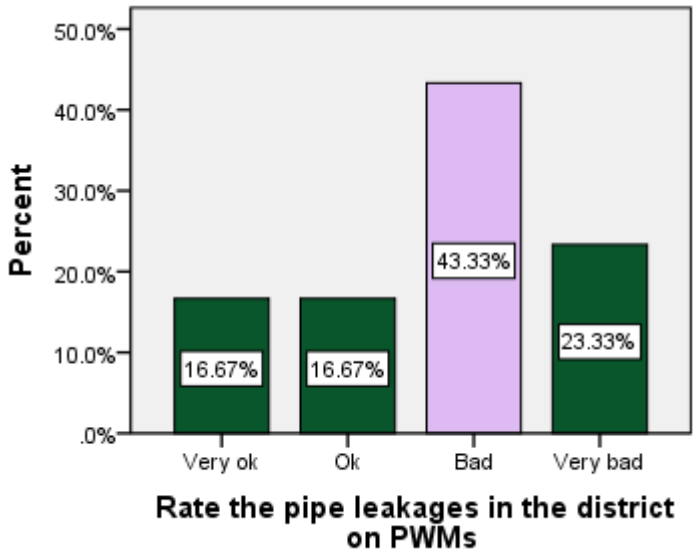
From table 9: question 3,10/11 Respondents said there are many leakages in the district some which are visible and others are underground leakages. Respondent 6 "*We have quite many leakages and mostly pipe bursts. I think on average, we have two pipe bursts every week*". From the findings, through leakages, debris penetrate in the network which eventually choke the meters. Furthermore, findings indicated 5/11 stated that the leakages are worked on as they are reported however Respondent 2 argued to say, "*there are complaints of no water and there are others with leakages, so you concentrate first on those with no water and later deal with the leakages*".

The findings brought to light that on average, it takes 8hrs to 12 hrs to work on a burst. As they manually excavate and some pipes are 2meters deep. Respondent 10 added "*but burst pipes normally take about 8hours to finish. What happens when we are working on a burst pipe, we isolate if it is on a line which is easily isolated or has isolating valves. So, we isolate then maintain supply in other areas, but most of these areas they do not have isolating points so we close the district for 8hours*".

However, Respondent 4 added that the practices of the operation team when attending to burst pipes is bad. After attending to a burst pipe, they normally restore supply without flushing the network and this increases the chances of dirt entering the network adversely choking the meters.

From questionnaires on low water pressure, figure 11 show the responses of customers on a statement: rate the pipe leakages in the district on PWMs. The highest rate was that the leakages are very bad and bad with 66.66% meaning, there could be several visible leakages that customers see around. This relates with the results from the interview stated above.

Figure 11:Rate the pipe leakages in the district on PWMs



From both interviews and questionnaires, findings indicated that there are many leakages around in the district. These leakages together with other factors mentioned above affect the pressure in the distribution network.

Summary of how low pressure is influencing LWSC revenue

From table 9: question 4,10/11 respondents indicated that low pressure in the network has affected revenue because customers consume water only for few hours in some district areas. Respondent 8 stated; "*The burst pipes also are just too much in this branch, engineering team are all the time busy repairing instead of supplying water to customers"*. The findings reviewed that it takes days for pressure to normalise after an isolation of supply or shutdown. Some areas keep receiving low pressure until the team visits and flush out the air locks in the pipes. This finding was expected as literature in chapter 2 stated that supply interruption creates air vacuums in the network which leads to stuck meters, (Heymans, Kathy, et al., 2014)

Furthermore, customers tend not to consume water especially when burst pipes are being worked on. Respondent 6 added*; "It does affect especially where you have a burst pipe and for example in C5 for two days that area may receive low water to no water and means no sales all that time for the branch."*

According to 7/11 Respondents, low pressures in the network has contributed to meters getting stuck. Because of intermittent supply, frequent burst pipes and leakages in the district. They added, meters are under recording and some valve stuck open in open position. "*when they work on the leakages and are done, the following day you discover the meters are stuck open and you just have to check as the units will just not be moving but water just dispensing*."

However, repair materials for the stuck meters are a challenge therefore, many customers end up drinking free water as repair works take long.

2. How are changes in water consumption efficiency and Meter tampering influencing the reduction of revenue of LWSC in Kafue district?

4.2.3 Behaviour factor

Under this section, two sub variables will be looked at. Meter tampering and consumption efficiency**.** To be able to answer the sub- question above, the following questions were asked using interviews. Opinions on meter tampering on PWMs and, how meter tampering influence revenue, other illegalities noticed and how they are influencing revenue. Lastly, measures put in place to curb down such illegal activities. Under consumption efficiency, the following questions were inquired: Water sales before and after the introduction of PWMs, duration customers take for the next purchase, how consumption efficiency reduced LWS revenue. Many questions were also asked to customers regarding the behaviour factors using questionnaires.

4.2.3.1 Meter tampering

From the interviews, a summary of findings on meter tampering is depicted in table 10

Table 10:Summary of findings on meter tampering

	Question	Summary responses	Frequency
1	Opinions on meter tampering on PWM and causes	- Meter tampering is high in the district	7
		-There is no inspection team in charge of illegalities, hence it is difficult for the utility to capture.	10
		- The meters are subjected to malpractices by LWSC own staff	4
		- The meters lack anti- temper warning devices like seals to make use in litigation whenever tampering is apparent	3
2	Measures put in place to curb down such illegal activities	- There is a policy were different fines for different offences They write warning letters For illegal connection, they plug off property from the network	4
3	How meter tampering and by-passes influence revenue	- Contribute to Non-revenue water of the branch and reduces pressure	5
		-Customers are benefiting free water	10

As seen in table 10 the most highlighted findings will be discussed in depth following the sequence and considering the indicators; Meter tampering and by-passes on PWM and How meter tampering and by-passes influence revenue.

Meter tampering on PWM and causes

From table10: question 1, 7/11 Respondents stated that meter tampering is high. Respondent 1 stated, "*The illegal connections are there, meter tampering is there and by passes and it also affects the revenue of the company"*. All Respondent agreed that lack of inspection had been causing an increase in the numbers of meter tampering. Findings reviewed that the district does not have a stationed inspectorial team. They depend on an inspectorial team from Lusaka which rarely conducts inspection unless requested for. Respondent 3 "*…like here in Kafue we don't have an inspectoral team*". However, findings reviewed that, the other way the branch discovers the meters are tampered is when a drive by is conducted. Respondent 9 argued, "*…we have the garget but it does not capture. So, in terms of rates of illegalities, they are on a higher side…"*

Furthermore,4/11 Respondents reviewed that meter tampering is being caused by malpractices by the internal staff of LWSC. Respondent 10 stated; "*there is a lot of sidekicks to these meters by the field people, they go out and give water to the customers and they are paid*".

From the questionnaire on meter tampering, figure 12 indicates the responses of customers to a statement: illegalities of meter tampering and by-passes are caused because of lack of inspection by LWSC.63.33% strongly agreed and agreed that it was due to lack of inspection by LWSC, which supports responses from the interviews stated above. This could mean, customers are aware that LWSC do not conduct routine inspections hence engage in these illegalities. In addition, figure13 shows responses to a statement: illegalities of meter tampering and by passes are caused because of water users cannot afford buying water on PWMs.58.9% of the respondents strongly disagreed and disagreed. This indicate that most customer can afford purchase of water.

Figure 12:Illegalities of meter tampering and by-passes are caused because of lack of inspection by LWSC

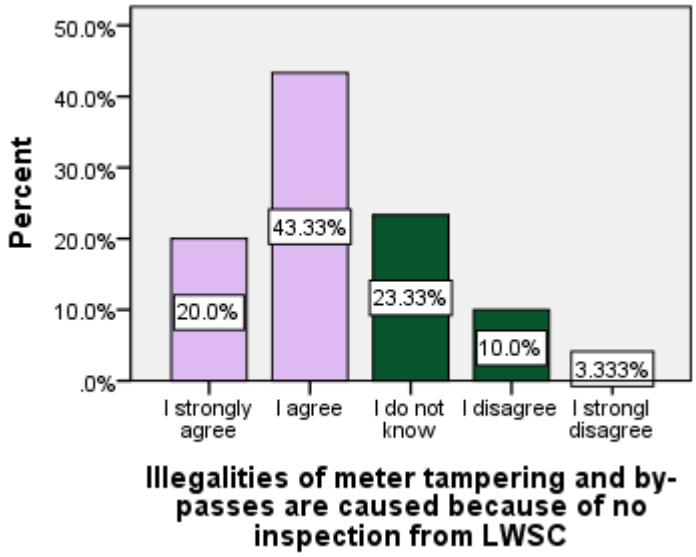
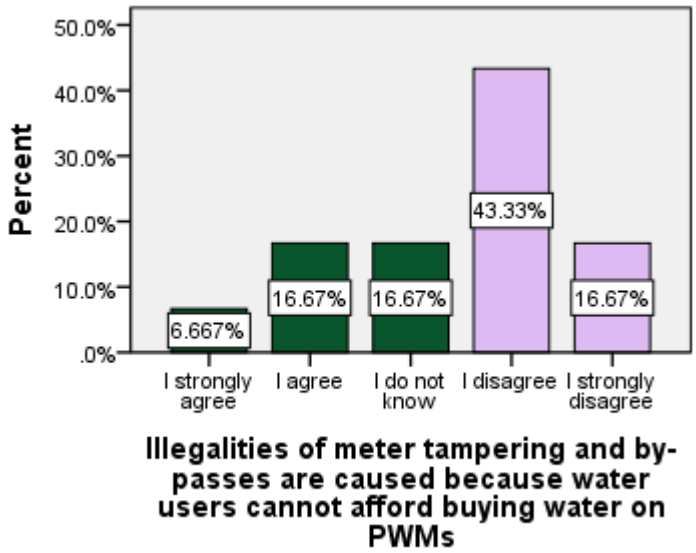


Figure 13:Illegalities of meters tampering and by-passes are caused because water users cannot afford buying water on PWMs



Also, secondary data shown in table 11 numbers of suspected meter tampering captured during a drive from collection and purchase exceptional report for four months. This agrees with results from interviews and questionnaires that the tampering is high and it is so because of lack of inspection by LWSC to make follow ups. PWMs are vulnerable to tampering especially those installed on domestic connection. Additionally, frequent physical checking of the metres optimizes identifying of anomalies of water losses through illegal means like; meter by-passing, tampering and illegal connection (Heymans, Kathy, et al., 2014).

According to planned behaviour theory, a customer mostly calculates the benefits and cost before an action is undertaken, and the options adopted are usually in favour of their net befit (Solomon, Russell-Bennett, et al., 2012). Further, Ajzen (1991) explained that, the theory of planned behaviour theory focuses on the intention that drives an individual in performing a behaviour. There may be several motivation factors that affect the final behaviour of customers in the purchase and consumption of water for instance income level and affordability. However, findings showed 58.9% respondents disagreed that customers engage in illegalities because of affordability challenges.

Table 11:Number of suspected tampering captured during a drive-by

	Month	Meter read	Tamper status	Uncaptured meters
1	February	5550	358	1991
2	March	1373	144	2308
3	May	4617	274	2352
4	June	1261	276	2573

Source: (collection and purchase exceptional reports)

How meter tampering influence revenue

From table 10: question 3, 10/11 Respondents reviewed that customers are benefiting free water because of the illegal practices in line with literature, Monedero and Biscarri et al (2015) from chapter 2 stated that, the service provider has no control regarding the

consumption, as the registration of the consumption of the water user does not reflect as a right billing of a service. These losses translated into money amounts to huge revenue losses to the utility. Furthermore, the findings indicated that meters are open and freely allow water which is not paid for. However, discovering these meters is a challenge as the company only rely on data captured from AMR which has inaccuracies in data management. Respondent 8 added that on PPMs when conducting disconnections illegalities would also be noticed hence customers had that fear to tamper with the meters, nonetheless on PWMs customers even know that LWSC rarely conduct inspections.

In addition, Respondent stated that the illegalities are contributing to Non-revenue water. "*When there is such illegalities people are using water for free and this gets to increase the non-revenue water. I cannot quantify but there are several cases where we have had such complaints"*. Respondent 6 said. Findings reviewed that Non-revenue water for the district is high, 70% from last year's calculation. It can even be more because the utility does not have district meters to give accurate readings.

Furthermore, , "*these meters are subjected to malpractices by our own staff. There is a gadget, a computer they go with in the field, if a customer has a complaint, they go with it, it allows you to give water to the customer, what to give, if the customer says no the meter is losing credit if the customer bought water for k100 or k200, and you want to give the customer free token, it will give the last purchase that has been a source of challenge with the revenue. This gadget has been given to people and they tend to use it as their source of income"*. Respondent 6 alluded. The finding reviewed that the gadget is not only used by the supervisor, but any plumber uses it. Respondent 6 added, even clearing negative balances on the meter, the garget s able to delete a negative on the customers meter and the person is paid less than what the customer owed LWSC and it is business as usual.

4.2.3.2 Consumption efficiency

Consumption efficiency: According to Vickers (2001), consumption efficiency is a way in which water wastage and loss is minimised due to "doing more with less water and only using water that one needs. To be able to answer the research question of how changes in consumption efficiency influence on LWSC revenue, both interviews and questionnaires were used. The following questions were asked using interviews; Water sales before and after the introduction of PWMs, duration customers take for the next purchase and how consumption efficiency reduced LWS revenue. Table 12 shows summary of responses on consumption efficiency.

Table 12:Summary of responses on consumption efficiency from interviews

	Question	Summary response	Frequency
1	How were water sales before and after the introduction of PWMs	- Sales improved initially but has been declining because; customers have become responsible in water usage. Customers dug shallow wells for gardening; Customers oversee the amount they want to purchase, mostly buy less.	10
		debt collection also improved [3]	5

2	Duration customers take for the next purchase	-Depends on the customer	11
3	How consumption efficiency reduced LWS revenue.	-Fear of spending more therefore reducing the spending power of LWSC.	9
		-Less consumption also contributing to more pressure in the network, causing burst pipe	5

Findings from table 12 will be discussed in a sequence presented in the table

How were water sales before and after the introduction of PWMs

From table 12: question1, all the employees stated that the water sales on PWMs initially improved. Among the mentioned reasons that lead to the improvement include metering some of the properties which were unmetered and capturing unregistered. Respondent 6 stated; "*The sales improved and debt" because before they installed the prepaid meters some customers were billing them on fixed consumption*". Furthermore, Respondent 5 stated "*For Kafue, it really helped us even on debt collection and from the beginning, the revenue improved but started going down when these challenges of valves, WMD and the like"*. However, findings reviewed that debt is mostly stagnant on those meters which go into negative and get disconnected.

On the other hand, findings showed that introduction of PWMs brought about reduced consumption on properties which reflected sales reduction. This is because, as reviewed by all respondents that the utility does not have much control on customers' water purchases. Customers plan and see how much they can manage. Respondent 4 said*; "with PWMs, LWSC don't have much control, the customer has, if they decide to buy water for K20 they use it .so I as a client for example say, ok I do not want to stress myself, I will reduce on my consumption at the same time, I will buy after two months that is my decision"*

Furthermore, findings indicated that most people are not in formal employment in Kafue therefore, PWM allows them to purchase what they can manage. In line with literature, among the advantages of PWMs is that control is in the hands of the customer therefore, budgeting becomes easy as payment is only made on how much one needs and controls the duration before another purchase. Also, customers can purchase even with small payment, which is far better than paying a huge bill at once and avoids disconnections (Heymans, Kathy, et al., 2014)

Furthermore, findings reviewed that most customers had become conscious of how they were using water. Most customers with gardens used to do a lot of watering mostly because on PPMs, a customer uses water and is expected to pay at the end of the month. So, he can use as much water as he likes with some negligence involved. But with a PWM, it has brought in that responsibility on the client to monitor their consumption daily. Besides, areas where gardening was rampant has reduced to minimal and some people have gone to alternatives of digging shallow wells for their gardens. Respondents mentioned.

Findings further indicated that customers also begun to report leakages especially those after the meter. Respondent 4 stated; *"Initially before we installed the prepaid you'd find somebody has a broken tap, leaking tap or a broken pipe, they wouldn't report. But there has been that sense, prepaid brought a bit of responsibility on the part of the customers"*.

The finding was expected because literature stated that consumption and misuse of water is less as customers become more careful in the way they use water on PWMs (Heymans, Kathy, et al., 2014).On the other hand, if customers consume less, cash flows for the utility reduces.

Respondent 6 argued that less consumption pressurises the network and some areas are experiencing burst pipes, "*we are losing this water through burst pipes as lines get pressurized since few customers are using water*". This finding is expected as literature in chapter 2 of this research stated that reduction in consumption may mean increase in pressures in the pipeline causing burst pipes and leakages especially when the pipe network is old (Heymans, Kathy, et al., 2014).

From the questionnaires on consumption efficiency, respondents were asked concerning their debt, spending, budgeting and expenditure monthly on PWMs. This was included, as it would indicate changes in the budgeting and expenses of customers before the introduction and after PWMs were introduced. The following are shown below: Table 13 my budgeting on PWMs compared to before, table 14 my spending on PWMs compared to before, figure13 water expenditure per month on PWMs and figure 14 shows responses to a question do you still have debt

Table 13:My budgeting on PWMs compared to before

My budgeting on PWMs compared to before					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very low	8	26.7	26.7	26.7
	Slightly low	7	23.3	23.3	50.0
	Low	7	23.3	23.3	73.3
	High	4	13.3	13.3	86.7
	Very high	4	13.3	13.3	100.0
	Total	30	100.0	100.0	

Table 14:My spending on PWMs compared to before

My spending on PWMs compared to before					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very less	7	23.3	23.3	23.3
	Slightly less	10	33.3	33.3	56.7
	Less	5	16.7	16.7	73.3
	High	5	16.7	16.7	90.0
	Very high	3	10.0	10.0	100.0
	Total	30	100.0	100.0	

Figure 14:Historical debt

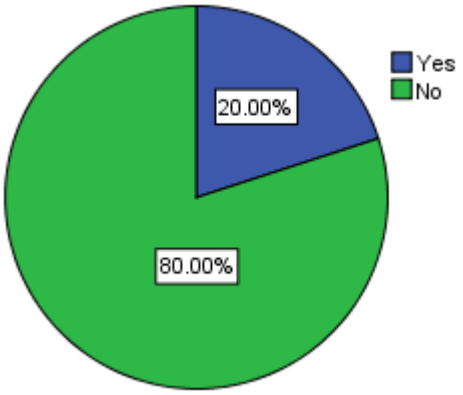
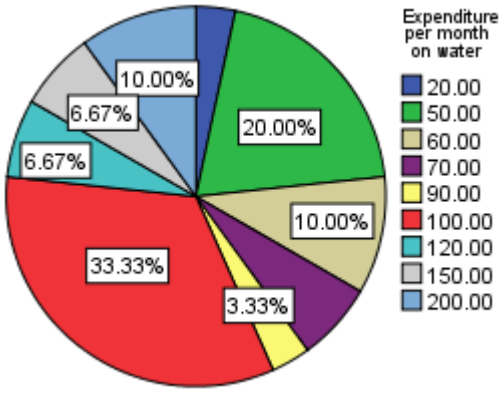


Figure 15:Expenditure per month on water



Findings from the questionnaires shown in table 13 and 14 indicate that most customers budgeting and spending has reduced on PWMs as compared to before. 73% of respondents from both table 14 and 15 indicated this. From the results, it seems that the customers are more conscious on how much they consume and spend hence the low budgeting. Also, when the customers were asked regarding their actual monthly expenditure, 66.66% of the respondents spend between K20 to K100. However, the average number of people per household respondents is 6 to 7members.
Furthermore, 80% of the respondents indicated that the debt which was transferred to PPMs to PWMs had been cleared. Which agrees with interviews from table 12: question1

From secondary data also seen in table 15 on actual outstanding debt from May 2013 to July 2017 from (Collection and purchase exception report) shows that the utility has recovered 60% of the debt which was transferred to PWMs. Findings reviewed that company deduct 40% of the total purchase as payment to arrears therefore, most of those meters working properly have cleared the debt. One of the advantages of PWMs according to literature in chapter 2, is that customers are given a chance to settle debt bit by bit without being pressured. Additionally, debt collection from the owing accounts is increased through monthly automatic deduction (Heymans, Kathy, et al., 2014).

Table 15:Actual outstanding debt from May 2013 to July 2017

Branch	Total arrears transferred (Kwacha)	Arrears Recovered (Kwacha)	Balance (Kwacha)	Percentage recovery (Kwacha)
Kafue	3,325,477.21	1,995,286.33	1,330,190.88	60%

Source :(Collection and purchase exception report)

Furthermore, from secondary data, table 16 shows water sales on PWMs from May 2013 when meters were installed to June 2017. This is in line with results from both interviews

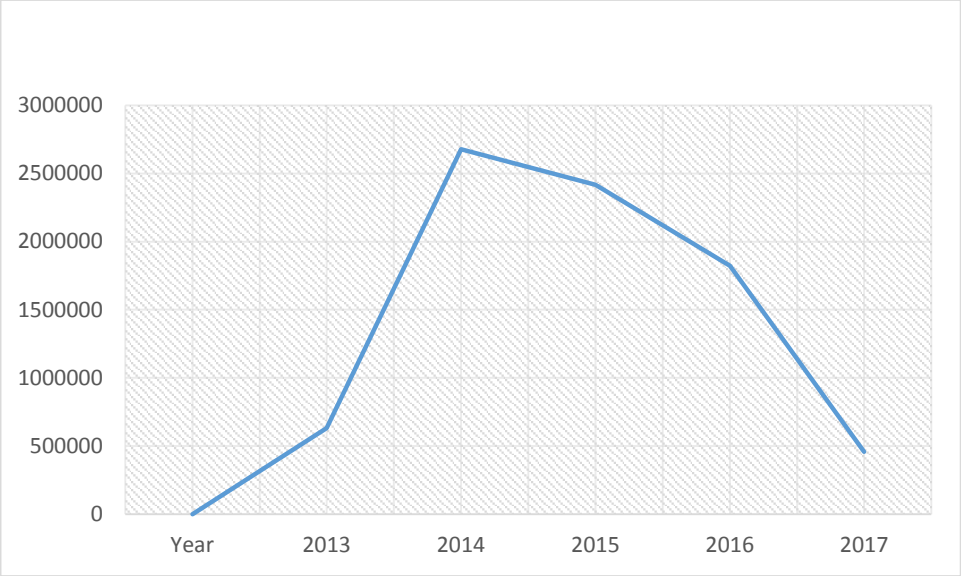
and questionnaires that sales increased at the beginning then started dropping due to the same reasons already stated. This can also be seen in figure 16, graph on water sales.

Table 16:Water sales on PWMs from May 2013 to June 2017

	Period	Water consumption sales (kwacha)
1	May 2013- December 2013	631,762.70
2	January 2014- December 2014	2,676,597.750
3	January 2015- December 2015	2,416,225.75
5	January 2016- December 2016	1,821,789.63
6	January 2017- June 2017	458,791.50

Source:(LWSC Edams)

Figure 16:Graph the water sales on PWMs from May 2013 to June 2017



Duration customers take for the next purchase

From interviews table 12: question 2, all respondents indicated that it all depends on the customers consumption. Respondent 8 said; "*prepaid also has a low rate in terms of monitoring customer buying of units. It has a low rate in terms of revenue in a way where a customer buys unit for K20 which he can use or the whole month sometimes*". However, Respondent 3 contended that some of the customers who buy as low as K20, have faulty meters and they take advantage by buying less. Respondent 4 added that, PWMs had forced people to use less water hence most customers only buy once.

From the questionnaire, figure 17 shows opinions of customers to PWMs encouraging avoiding water wastage and figure 17 indicating the number of times in month water units are purchased. 89% of the respondents strongly agreed and agree to the statement that PWMs encourage avoiding wastage of water. Furthermore, from figure 18, the majority 71.43% said they buy water only once, 25% said twice and 3.57% said five times. The findings suggest that customers do not often run out of water as they are conscious on their consumption. However, the 3.57% of customers who buy water five times in a month, may include those

commercial customers who are engaged in some form of business such as home brick construction.

Figure 17:PWMs is encouraging you to avoid wasting water

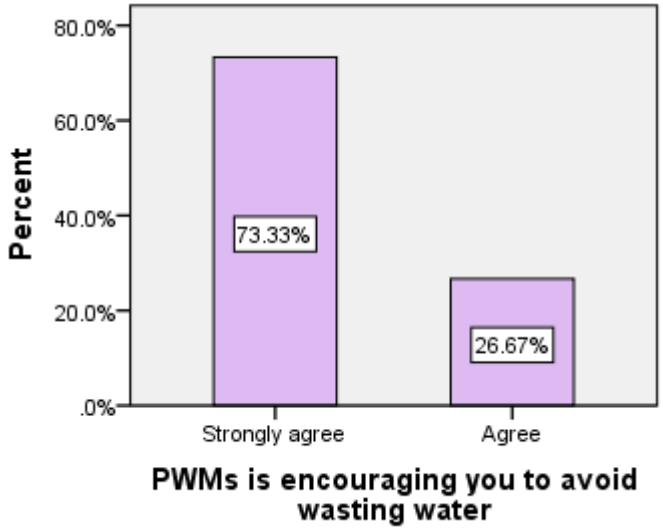
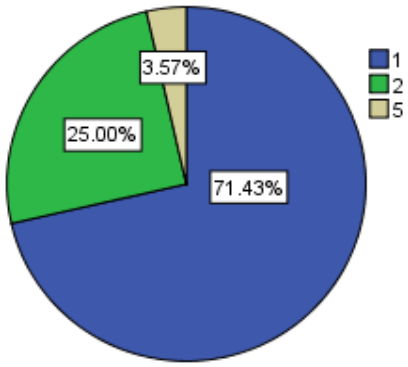


Figure 18:Number of times in a month water unit are purchased



From both interviews and questionnaires, findings review that most customers buy water once as they are conscious on water usage. Additionally, this confirms with equity theory which states that a customer would maintain the equity by either paying for the improved service or minimise on the consumption of water to still receive the service (Homburg.C, Koschate.N, et al., 2005)

How consumption efficiency reduces LWSC revenue.

From table 12: question 3, finding reviewed that the introduction of PWM had brought awareness of how to use water wisely to the customers as indicated earlier. Therefore, customers have the power when to buy and how much they buy. Respondent 4 added, "*but you cannot force a person to go and buy water at the month end only because it is him who now controls consumption. Secondly if he has alternatives, say I have a cousin who says like cannot drink water from LWSC but buys from these shops like pick and pay meaning if they don't use water for washing and these other things, we won't get any money from such*". Respondent 3 added that less consumption on some properties promotes reduction in sales

However, findings reviewed that the utility was expected to have had enough water in the system because of the consumption efficiency PWMs comes with. but, they have made a loss because of old infrastructure. In line with literature, prepayment system demands a reliability

in supply and a better piped network to avoid burst pipes resulting from increase in pressure that comes with consumption efficiency (Heymans, Kathy, et al., 2014)

The finding reviews that the coming up of PWMs has changed the expenditure budgets to meet monthly obligations such as salaries. As PWMs has no standard billing date and LWSC revenue cycles has always been 30 days related to the way LWSC make their expenditures budget. Therefore, it has reduced the spending power because some customers do not buy water monthly. others buy in advance unlike on PPWs.

3.What other technical and behaviour factors are influencing the reduction of revenue of LWSC in Kafue district?

To answer this research questions, factors other than valve failures, low pressure, meter tampering and consumption efficiency were obtained and how they are reducing the revenue of LWSC. Table 17 shows summary of other technical and behaviour factors influencing the reduction of revenue obtained through interviews

Table 17:Summary of other technical and behaviour factors influencing the reduction of revenue from interviews

	Question	Summary of responses	Frequency
1	Other technical factors	-Dilapidated network. The distribution network is very old because of its age it carries with it a lot of debris, and goes to choke the meter [4]	10
		- Meter quality is poor	6
		- Water Management Device going off. (WMD) -User Interface Unit going off, because of battery life span	10
	How other technical factors are influencing revenue	-Frequent burst pipes and leakages which further compromise the quality of water, pressure and stuck the meters	10
		-Meter is not robust to the quality of water and intermittent supply the utility experiences hence, stuck the valve	3

		- No reference point when WMD is off. Customers consume free water	7
3	Other practiced illegalities noticed	Cable getting cut -Covering meter with iron or magnet shielding or stuck the meter by opening - Inserting plastics inside the meter -illegal connection	8
	Other adopted behaviour factors	Alternative source, e.g. digging shallow wells for their gardens Damages of the meter especially by women	3
	How other behaviour factors are influencing revenue		

From table 17, a detailed discussion on some other technical and behaviour factors and how they reduce revenue is indicated below.

Technical factors and how they are reducing revenue of LWSC

From the table 17, question 1, all Respondents indicated that the water pipe network of the district is old. The current existing network is old, about 80km from what is showing on the map. However, Respondent 10 stated that LWSC only upgraded a portion before installation of PWMs but the pipes did not go beyond 10km.He added that it lacks many fittings, most valves are buried. It lacks strainers and pressure relief valves. Respondent 4 mentioned that LWSC managed to install strainers in 6 district areas out of 9 areas just to improve the performance of the PWMs. Respondent 4 further added; "*the distribution network is very old because of its age it carries with it a lot of debris, some comes from the internal lining of the pipes and goes to choke the meter and the like. I think the meters that we have would work well in an environment where there is good network*".

Findings from all the Respondents reviewed that the utility experiences many burst pipes and leakages which further compromises the water quality and pressure then chokes the meter. Esmaili (2012) stated in chapter 2 that occurrences of faults and defects becomes more as the asset is in use and aging. To prolong the service life, maintenance is necessary though costly but becomes more if it is neglected and worse as the asset approached the end of its life-span.

Respondent 5 added, "*If the network is not worked on, it's pointless for us to continue with prepaid meters*". (Heymans, Kathy, et al., 2014) agrees stating, efforts by organization in

trying to improve the low collection levels through prepayment water meters would only worsen with minimum improvements in the defects of the service provided.

All the respondents brought to light that the failure rate of the valve is also because of poor meter quality that the company purchased. It goes with the question whether the manufacturer understood the quality of water in Zambia particularly in Lusaka or not. The findings reviewed that even from the river, there are issues of turbidity during the rainy season which is quite high than in dry seasons. Respondent 1 alluded that turbidity of the water was to be considered and get a more robust meter. In line with Heymans and Kathy et al (2014) poor quality of water especially with sand and grit, destroys the seals of the meter (diaphragm) and blocks strainers as most PWM system have moving piston and multijet.

10/11 Respondents attributed WMD going off and UIU going off, to battery life span. A respondent from senior management added that, in 2015 just clocking over from 2014 to 2015, because of the change of the calendar from 2014 to 2015, what was noticed was that meters skipped for example if a client had 9000 litres, WMD changed to around negative 86,000 litres while still dispensing water. And that happened in regions in some area parts of the branch. He added that this had brought a lot of challenge because they could not even know the actual quantity the meter had but they were giving free units to customers. Till now the utility does not know why it happened, even now, some meters issue free units. **"***The meter keeps dispensing water the moment the period of 30days or so clock, it uploads the same number of units again. So, you find that it's a cycle even now there are so many meters that are doing that and customers never buy because they never run out of units"*. Revenue is being lost.

Furthermore, findings indicated that lack of continuity or uniformity of consumption or information on both the WMD and mechanical meter after replacement of the WMD is a source of revenue loss to the company.

On the other hand, findings reviewed that UIUs go off because, the said battery life was not the true battery life. After a year plus, the battery finished instead of 8years which was the initial life span the utility was told. Additionally, meters have a short working life cycle approximately 5 to 7years as compared to ordinally conventional meters with 15 to 20 years (Heymans, Kathy, et al., 2014).One of the respondents from senior management argued that lack of technical know-how by employees could have a bearing on the short life span of the batteries.

Findings showed 8/11 stated that failing to recharge using the (UIU), buttons become stiff. One of the respondents alluded that many customers bring complaints of failing to charge or load units and plumbers must go to customers property to help them recharge no matter how small the unit token purchased is. By doing so, the fuel expenses and time is wasted on resolving these issues in the field. The finding is in line with what, Heymans and Kathy et al (2014) stated regarding the PWMs system. The technology is more vulnerable and complex than PPWs. "Batteries fail, valve diaphragms and seals wear, moisture disrupts the circuitry, and communication errors between the credit token reader and meter can affect supply".

Other behaviour factors and how they are reducing revenue of LWSC.

From Table 17: question 3, 8/11 Respondents mentioned common illegalities customers practice: Covering meter with iron or magnet shielding which prevents the meter from closing, opening of the meter and stuck it, so that the meter stops moving but dispense free water. Usually plastics are inserted inside the meter. Also, Illegal connections by customers and internal staff. Lastly, staff practices of deleting negative balance and issuing free units.

Additionally, "*There is a cable between the Kent meter and the prepaid meter so customers tend to do is that they cut the cable so that it does not communicate with the meter and customers continues to access free water as the prepaid meter cannot detect that these units are finished"* Respondent 8 stated. Illegal practices as stated earlier according to literature, contribute to the revenue loss of utilities. Heyman and Kathy el al (2014) stated that "Since PWMs uses electromagnetic wave, metallic object between two devices would significantly attenuate the signal"

Findings also reviewed that the record keeping showing trends of such illegalities from the time the PWMs were installed to date was not available.

4/11 Respondent stated that customers especially women have been damages meter, as they tend to use them as tools when doing washing. Respondent; "*We have had a number of cases where the client damages the meter because the meter looks like a stool where when they are washing they put something heavy or tend to sit on it. we have had number of damages to the meter"*. Some customers dug shallow wells for gardening instead of using LWSC water by doing this, customers consume less hence affect revenue.

4.3 Results from Pearson Correlation and Multiple Regression

4.3.1 Pearson correlation

Using SPSS tool, a Pearson correlation test was conducted between revenue collection and behaviour factors on PWMs . Also, a correlation between revenue and technical factors was done. Both table 18 and 19 displays the correlation between revenue collection and behaviour factors and technical respectively

Table 18:Pearson correlation on revenue collection and behaviour factors

Correlations

		Revenue_Collection	Behavour_Factors
Revenue_Collection	Pearson Correlation	1	.665**
	Sig. (2-tailed)		.000
	N	28	28
Behavour_Factors	Pearson Correlation	.665**	1
	Sig. (2-tailed)	.000	
	N	28	30

**. Correlation is significant at the 0.01 level (2-tailed).

Table 19:Pearson correlation on revenue collection and technical factors

Correlations

		Revenue_Collection	Technical_Factors
Revenue_Collection	Pearson Correlation	1	.701**
	Sig. (2-tailed)		.000
	N	28	28
Technical_Factors	Pearson Correlation	.701**	1
	Sig. (2-tailed)	.000	
	N	28	30

**. Correlation is significant at the 0.01 level (2-tailed).

From table 18, the statistics shows a correlation of .665 between revenue collection and behaviour factors. This implies that the relationship between the two variable is stronger statistically. Additionally, table 19 indicates a stronger association as well of .701 but much stronger than behaviour factors. These results support the discussion findings from the interviews regarding the three sub questions earlier discussed in this chapter.

4.3.2 Results from Multiple Regression

To test whether the changes in one variable is influenced by changes in the other variables while controlling for effects of irrelevant variables statistically, a regression was conducted and table 20 and 21 shows model summary and coefficient results of the regression respectively.

Table 20:Model summary

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.886[a]	.784	.767	2.42405

a. Predictors: (Constant), Technical_Factors, Behavour_Factors

Table 21:Coefficient table

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	15.324	1.855		8.259	.000
	Behavour_Factors	.951	.163	.552	5.830	.000
	Technical_Factors	1.156	.184	.596	6.292	.000

a. Dependent Variable: Revenue_Collection

From table 20, the results show that Adjusted R Squared is .767, which means that 76.7% of the variance of the dependent which is reduction in revenue collection is explained by the two independent variables which are behaviour and technical factors. Also, from table 21, shows unstandardized coefficients where the B values for behaviour factors is .951 while for the technical factors is 1. 156.This implies that for every one unit of change in behaviour and technical factors the reduction in revenue collection increases by .951 and 1.156 respectively. This means that technical factors influence revenue collection more than behaviour factors.

Chapter 5: Conclusions and recommendations

5.0. Introduction

This chapter briefly gives a run through of the key research findings in relation to the main research question, sub-questions and the objective of the research, and eventually provides its conclusion and ends with recommendations. The main findings are presented in line with literature stated in the previous chapter (2).

The objective of this research, is to explain the extent to which technical and behaviour factors related to prepaid water meter system have influenced the reduction of revenue collection. To achieve this objective, the research attempted to give solutions to the sub research questions which further assisted answering the main research question: to what extent technical (valve failures and low pressure) and behaviour factors (consumption efficiency and meter tampering) on prepaid water meters have influenced reduction of the revenue collection of LWSC in Kafue district. From the results gathered, it is clearly seen that the utility is facing many problems with the prepaid water meters, which has shown in the reduction of revenue collection of the company.

1.How valve failures and low pressure related to prepaid water meters influencing the reduction of revenue collection of LWSC in Kafue district

Clearly, the findings suggest that the common valve failures of the PWMs being faced by the utility is, meters getting stuck in open position and meters not shutting at zero, giving negative balances to the customers. From the findings, 70% of the meters installed go into negative or get stuck. 50% of the complaints are related to valve failures. From collection and purchase exceptional report shown on page 35 Table 7 indicates the numbers of faulty valve in the five months the inspection was conducted. The rate at which the valves are failing in the district is alarming going by the evidence gathered. Therefore, the company is overwhelmed with the complaint resolutions hence takes time to resolve. Unreliable response time to faults is one of the most compromising possible factor of revenue loss in prepayment system (Heymans, Kathy, et al., 2014) . According to equity theory, customers are the major source of revenue and one way of continuing receiving payments from them, is to balance the equity. Similar, if the level of service is low, the satisfaction is less and customers respond negatively as a fair balance for such services (Bolton and Lemon, 1999). Meanwhile, the ratio of Billing and Revenue Assistants (BRAs) employees to handle these challenges stands at 4:8000 PWMs. Indicating that only four employees oversee the inspections and maintenance works on the PWMs which is not sufficient comparing to the rates of failures indicated above.

Furthermore, findings from this research reviewed that inadequacy of technical know-how by prepaid department in the branch is way lower than the prepaid technology. The BRAs did not have any proper training regarding the operations and technics that surrounds the meter. As a result, repairing these meters is a challenge and comparing to the rate of failure, more revenue is lost for the utility. Heymans and Kathy et al (2014) stated that most utilities neglect the importance of trained technical staff to quickly respond to PWM faults rather, their focal point is maximising the revenue collection and arrears. Utilities need to plan for the extra budget for equipped staff

Findings indicated that because the meters that are failing every now and then, most of the customers end up drinking free water if the property is not discovered by the utility. 60% of the customers from the questionnaires indicated that their meter does not cut once units are

depleted. This means that some customers stay for months without purchasing while others have never purchased from the time the meter was installed, Table 8: page 39 shows some of the properties captured from 2017 collection and purchase exceptional reports. If the meter is stuck in an open position, water continues to come out therefore most customers are relaxed to purchase credit while other are buying less. Findings also showed lack of consistent reading of AMR and inefficiency of the AMR enables customers not to be discovered. Also, there lacks a mechanism system where the utility can quickly check on the computer to identify meters dispensing water.

Furthermore, findings reviewed that, there are pending queries on some accounts which go into negative and accumulate huge negative balances, customers refuse to settle full bill in time and blame the utility for the meter failure. While other customers when disconnected because of huge negative balance, find alternative water source from neighbours and purchase at a less price while the account becomes inactive with stagnant debt.

Findings also reviewed that major customers have moved to alternative water sources like private boreholes because of frequent breakdown and lack of quick response to these faults by the company.

Low Pressure in the distribution network

From the findings, the pressure is generally lower in most parts of the upper stream of the district than the downstream. According to the evidence collected, some of the reasons influencing pressure in the network included; intermittent supply, aged network and frequent burst pipes and leakages. From the findings, all these challenges are centred on the delapidated network of the district. Findings reviewed that 80km of the network in Kafue was laid before 1964 before the country got its independence according to Kafue map. However, when prepaid project started, only 10km of the pipe was upgraded. Pipe linings from the aged pipes, debris, grit and sand are carried along and stuck the meters. Heyman and Kathy el al (2014), highlight that in most cases, valve failures occur because of suspended particles in the distribution networks. These cause meter inaccuracies for instance; some meter valves indicate that they are closed fully meanwhile are open and allow continuous flow of water even after the purchased units in the PWM are depleted, others under record as the valve is partially open. If pipe network is not consistently maintained, debris and sand in the pipe networks will choke the meters and stuck it. According to Heymans and Kathy et al (2014), if pipe network is not consistently maintained, debris and sand in the pipe networks will choke the meters and stuck it. Meaning, more cost on replacement and revenue loss through faulty valves.

In addition, findings reviewed that burst pipes and leakages occurred on main pipes twice in a week. The average hours the team takes to finish working on a burst pipe is 8 to 12 hours. However, some leakages take long to be repair because of lack of repair materials. This also contributes to the high percentage of non-revenue water which is at 70% and is above <25% benchmark set by the regulator (NWASCO,2017). Physical losses are mainly through leakages and pipe bursts (Farley and Trow, 2003, Farley, Wyeth, et al., 2010).This finding was also supported by the responses from the customers, 66.66. % indicated that there are many leakages in district.

Supply hours varies per district and depends on the water levels in the reservoir and power supply from ZESCO which is a power supply company. Findings reviewed that on average, supply hours are between 6-12 hours per day which is lower than the acceptable level of the

regulator which should be >18 hours per day (NWASCO,2017). Heymans and Kathy et al (2014) indicated that PWMs must be on "twenty-four/seven" water supply due to the presence of air and sand which easily get sucked into the pipes after a no supply period. Supply interruption creates air vacuums in the network which leads to stuck meters, eventually degradation. At times, the meter counters run at a faster rate and depletes the loaded units without suppling any water. Water utilities need to budget for extra to cover network upgrade before PWMs are installed

Furthermore, as explained above, findings reviewed that low pressure has reduced revenue through valves getting stuck, and customers stay for longer hours without consuming water especially when burst pipes are being worked on. Lastly, the hours of supply schedule had reduced in some areas because of low pressure in the distribution network. According to Heyman and Kathy el at (2014), utilities require to invest more in network upgrade if they want to enjoy the benefits of the new technology. The findings indicated that in dry season, the pressure is very bad.

2.How are changes in water consumption efficiency and Meter tampering influencing the reduction of revenue of LWSC in Kafue district

Meter tampering

Findings indicated that the rate of tampering is high in the district as indicated in table 11: page 47 from 2017 collection and purchase exceptional reports. However, the level of meter by passes is low. The discovery of such meters by the organization is hampered by the lack of effective monitoring and inspection schedule by LWSC staff**.** According to Heymans and Kathy et al (2014) lack of continuous monitoring and response rate to customer complaints regarding meter failures, is a beginning for tampering and meter by passes. In addition, findings reviewed that meters lacks seals and have unsecured meter chambers so they are vulnerable to anyone tampering. As indicated earlier in sub-question 1, there is inconsistency with AMR to allow follow-ups on issues from exceptional report. Findings from customers also noted that illegalities are occurring because of lack of inspection from the utility. According to planned behaviour theory, Ajzen (1991) explained that, the theory of planned behaviour theory focuses on the intention that drives an individual in performing a behaviour. There may be several motivation factors that affect the final behaviour of customers in the purchase and consumption of water for instance income level and affordability. Nonetheless, findings showed that most customers can manage to purchase water PWM, it was just selfishness and dishonesty.

From the gathered findings, it reviewed that meter tampering contribute to non-revenue water through unauthorized consumptions. For a utility to reduce on Non-revenue water, it must be swift in follow up regarding the results from exception reports after drive- by are conducted (Heymans, Kathy, et al., 2014) . In addition, NRW is one of the indicators used to measure the operation efficiency of a water provider and if managed well, may improve the revenue collection (Farley, Wyeth, et al., 2010).

Furthermore, internal staff are also practicing illegalities by giving free water to the customers as a source of income for themselves. Additionally, Illegal practices are sources of low pressure in the distribution system and revenue losses for service providers (Monedero, Biscarri, et al., 2015).

Consumption efficiency

The study has shown, that careful usage of water by customers following the installation of PWMs makes it extremely challenging for the utility to grow its revenues using prepaid water

meters. Empirical evidence from the study indicated that customers had benefited greatly to the extent where they spend less money on water services compared to when they had post-paid water. According to Heyman and Kathy el at (2014), if customers consume less, cash flows for the utility reduces. Findings reviewed that many of the customers' expenditure on water is between K50 and K100 per month. However, the average number per household was 5 to 6 members. Additionally, equity theory also states that a customer would maintain the equity by either paying for the improved service or minimise on the consumption of water to still receive the service (Homburg.C, Koschate.N, et al., 2005). However, because of dilapidated network, much of the water ends up being lost through pipe burst in the district. This is in line with literature which states that reduction in consumption may mean increase in pressures in the pipeline causing burst pipes and leakages especially when the pipe network is old (Heymans, Kathy, et al., 2014).

3.Other technical and behaviour factors are influencing the reduction of revenue of LWSC in Kafue district

On one hand, other technical factors mentioned in the findings include; dilapidated network, meter quality, water management going off and user interface going off and failing to charge the UIU;

- Dilapidated network: As discussed in sub research question 1, the network is old and lacks many fittings, sand, internal lining and debris are carried along and compromise with the water quality and chokes the meter and stuck it.
- Poor meter quality: The findings reviewed that factors such as: water quality, intermittent supply and low pressure was not considered before adopting the current meter in use. The meter was to work well in a pressurised network with 24/7 supply of water. However, there are alternative types of meters which are suitable for aging networks especially in African cities. Those meters are robust to grit with high accuracy, despite them being expensive, 70% more which is not cost effective to be installed on domestic properties (Heymans, Kathy, et al., 2014).
- WMD going off: From the gathered findings, the numbers of meters having WMD going off are high. From secondary data, June 2017 prepaid monthly report, out of the 8,000 meters installed, 1,225 meters have been completely replaced with post-paid meters because of the WMD going off. Spares are a challenge as the supplier does not sell the assembly parts but completely assembled components (WMDs, UIUs, mechanical meters). Customer keep drinking free water as there is no reference point because the mechanical meter goes off too.
- UIUs go off: Because the said battery life was not the battery life. After a year plus, the battery finished instead of 8years which was the initial life span the utility was told. PWMs have a short working life cycle approximately 5 to 7years (Heymans, Kathy, et al., 2014).In addition, findings reviewed that the utility receives several complaints of UIU failing to load.

On the other hand, other behaviour factors stated in this study are; Covering meter with iron or magnet shielding which prevents the meter from closing, opening of the meter and stuck it, so that the meter stops moving but dispense free water. Usually plastics are inserted inside the meter. Also, Illegal connections by customers and internal staff. Lastly, staff practices of deleting negative and issuing free units. Findings showed that the meters are mostly damaged by women as they use the meters as stools when washing. Also, some customers dug shallow wells for gardening as cost effective measure.

To answer the main research question of this research **"to what extent technical (valve failures and low pressure) and behaviour factors (consumption efficiency and meter tampering) on prepaid water meters have influenced reduction of the revenue collection of LWSC in Kafue district"**

From the results demonstrated from the field findings of this research, both technical and behaviour factors have influenced the reduction of the revenue collection also seen from the Adjusted R Squared (76.7%) in table 20: page57. However, we can state that technical factors have more strongly influenced revenue collection than behaviour factors as confirmed by the results from regression, questionnaires and interviews. Tables 21: page 57 showed that for every unit change in technical factors, reduction in revenue increases by 1.156 while for a unit change in behaviour factors, reduction in revenue increases by 0. 951.Although from the conducted literature of this study, there was no clear indication which factors strongly influence more than the other.

As discussed in the findings, 70% of the meters that were installed have faulty valve, the meters are either stuck in open position and never shut at zero when units are depleted or give a negative balance. 50% of the complaints the utility is dealing with are meter faults related and because of the high rate of failures, the response time to resolve them is very low. Furthermore, secondary data showed from collection and purchase exceptional reports that customers stay for three months without making purchase and other properties have never made any purchase since installation of the meters. Some major customers have moved away from LWSC services.

Furthermore, 80km of the network is old, the utility experiences frequent burst pipes and leakages at least twice in a week on the main distribution line. Thereby, supply is isolated in some areas as the works are being done because the network lacks isolation valves. Supply hours is between 6 to 12 hours per day in most areas of the district which is below acceptable standard set by the utility regular (>18hrs) (NWASCO,2017). Furthermore, the Non-revenue water is 70% way above the benchmark of <25% (NWASCO,2017).

The customers have also reduced on the consumption, as indicated in the findings, most customers average expenditure is between K50 to K100 in a month. They resorted to shallow wells for their gardening. Furthermore, the findings showed that illegal practices with the meter are high both from the internal staff and customers.

Lastly, 1,225 meters have been completely replaced with post-paid meters because of WMD going off. Reports from collection and purchase exceptional report has clearly reviewed reduction of revenue collection and the utility is failing to generate enough revenue for operations and maintenance because of the challenges discussed in the findings. However, Heymans and Kathy et al (2014) indicated that PWMs should not be a miracle for revenue collection as it comes with its own challenges. And requires proper management, inspection and extra budget for upgrade of old networks. Additionally, PWMs require pressurised network and a 24hours supply which is not the case for most utilities in developing countries. LWSC also lacks these attributes.

In conclusion, PWMs is the best technology as the utility is coming from a background, where they questioned what meter readers brought in terms of meter reading from the field and where the company wanted to reduce on its debt and operation expenses which was too high. If all these are incorporated into a technology where there are no such issues then they stand to gain as a company over all with a lot of positives. However, the operational

challenges surrounding the technology of meters tend to overshadow the many positive attributes of the prepaid water meters.

Conclusively, it can be said that technical factors have strongly influenced more than behaviour factors in the reduction of revenue collection of Kafue district. However, it should also be considered that the result for the questionnaires was based on a sample of 30 which is not a representative sample to fully give this indication. Nonetheless, the results from the interviews supports this indication. Also, this research acknowledged the fact that there are other factors like: insufficient water production capacity, tariff which explain the reduction of revenue collection of the utility. However, because of time, the study scope was limited to only valve failures, low pressure, meter tampering and consumption efficiency on PWMs in Kafue district. For future research, other districts and branches in the entire Lusaka province should be extended to investigate the actual influence of PWMs on revenue collection of LWSC.

In addition, PWMs is relatively a new topic with very few literatures, based on this, a call for further study to increase the knowledge and improved application especially in commercialised utilities is recommended. From the research, behaviour factors and technical factors may have aspects interrelated between each other therefore, more research is required to uncover what the possible relationship between the technical and behavioural aspects may be. Also, a study on assessing the impact of introducing PWMs on the operational costs of LWSC is recommended for future studies to analyze the correlation in terms of initial investment costs, maintenance cost and labor costs.

In finishing, the following recommendations should be considered by LWSC for the betterment of PWMs in the district. Firstly, the utility should invest more in the upgrading of the distribution network. This option must be undertaken with the installation of strategic network valves to enable water balancing in the network which will ultimately lead to achieving effective water demand management. Secondly, to mitigate supply interruptions caused by frequent power outages and maintenance works, the utility should plan construction of more water reservoirs thereby greatly reduce the inconvenience for prepaid customers who pay LWSC in advance. Furthermore, the up scaling of technical capability skills among LWSC staff is crucially important. The utility should plan for a transfer of knowledge whenever it embarks on projects of great magnitude. This is likely to lead to better response management approaches by LWSC to faults and relatively lower maintenance costs. Lastly, the utility should seal the gaps discussed in physical inspection and ultimately management of the PWMs to avoid illegalities and capture properties consuming free water.

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Annex 1: Interviews and Questionnaires guide

Table:1 showing Interview Guide to be used on water users (Commercial users)

My names are Faith Bwalya Lesa studying at Institute for Housing and Development Studies, of the Erasmus University, Rotterdam, in Netherlands. I am carrying out a research on the influence of technical and behavioural factors on prepaid water meters on revenue collection, a case of Lusaka Water and Sewerage company, Kafue district.

I would like to seek your opinion and experiences regarding the topic. The interview will take about 30minutes of your time. Would you please permit me to record the discussion? This will help with analysing data.

Thank you for participating, your contribution and comments are appreciated.

Table 1: Interview guide

no	Indicator	Question
		Behaviour factor-Consumption efficiency
		- Please tell me about the main uses of water in your daily activities and the activities which demands more water
1	Expenditure/budgeting	-Please elaborate how your water consumption per month was before PWMs and how it is currently. -Could you tell me about your spending pattern on water since the introduction of PWMs -How would you describe the budgeting on water since the introduction of PWMs. -Can you tell me about your monthly expenditure on water against the average income - Can you tell me your views on PWMs in general
2	Duration/ next purchase	-Could you tell me about your purchases of water in a month
		Behaviour factor-Meter tampering
		- Please elaborate on the other alternative sources of water
3	Meter tampering/by-passes	-Could you please tell me if there are any ways PWMs are being tampered /by-passes
		Technical factors-valve failures and low pressure in the distribution pipe
4	Average pressure	-In your opinion, can you tell me about the pressure on the taps
5	Supply interruptions/month	-Could you tell me how the water supply under the PWMs is

6	No. leakages/month	-Could you please tell me about water leakages under the PWMs -Can you tell me about the response of municipality to solve the leakages once reported
7	Valves failures recorded	Do you experience meters going into negative? If yes, how often
		Revenue collection
8	% of recovered arrears	Could you tell me about your historical debt from PPMs and whether you still have debt
		-Do you have any problems with the PWMs -Given a chance to choose between PWMs and PPWMs, which one would you choose and why?

Table: 2 showing interview guide for the semi-structured interview on LWSC employees.

My names are Faith Bwalya Lesa studying at Institute for Housing and Development Studies, of the Erasmus University, Rotterdam, in Netherlands. I am carrying out a research on the influence of technical and behavioural factors on prepaid water meters on revenue collection, a case of Lusaka Water and Sewerage company, Kafue district.

I would like to seek your opinion and experiences regarding this topic. The interview will take about 30minutes of your time. Would you please permit me to record the discussion? This will help with analysing data.

Thank you for participating, your contribution and comments are appreciated.

Table 2: Interview guide

No	Indicator	Question
		Technical factors- valve failures and low pressure in the distribution pipe
		-What is your own opinion on valve failures of the PWMs regarding the reduction of revenue collection in general
1	Frequency valve failures/total meters connected	-How would you rate the failures of the valves to the total meters connected in the branch. -Can you tell me some of the common failures of the valve meters and why these failures are occurring
	Number of recorded valve failures/month	-What is the total number of recorded valve failures in a month
		-How are these failures discovered? -What measures are put in place to reduce these failures

	- Average pipe pressure (bars)	-Can you tell me about the average pressures in the distribution lines and what is the set pressures for the PWMs in use -Can you tell me about your pressure management
	- Water interruptions/month	-Could you tell me about the supply hours under PWM -Could you please explain the reliability of the water supply
	Pipe leakages recorded /month	- Tel me about pipe leakages in the district and how the company control the leakages -Please tell me about total recorded leakages per month
		-Can you tell me other technical factors potentially affecting performance of PWMs installed in the district -In your opinion can you explain how valve failures and low-pressure influence revenue collection -In your own option, what can you say about PWM in general
		Behaviour factors-consumption efficiency and meter tampering.
		-Please explain how the water sales before and after the introduction of PWMs has been
	Duration/next purchase	-Could you tell me about the duration customers takes for the next purchase
	Meter tampering recorded/m	-Could you take me about meter tampering under PWMs -What is the total recorded meter tampered in a month
	-Meter-by-passes recorded/m	-Could you tell me about by-passes under PWMs - What is the total recorded meter by-passes in a month
		-Are there other illegal activities customers engaged in under PWMs - What measures has the company put in place to curb down such illegal activities --What other behaviour changes have been noticed under the PWMs -In your opinion, how does behaviour factors affect revenue collection

		-Can you tell me more regarding alternative sources of water
		Revenue collection
	% Arrears recovered	-What is the proportion of arrears recovered per year
	% Revenue from billed consumption	-What is the proportion of revenue collected from the billed consumption per year
	Total revenue	-What is the total revenue collected per year
		-The revenue collection for LWSC is known to be reducing under the PWMs, could you explain what factors are influencing the revenue collection and how this has affected the company

We have now come to the end of the interview.

Is there anything you would like to add or is there anything you feel I could have left out?

Table:3 showing questionnaires to be used on domestic water users (Households)

My names are Faith Bwalya Lesa studying at Institute for Housing and Development Studies, of the Erasmus University, Rotterdam, in Netherlands. I am carrying out a research on the influence of technical and behavioural factors on prepaid water meters on revenue collection a case of Lusaka Water and Sewerage company, Kafue district.

I would like to seek your opinion on this topic through answering this questionnaire. Thank you for participating, your contribution and comments are appreciated.

Table 3: questionnaires to be used on domestic water users (Households)

Questions	**Response** (Kindly explain or tick suitable response)
Section A, General information	
1.What is the sex of the head of the house	F / M
2. What is total number of people in the household.	…….
3.What is the number of people who stay at home?	……

4.What is your monthly income	……
Section B, PWMs in general	
1.How long have you been on PWM	……..
2. To what extent do you agree or disagree on a scale of 1-5. PWMs are problematic and I am experiencing problems with the meters	Very much agree / Agree / Not sure / Disagree / Strongly disagree
3. Rate water services under PWM on a scale of 1-5	Very good / Good / Fair / bad / Very bad
Section C, consumption efficiency and Meter Tampering	
1. Rate the importance of water in your daily activities on a scale of 1-5	Extremely important / Very important / important / Slightly Important / Not important
2 Rate the importance of paying for water services on a scale of 1-5	Very important / Important / Moderate important / Of little importance / Not important
3.Do you still have historical debt on a scale of 1-5	Yes / No
4.Rate your spending on PWMs than before on a scale of 1-5	Very less / Slightly less / Less / high / Very high
5.Rate your budgeting on PWMs compared to before on a scale of 1-5	Very low / Slightly low / Low / high / Very High
6.What is your expenditure per month on water(kwacha)	……
7. How many times do you buy water units in a month	……..

8.Rate how often you run out of water units in a month on a scale of 1-5	Very often	Often	Not sure	Slightly often	Not often
9. To what extent do you agree or disagree on a scale of 1-5. Water cut once loaded units are finished in the metre	I strongly agree	I agree	Not sure	I disagree	I strongly disagree
10. To what extent do you agree or disagree on a scale of 1-5. PWMs is encouraging you to avoid wasting water	Strongly agree	Agree	Not sure	Strongly disagree	Disagree
11. To what extent do you agree or disagree on a scale of 1-5. Prepaid water meter forced my household to use water wisely	Strongly agree	Agree	Not sure	Strongly disagree	Disagree
12.To what extent do you agree. There are alternative sources of water used other than LWS (private drilled borehole) once PWMs is disconnected	I strongly agree	I agree	Not sure	I disagree	I strongly disagree
13. Water users under PWMs engage in illegalities like meter tampering\by-passes	I strongly agree	I agree	I do not know	I disagree	I strongly disagree
14.To what extent do you agree/disagree. Illegality of meter tampering/by-passes are caused because of no inspection from LWSC	I strongly agree	I agree	I do not know	I disagree	I strongly disagree
15.To what extent do you agree/disagree. Illegality of meter tampering/by-passes are caused because water user cannot afford buying water on PWMs	I strongly agree	I agree	I do not know	I disagree	I strongly disagree

Section D-Valve failures and Low pressure					
16. Rate the water pressure on PWMs on a scale of 1-5	Very good	Good	Not sure	Poor	Very poor
17.Rate PWM in allowing you access to water everyday	Very good	Good	Not sure	Poor	Very poor
18. On an average for how many hours in a day is the water supplied on PWMs	……..				
19.Rate the leakages in the district under PWMs	Very ok	Ok	Not sure	bad	very bad
20. To what extent do you agree/disagree on a scale of 1-5. my PWM go into negative once units are depleted	Strongly agree	Agree	Not sure	Disagree	Strongly disagree
21. Rate the response of LWSC to solve the problems with your PWM	Very good	Good	Not sure	Poor	Very poor

Annex2: Water network for Kafue district

Annex 3: IHS copyright form

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