FACTORS INFLUENCING NON-REVENUE WATER IN KIMILILI WATER SUPPLY, BUNGOMA COUNTY, KENYA

BY:

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DECLARATION

This research project report is my original work and has not been presented to any other University

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L50/73528/2014

This research project report has been submitted for examination with my approval as University Supervisor.

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DEDICATION

This research project is dedicated to my parents Mr. Ambrose Benjamin Madara and the Late Mirriam Ethel Akewera for mentoring, guiding, coaching and educating me. I also dedicate to my children David Alila and twins Mirriam Akewera and Ambrose Ododa for they have been my source of strength and inspiration and I have sacrificed quality family time to focus on studies.

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ABBREVIATIONS AND ACRONYMS

AWWA	American Water Works Association
DMAs	District Metered Areas
IWA	International Water Association
JICA	Japan International Corporation Agency
KFW	Kreditanstalt Fur Wiederaufbau
LVNWSB	Lake Victoria North Water Services Board
MEWNR	Ministry of Environment, Water and natural Resources
NRW	Non-revenue water
NZOWASCO	Nzoia Water Services Company Limited
OECD	Organization for Economic Co-operation and Development
UFW	Unaccounted for Water
UN	United Nations
WSP	Water Service Provider
WASREB	Water Services Regulatory Board
WSB	Water Service Board

ABSTRACT

Millennium Development Goal (MDG) 7C on environmental sustainability target was "to halve by 2015 the proportion of people without sustainable access to safe drinking water and sanitation services". Access to safe water is the percentage of the population with reasonable access (20lts/person/day) to and adequate amount of water from an improved source as household connection, water kiosk, or standpipe, borehole, protected well or spring or rainwater collection. Unimproved sources include vendors (donkey cart, push cart (mkokoteni), tanker trucks and unprotected wells and springs. This has not improved much in addressing the problem of water scarcity despite the numerous water projects. The purpose of this study was to examine the factors influencing non-revenue water in Kimilili water supply. Non-revenue water is water loss from the total water supplied. The study objectives are; to assess the extent to which mechanical conditions of water meters influence non-revenue water in Kimilili water supply, Bungoma County. To establish whether unmetered connections influence non-revenue water in Kimilili water supply, Bungoma County. To examine whether customer base influence non-revenue water in Kimilili water supply, Bungoma County. To establish the extent to which water bursts and leaks influence non-revenue water in Kimilili water supply, Bungoma County. The study research questions were; how does mechanical condition of water meter influence the level of non-revenue water in Kimilili water supply, Bungoma County? To what extent do unmetered connections influence the level of non-revenue water in Kimilili water supply, Bungoma County? To what extent does customer base influence non-revenue water in Kimilili water supply, Bungoma County? How do water bursts and leaks influence non-revenue water in Kimilili water supply, Bungoma County? The information is limited to Kimilili water supply in Bungoma County, Kenya. The study population size was 2,136 registered active water connections, 23 water supply staff and 4 from administration members. Descriptive survey design was used. Representative sample units were selected using stratified random proportionate sampling using Cochran formulae (1963) and purposive sampling; sample size 186 customers, 2 administration and 2 staff. The primary data was collected using questionnaires and interview guide. The secondary data for this study was obtained through document review. The response rate of the sampled administration and staff was 100% while from the customers was 80.12%. The questionnaire was pilot-tested using a sample of ten (10) respondents from Webuye Water Supply after which its reliability was determined using Pearson product moment correlation coefficient (r) and obtained r = +0.78. The study used frequency distribution, percentages and IBM SPSS Version 20 to analyze data. The study established that mechanical condition of water meters influence NRW thorough meter class and age, unmetered connections through illegal connections and flat rates, customer base through the customer attitude and ability to pay and lastly, water bursts and leaks influence NRW. Based on the study findings it is suggested that; Kimilili Water Supply should develop and implement a NRW reduction strategy which should include water meter registration accuracy enhancement, meter replacement schedule, meter all flat rates and carry out regular servicing and calibration of consumer water meters. There is also need to curb illegal water consumption by carrying out periodic customer base audit by reconciling office consumer database with field connections through meter census.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Kenya is classified as a chronically water scarce country, with an annual renewable fresh water supply of only 647m^3 per capita. Globally a country is categorized as water stressed if its annual renewable freshwater supplies are between 1000 and 1700m^3 per capita and water scarce if its renewable fresh water supplies are less than 1000m^3 per capita. However, the current level of development of water resources in Kenya is very low; only 15% of the safe yield of renewable fresh water resources has been developed so far. There remains an opportunity to exploit the balance of 85% (World Bank, 2012). The demand for fresh water is ever increasing. As we lose or waste water we need to think critically of the demand as Kenya's ever expanding population that is steadily growing at an annual rate of 2.5%. The 2010 census showed that Kenya is currently home to a total population of 38.6 million in habitants, compared to 29 million in 2000. Rural–urban migration is high, leading to a strong growth of the informal settlements in and around the towns and cities. The UN Population Division expects an urbanization rate of 42% for Kenya in 2015. Urban growth poses large challenges for local authorities and Water Services Providers (WSPs) to service the population with appropriate water and sanitation services (UNDP, 2012).

The study was based on the International Water Association's theory of water balance. The theory (concept) proposes that a water utility system input volume can be subdivided into two components namely authorized consumption and Water losses, (Farley et al., 2008). WASREB (2012), states that “non-revenue water is the difference between amount of water produced for distribution and the amount of water billed to consumers".

WASREB (2013) states that consequences of high Non-Revenue Water (NRW) includes among others loss of income affecting WSP capacity to offer additional outlets for underserved thus limiting response to demand/rights, wastage by connected consumers leaves less water for the urban poor depriving rights of underserved with given water system and finally negative image of the WSPs among public and politicians. High non-revenue water in a way infringes rights of underserved and connected consumers as it limits cost recovery and sustainability leading to unjustified burden for paying consumers. The global volume of non-revenue water (NRW) or water losses is staggering. Each year more than 32 billion m^3 of treated water are lost through leakage from distribution networks. An additional 16 billion m^3 per year are delivered to customers but not invoiced because of theft, poor metering, or corruption (Farley, 2008). Shilehwa (2012), indicates non-revenue water levels of some selected countries expressed in percentage terms as Singapore 5, Denmark 6, Germany (2005) 7, Netherlands 6, Japan (2007) 7, Mexico (2004) 51, Philippines (2009) 16, England (2005) 19, France (2005) 26, Zambia (2009) 45, Tunisia (2004) 18, Nigeria 42, Uganda (2009) 22 and Kenya (2012) 45.

J.W.A (2011) indicates that average non-revenue water in Japan was 7.3% in 2007, varying from less than 5% up to 15%. The low level of water leakage, down from

18% in 1978, has been achieved through speedy repairs that are typically undertaken the same day that a connection is reported, and through the use of high-quality pipe materials. The government's target is to reduce losses to 2% for large utilities and 5% for small utilities. In the U.S., utilities lose on average 20 percent of their water, according to the Strategic Directions Water Report (2013). The seriousness of the problem generally depends on the age of the water system infrastructure – U.S. cities in the Northeast and Midwest tend to have the oldest pipeline networks and the highest leakage. The age of a system's meters – which affects metering accuracy and billing losses – is less regional in nature and can be an issue at any utility, depending on its replacement practices. The NRW figure for South Africa is similar to the estimated world average of 36.6%, but is considered high in comparison to developed countries and low when compared to developing countries. (Water Research Commission Report, 2013). South Africa has managed NRW through leakage control i.e. wastage from their potable reticulation systems since the early 1990s. South Africa was one of the first countries outside the UK to fully recognize the benefits of adopting the Burst and Background Estimate (BABE) methodology that was initially developed by the UK water industry when the major water suppliers in England and Wales were privatized in the early 1990s.

WASREB, (2012), describes the situation in Kenya as, best performing in NRW is linked to overall performance of WSPs. Nyeri 26% (No. 1 overall), Meru 23% (Number 2 overall), Average in Kenya 2010/2011 was 45%, the target was 20% but 25% is acceptable. NRW reduction is crucial contribution to higher service level to reach minimum service level rights. There was sector commitment in making a commitment to reduce NRW to the target of less than 20% by the year 2017. Kimilili Water supply is part of cluster supplies which for Nzoia Water Services Company. At the close of F/Y 2013/2014 by June 2014 NRW was as follows: Kitale 36.54%, Bungoma 36.35%, Webuye 42.33%, Kimilili 65.47% and Malaba Kocholia 50.28% with an average of 46.2% for the entire company (WARIS, 2014).

1.2 Statement of the Problem

Studies carried out show that non-revenue water (NRW) is attributed to have direct impact on the financial sustainability of water utilities. The higher the NRW in a water system the less the water billed hence less revenue collected, which results to higher operational and maintenance cost being incurred in producing water with aim of meeting the demand. NRW is an indicator of operational performance of Water Service Provider (WSP). NRW is good indicator of asset performance of the company's overall financial performance. The lower levels of NRW indicate high revenues are being billed or that operating costs are low (http://www.rws.com.my/index.php/non-revenue-water).

Kimilili water supply had non-revenue water percentage of 68.61 by December, 2014 (WARIS Report, 2014) with percentage coverage of 49 within the entire licensed area of operation. The World Bank recommends that NRW should be less than 25%. Kenya's target is 20%. AWWA recommends that water utilities should track volumes of apparent and real losses and the annual cost impacts of these losses and 10 percent benchmark for non-revenue water. High levels of NRW are detrimental to the financial viability of water utilities, as well to the quality of water itself. Treated water is lost despite having incurred costs in; chemicals electricity, labour, maintenance of the plant and the system to ensure production and distribution, Water Resources Management Authority abstraction charges, County leasing charges, Lake Victoria North Water Services Board & Water Services Regulatory Board regulatory levies.

In view of this discrepancy, there was need to determine suitable techniques that can reduce the NRW to acceptable limit or better still the Kenya's target and improve financial sustainability of the water supply and improve service delivery to the general population. If this was not addressed, the influence of high NRW may trickle down to customers who will carry the burden of high operational costs and impact negatively on service delivery. This was a dangerous president and for the future of the whole country. Therefore the study sought to examine the factors influencing the level of non-revenue water in Kimilili water supply, Bungoma County, Kenya with the aim of developing NRW reduction strategy which may attract donor funding.

1.3 Purpose of the Study

The purpose of this research study was to establish the factors influencing non-revenue water in Kimilili water supply, Bungoma County, Kenya. With the view of reducing water loss and improving efficiency, the study examined the influence of mechanical condition of water meters, unmetered connections, customer base and water bursts and leaks on non-revenue water.

1.4 Objectives of the Study

The study was guided by the following objectives;

1. To assess the extent to which mechanical conditions of water meters influence non-revenue water in Kimilili water supply, Bungoma County.
2. To establish whether unmetered connections influence non-revenue water in Kimilili water supply, Bungoma County.
3. To examine whether customer base influence non-revenue water in Kimilili water supply, Bungoma County.
4. To establish the extent to which water bursts and leaks influence non-revenue water in Kimilili water supply, Bungoma County.

1.5 Research questions

The study was guided by the following questions;

1. How does mechanical condition of water meters influence non-revenue water in Kimilili water supply, Bungoma County?
2. To what extent do unmetered connections influence non-revenue water in Kimilili water supply, Bungoma County?
3. To what extent does customer base influence non-revenue water in Kimilili water supply, Bungoma County?
4. How do water bursts and leaks influence non-revenue water in Kimilili water supply, Bungoma County?

1.6 Significance of the Study

The main aim of the study was to establish non-revenue water (NRW) indicators in Kimilili water supply and make recommendations for best practices to enhance efficiency and effectiveness in service delivery hence financial sustainability. The study findings helps the Water Service Provider develop NRW reduction strategy and also contribute valuable knowledge to the field of non-revenue water in general as there is limited research on customer base attitude and paying ability influence of non-revenue water. This study also suggests policy statements through its recommendations.

Benefits of low level NRW includes; water utilities gain more access to more money inform of improved generated cash flow, reducing illegal connections supporting greater fairness between users, more efficient and sustainable utilities improves customer service, new business opportunities creating thousands of more jobs, improved water supply and distribution system management, improved level of services for pressure and quality and quantity of supply, improved billing revenue and optimized capital investment, reduction of water losses and controlled non-revenue water, having the latest technology transferred including managerial system, software tools and equipment and development of comprehensive long term pipe rehabilitation programme. This was valuable contribution towards meeting Millennium Development Goal 7 C on environmental sustainability “to halve by 2015 the proportion of people without sustainable access to safe drinking water and sanitation services”. The study will also be beneficial to the customers as they will receive quality, affordable and sustainable services. This study lay’s the basis for researchers who are interested in this area of study in future.

1.7 Basic Assumptions of the Study

It was assumed that Water Service Provider licensed to operate within the area provided information willingly and honestly. It was also assumed that the operational field staff would offer required technical assistance and customers provided correct and objective information. Also another assumption was that mechanical condition of water meters, unmetered connections, customer base and water leaks and bursts influence non-revenue water.

1.8 Limitations of the Study

This study was limited on obtaining some information on unmetered connections due to suspicion by the users that they will be reported and some legal action taken against them. By use of the transmittal letter, rapport was established to increase cooperation through instilling confidence. The study also supplemented with information obtained from the document review on illegal connections. The other limitation was language barrier which was handled by use of research assistants who are familiar with the local dialect. Finally the other limitation was knowledge of the exact site location of the customer connections. Meter readers were used to offer guidance to the research assistants on the location of the customer connections.

1.9 Delimitations of the Study

This study was confined to the factors influencing non-revenue water in Kimilili water supply in Bungoma County, Kenya using descriptive survey research design. The study specifically focused on the influence of mechanical condition of water meters, unmetered connections, customer base and water leaks and bursts on non-revenue water. The target population was the administration, staff and customers of Kimilili water supply. The data collection instruments used was interview guide and questionnaires. Data was collected with the assistance of two research assistants.

1.10 Definition of Significant Terms

Non-revenue water: Non-revenue water (NRW) is the difference between water supplied and the amount of water sold to all customers expressed as a percentage.

Sustainability: meeting the current needs without compromising the opportunities of future generations to meet their needs.

Financial sustainability is the long term guaranty of revenues obtained covering full costs of provision of water and sanitation services also including the costs of operation & maintenance, rehabilitation and expansion.

Water Utility: Licensed Water Services Provider to provide water and sewerage services

Water act, 2002 is a policy gazetted by the government of Kenya in 2002 as a result of the act of Parliament to provide for the management, conservation, use and control of water resources and for the acquisition and regulation of rights to use water; to provide for the regulation and management of water supply and sewerage services.

Water tariff is a gazetted price structure in the year 2010 assigned to water consumed by customers by a public water utility through a piped network.

Unaccounted for Water (UFW) is the difference between the volume of water injected into a water utility's pipeline network system and the volume of water authorized for consumption.

Water Losses is the difference between water utility's system input volume of water and authorized consumed volume of water.

Commercial Losses is also referred to as 'apparent losses' and it consists of unauthorized consumption (illegal consumption), data handling errors and all types of metering inaccuracies.

Physical Losses also referred to as 'real losses', is the annual volumes lost through all types of leaks, bursts and overflows on mains, service reservoirs and service connections, up to the point of customer metering.

CHAPTER TWO

LITERATURE REVIEW

2.1. Introduction

This chapter provides review on the literature related to factors influencing non-revenue water Kimilili water supply, Bungoma County. It particularly focuses on influence of mechanical condition of water meters, unmetered connections, customer base and bursts and leaks on the level of non-revenue water. These are the main pillars of the study.

2.2 Introduction to non-revenue water and water service providers

Responsibility for water and sanitation service provision is in the hands of Water Services Boards. However, they are not required to provide services directly – they can delegate them to commercially oriented public enterprises, the so-called Water Service Providers (WSPs). Service provision is regulated by service provision agreements (SPAs) to ensure compliance with the standards on quality, service levels and performance established by Water Services Regulatory Board (KNWD, 2010, Water Act, 2002). The International Water Association (IWA) is the global network of 10,000 water professionals spanning the continuum between research and practice and covering all facets of the water cycle. IWA, (2000) states that non-revenue water (NRW) is the difference between water supplied and the amount of water sold to all customers. It is represented with the following formula:

$$\mathbf{NB}: \text{NRW} = \left(\frac{\text{M}^3\text{Supplied} - \text{M}^3\text{ sold}}{\text{M}^3\text{Supplied}}\right)\text{x}100$$

“Non-revenue water is the difference between the volume of water put into a water distribution system and the volume that is billed to customers. NRW comprises three components: physical (or real) losses, commercial (or apparent) losses, and unbilled authorized consumption” (WASREB, 2013). Physical losses comprise leakage from all parts of the system and overflows at the utility’s storage tanks. They are caused by poor operations and maintenance, the lack of active leakage control, and poor quality of underground assets. This technical losses lies on physical failures on the distribution system (pipe leaks and bursts), being some of them easily identified and corrected. Commercial losses are caused by customer meter under registration, data-handling errors, and theft of water in various forms. Commercial component is in part linked to lack of measuring (faulty meters that inaccurately register consumption). This is the water used but not paid for. The commercial component of NRW is also associated with illegal connections established by users stealing water or taking it without any legal means to measure it or simply by shifting connections in order to lower consumption measurement. Unbilled authorized consumption includes water used by the utility for operational purposes, water used for firefighting, and water provided for free to certain consumer groups (Lambert, 2001).

In most developed countries, there are no or very limited apparent losses. For developing countries the World Bank has estimated that, on average, apparent losses - in particular theft through illegal connections - account for about 40% of NRW. In some cities, apparent losses can be higher than real losses (Lambert, 2001). “A water audit is a key tool to assess the breakdown of NRW and to develop a program for NRW reduction”

(Fanner, 2009). The AWWA (2013) has developed Water Audit Software which allows utilities to rate the overall degree of validity of their water audit data. Guidance on loss control planning is given based upon the credibility of the data and the measure of losses displayed by the water audit. NRW is sometimes also referred to as unaccounted-for water (UFW). While the two terms are similar, they are not identical, since non-revenue water includes authorized unbilled consumption (e.g. for firefighting or, in some countries, for use by religious institutions) while unaccounted-for water excludes it (IB-NET, 2013)

The World Bank recommends that NRW should be less than 25%. In England and Wales non-revenue water level stands at 19%. In the United States the American Water Works Association's (AWWA, 2013) Water Loss Control Committee recommended in 2013 that water utilities conduct annual water audits as a standard business practice. According to Liemberger and Farley (2005), "the first step in developing a NRW strategy is to ask some questions about the network characteristics and the operating practices, and then use the available tools and mechanisms to suggest appropriate solutions, which are used to formulate the strategy".

Kenya launched of an ambitious project on 4th September, 2014 to support water service providers (WSPs) in Kenya to reduce non-revenue water levels in order to enhance their financial sustainability and improve access to water services to their consumers. The new project, "Addressing Non-Revenue Water in Kenya", will run through the end of 2015, during which at least 10 county WSPs are expected to benefit.

The project is funded by the Ministry of Foreign Affairs of the Government of the Netherlands (DGIS) and implemented by SNV Kenya in partnership with Vitens Evides International (VEI), and capacity building support from the Kenya Water Institute (KEWI). Key water sector institutions such as MEWNR, the Water Services Regulatory Board (WASREB), and the Water Service Providers Association (WASPA) will play a key role in coordination, regulation and sustainability of the project processes. NRW levels remained high for the Kenyan water sector at an average of 45% for urban sub-sector, more than double the recommended best practice of 20%. Converted to money, this translates into losses of over KES 10 billion (some €86 million) annually due to NRW, despite the overall limited availability of water resources for development. NRWs undermine cost recovery and sustainability and lead to unjustified burdens on consumers, thereby infringing on their right to water services. There is sector commitment in making a commitment to reduce NRW to the target of less than 20% by the year 2017.There is newly launched national standards on NRW management in 2014, that was developed with the support of JICA, to guide them in addressing NRW issues (Non-Revenue Water management a high priority for Kenya _ SNV World.htm 2014).

2.3 Mechanical conditions of water meters and non-revenue water

"A meter is a device fitted to the water pipes serving your home to measure the volume of water passing through the pipe" (AWWA, 2013). Mechanical condition of the meter refers to the functionality of the meter to give accurate water consumption readings. Water meters can also be used at the water source, well, or throughout a water system to determine flow through a particular portion of the system. In most of the world water meters measure flow in cubic metres (m^3) or litres but in the USA and some other countries water meters are calibrated in cubic feet ($ft.^3$) or US gallons on a mechanical or electronic register. Some electronic meter registers can display rate-of-flow in addition to total usage (AWWA, 2013). There are several types of water meters in common use. The choice depends on the flow measurement method, the type of end user, the required flow rates, and accuracy requirements. Water meter can either under register, over register or read accurately depending on the class of water meter, age of the water meter and water quality. Stuck Meters also under register. If a customer's monthly water usage appears to be abnormally low, it is possible he/she has a stuck meter that does not accurately measure water usage (Ofwart, 2011).

Meter testing, calibration, repair, and replacement are also important. After determining the accuracy of the metering system, the utility should provide a schedule of activities necessary to correct meter deficiencies. Meters should be recalibrated on a regular basis to ensure accurate water accounting and billing. Calibration provides a utility with valuable information on the accuracy of the quantity of water being supplied, leading to appropriate decisions on maintenance or replacement frequency (Ofwart, 2011 2011).

The Kenyan standard non-revenue water manual (2014) states that size, accuracy, capacity, type, durability, there are numerous aspects that need to be taken into consideration before making final choice. Selection of a meter for a given application also depends on many factors including: meter operating principles, debris and particle tolerance, required accuracy , temporary vs. permanent, installation , convenience and ease of use , calibration and required maintenance , volume of flow and flow rate , size of pipe , types of flow (laminar vs. turbulent) , type of pipe , range of flow , pressure drop , installation location and orientation , meter orientation , required power , flow obstruction tolerance , data logging requirements , meter reading methods , durability , temperature and environment.

There are several ways water meters can be classified but meters encountered in water distribution systems either operate based on principles of positive displacement or the velocity of flowing water. Meters can also be classified by their placement and usage. Meter placement is critical for water audits and leak detection (Ofwart, 2011). Three types of meter usage based on placement in the distribution system are: master meters, district meters and service meters. Master Meters or Production Meters record the output of finished water flowing into the distribution system. A master meter can also be used to measure water being sold from the plant or a take-off point in the distribution system to another system. District Meters or Zone Meters measure the water used within a defined area such as a residential or business district. District meters are used to determine if leaks or losses are occurring within the metered area. Finally Service Meters or End User Meters measure the consumption by water users in the system at the service line (where the line goes from the distribution line to the household). Typically one service meter is positioned on the service line just past its connection with the distribution main (AWWA, 2009).

Following the manufacturer's installation instructions for a meter is also crucial to proper operation. A properly calibrated meter can register incorrectly if installed improperly. Meter sizing is very important since the accuracy of the meter is dependent on its design type and design flow (AWWA, 2013). Over time, most water meters fail to register an increasing proportion of the water flow through them. Under-registration results in lower billing and loss of potential revenue while at the same time erroneously indicating an increased level of water lost from the system. Just as with any mechanical or electrical system, meters are subject to inaccuracy or failure if not installed or maintained properly. Some of the common problems that necessitate calibration and testing of meters include: incorrect installation or sizing, higher or lower flows than designed for, debris in the water, scale builds up due to minerals in the water, tampering, environmental extremes including high or low temperature or vibration, and wear.

Meters should be calibrated according to manufacturers' instructions. A WSP should concentrate on testing accuracy of customers who consume more and have larger meters since errors in the larger meters will result in higher revenue losses. Depending on installation methods, residential meters can be tested in place or might have to be removed. Meter testing can be done with portable testing and calibrating equipment or the meters can be sent to a company that tests, calibrates and refurbishes them (AWWA, 2009). Many water systems test only a representative sample of residential meters and base their decisions to replace or repair meters in a selected area on the results of the tested sample. The more meters that are tested, the more accurate the results will be. Larger meters may require more frequent testing than domestic water meter.

If the Water Service Provider (WSP) has older meters in its distribution system, it might be a good idea to test or replace them. Determining when the optimum time to replace meters and setting up a replacement program can require a complex analysis (AWWA, 2013).

Water meters can be damaged and deteriorate with age, thus producing inaccurate readings. Inaccurate readings will give misleading information regarding water usage, make leak detection difficult, and result in lost revenue for the system. All meters, especially older meters, should be tested for accuracy on a regular basis. The system also should determine that meters are appropriately sized. Meters that are too large for a customer's level of use will tend to under-register water use. Meters should be able to accurately record the full range of expected flow rates (http://www1.gadnr.org/cws/Documents/Meter_Repair_Replacement.pd).

2.4 Unmetered connections and non-revenue water

"Flat rates are unmetered connections without water meters to measure the volume of water consumed for period of time" (WASREB, 2014). Meters are very important for all aspects of the water audit process. They make it possible to charge customers for the water they use. They record usage and therefore make billing fair for all customers. They can encourage conservation by making customers aware of their usage. They help detect leaks and establish accountability. Meters allow a Water Service Provider (WSP) to monitor treated water output and demand. WASREB (2013) advices that meter records provide historic demand and customer use data that is used for planning purposes to determine future needs. In short, metering data makes accurate water auditing possible. Metering programs involve several aspects of the revenue stream for a WSP.

EPD (2007) indicates that metering establishes billing procedures and income. Metering and accounting systems can also help detect leaks and other losses. Metering also has aspects that require expenditure including installation, maintenance, calibration, testing and replacement. Meters and metering programs are an integral part of billing systems. Metering is also used to determine performance and system efficiencies by monitoring specific equipment or areas. Accurate metering is crucial to performing a meaningful water audit. Metering helps determine the consumed volume against supplied volume. Unmetered connections could be unmetered billed consumptions e.g. consumer flat rates or unbilled unmetered consumption e.g. illegal connections, firefighting equipment usage by the county government fire department (EPD, 2007). Metering of water supplied by utilities to residential, commercial and industrial users is common in most developed countries, except for the United Kingdom where only about 38% of users are metered (Ofwart, 2010).

The benefits of metering are that in conjunction with volumetric pricing it provides an incentive for water conservation, it helps to detect water leaks in the distribution network, thus providing a basis for reducing the amount of non-revenue water and it is a precondition for quantity-targeting of water subsidies to the poor (EPD, 2007). “The costs of metering include the investment costs to purchase and install meters and the recurrent costs to read meters and to issue bills based on consumption instead of bills based on monthly flat fees" (GIZ & SNV, 2014). Problems associated with metering arise particularly in the case of intermittent supply, which is common in many developing countries. Sudden changes in pressure can damage meters to the extent that many meters in cities in developing countries are not functional. Also, some types of meters become less accurate as they age, and under-registering consumption leads to lower revenues if defective meters are not regularly replaced. Many types of meters also register air flows, which can lead to over-registration of consumption, especially in systems with intermittent supply, when water supply is re-established and the incoming water pushes air through the meters (WASREB, 2013).

Reducing apparent losses from illegal connections is often beyond what a utility can achieve by itself, because it requires a high level of political support. Illegal connections are often in slums which mean that their regularization in some cases particularly affects the poor (WASREB, 2013). With rates on the rise in many communities, some drinking water customers use their knowledge of how to bypass a water meter to get a free supply. While it might be a benefit for the customer to avoid a water bill, it's certainly not good for the utility trying to provide services on a tight budget. "A non-paying customer is a customer that hurts the utility's bottom line and other customers in the long run" (MEWNR, 2014). Some utility workers know it's going on. Others suspect it, but know they need proof before accusing someone. Stealing water is a touchy subject, and it's not a good idea to accuse a customer of water theft unless you've caught them red handed (WASREB, 2014). There are different ways that people can filch water from a utility. The utility has turned off the meter for nonpayment or some other reason and an individual turns it back on-self reconnection. Another way is that the utility has removed the meter and someone plumbs a pipe in the meter box to obtain water. In the third way, a construction crew or farmer uses an un-metered fire hydrant to obtain water with knowledge or approval from the utility. Lastly, a consumer has an un-metered supply to the main service line. In some of illegal cases, customers will turn the water off, take the meter out and put in a length of pipe the same length of the meter and then turn the water back on. It's called a meter jumper (http://www.nesc.wvu.edu/ndwc/articles/ot/wi04/ stealing.html, 2015). They usually leak, and they're not very good, but it allows them to get water for free. If they know what time the people read the meter each month, then they can allow a few days after the meter is read, turn the meter off, put the jumper in place of the meter, run it for a few weeks, and replace the meter before it is read again. With the work involved in stealing water, some would think it's not worth the hassle. But when you consider that many water and sewer bills are tied together and the sewer bill is determined by how much water a customer uses, then there's more financial incentive to fleece the system (WASREB &GIZ, 2014).

GIZ & SNV (2014) states that detection and deterrence is simple**,** the utility's billing department water use tracking is often the best way to spot a thief. If there is a customer going along using $50m^3$ month and suddenly usage drops to 15 or 25 m^3 for a month or two, then maybe you should test the meter to see if it's running slow. If the meter tests okay, then you have a pretty good indication that the customer has been in the (meter) housing doing something. Suggested using a lock on the meter setter to keep the water from being turned off, making it more difficult to bypass the meter (http://www.nesc.wvu.edu/ndwc/ articles/ot/wi04/ stealing.html, 2015). In most Water Service Providers (WSPs) in Kenya, they seal the meters using sealing wire, beads and sealing gun (WASREB, 2013). Not advisable for WSP usually to use anti-tampering devices until they run into a situation where they know a customer is stealing water. When systems spot a problem, they should take steps to lock/seal the meter up. Within the meter box there is a meter yoke or meter setter where the meter actually sits in the yoke. Most, if not all yokes, are capable of being locked in a way that you can turn the water on and lock the meter so they can't turn the water off. If they can't turn the water off to the meter, then they can't take the meter out. If they were to try bypassing the locked yoke, water would flood the meter housing, making it a much more complex job.

If suspected that a customer is stealing water, lock the meter and see if that usage continued. It might be quite possible that the customer found a leak in the house and fixed it. You don't just arbitrarily knock on the door and ask if they've been stealing water. There are some ways to verify that. Once you lock the meter housing, the customer can't tamper with it. If the low usage continues, then obviously he's repaired a leak somewhere in the house. There are cases where people will tap into the line prior to the water meter; it's a less common practice because there is a lot more work involved. You've got to dig the line up and make a tap without turning the water off. That gets you real wet, and, of course, it's very obvious. The easiest way for a customer to steal water is to actually do it through the meter by using a jumper or pulling the dial off (meter tampering) if you have that type of meter or, they can try some way to disable the meter. In India, an example of action taken by WSPs, as per the HMWS&SB Act, customers tapping water illegally would have to pay three-year penalty (minimum charges per month).

2.5 Customer base and non-revenue water

Christensen, Clayton, and Michael Raynor (2003), states that the customer base is the group of customers who repeatedly purchase the goods or services of a business. In Water Supply, customer base includes domestic consumers, institutions like schools, hospitals, commercials like hotels and restaurants and petrol stations and those who frequent the water kiosks to buy water (WASREB, 2013). Weier, Mary Hayes (2006), argue that companies with a customer base consisting mainly of large companies may increase their customer base by pursuing small and mid-size customers. Perhaps one of the most generalizable determinants of utility financial performance is facility size and customer base. Larger utilities can take advantage of economies of scale and spread their costs (which are mostly fixed) over a greater number of customers, thereby reducing costs per account. Smaller utilities have many of the same fixed costs and requirements with fewer customers to cover costs. Additionally, utility staff may lack time and expertise to strategically finance their utility. Larger systems are also more likely to have a diverse customer base (i.e. a healthy mix of residential, commercial, industrial, and wholesale customers) and are less vulnerable to revenue fluctuations as a result of individual customer behavior change (WASREB, 2013).

“Water Service Providers may be threatened with alternative sources of water namely boreholes, shallow wells, streams and rivers, springs, community projects and bottled water” (WASREB, 2014). This affects the attitude to pay for water services. The ability to pay for the services also affects revenue base in return the non-revenue water. Consumer attitudes are a composite of a consumer’s (1) beliefs about, (2) feelings about, (3) and behavioral intentions toward some object--within the context of marketing, usually a brand or retail store. These components are viewed together since they are highly interdependent and together represent forces that influence how the consumer will react to the object (http://www.consumerpsychologist.com/cb_Attitudes. html, 2015). An attitude is a person's feeling toward and evaluation of some object or event. Attitudes have two important aspects: Direction (positive/negative, for or against) and Intensity (strength of feeling). (http://psychology.ucdavis.edu/faculty_sites/sommerb/sommerdemo / scaling/attitude.htm, 2015).

WRF (2014) indicates that the factors influencing revenue resiliency include service area size & diversity: Utilities serving a larger customer base tend to have lower rates and stronger financial performance metrics than their smaller counterparts. WRF (2014) also indicates that strategies and practices for revenue resiliency include: demand projections: detailed, integrated, and updated, demand forecasting can help water resource managers and finance officers make plans with more confidence and less financial risk. Rethinking utility services: many utility managers have begun looking at options beyond selling traditional services to diversify revenues, including the sale of fire protection services. Alternative rate designs: the industry has an opportunity to adopt pricing models that better align cost-of-water to the cost-of-service. Customer affordability & assistance programs: keeping rates unsustainably low for all customers at the cost of water and wastewater infrastructure investment benefits no one in the long term. Affordability programs provide flexibility to utilities seeking revenue resiliency. Customer Assistance Program Cost Estimation Tool (CAPCET): This tool was developed to help utilities assess the costs and benefits of implementing a customer affordability program in their service area. Using information from the U.S. Census Bureau and water and wastewater rates inputted by the user, this interactive instrument incorporates information about the eligibility threshold to qualify for an affordability program, annual assistance offered per customer, percent of customers responsible for bad debt, among other fields. By adjusting the appropriate fields, the results provide insight into design considerations and program costs.

This process, of moving from low-end customers to more expensive and more profitable customers, is known as up streaming, and is an integral part of the theory of disruptive innovation (Christensen, Clayton, Thomas Craig, and Stuart Hart, 2001). Bargh, John, Mark Chen, and Lara Burrows (1996) explain customer base companies grow their customer base, and gain experience satisfying them, their customers grow accustomed to that business accomplishing a certain task for them. According to Dubrovski, Drago (2001), repeat buyers and users are also useful for further reasons, as they are the source of "word of mouth" advertising. Studies have shown that customer satisfaction with a brand leads to more purchases, from both the same and new customers. A satisfied customer expresses their enjoyment in the product, or even shows a friend the product and has them try it out, and a dissatisfied customer may speak against a product or not mention it at all. WASREB (2014), stated that the best performing water service provider (WSP) are those with large number of connections grouped as Very Large WSPs including those with more than 35,000 connections, Large WSPs with 10,000 – 34, 000 connections, Medium WSPs with 5,000-9,999 and finally small WSPs with 1,000 – 4,999 connections .

According to Jason Lemkin (2010) good relationships have business value. A customer that is happy with your products is a loyal customer. Loyal customers: Are willing to spend a larger wallet share, leading to increased revenue, are more willing to consider additional products and services, are less likely to churn and will serve as a brand advocate. A systematic process is important in the planning phase. The basic steps are categorization of customers according to their growth potential and the second step entails identification of growth targets for high potential customers and development of action plans (Dobbs, Huyett and Koller 2010).

2.6 Water bursts and leaks influence on non-revenue water.

"Water burst is when water comes out of the water pipes suddenly or violently especially from internal pressure. Water leakage is a way (usually an opening) for fluid to escape a container or fluid-contain system" (Fanner, 2009). Water losses during bursts and leaks can occur due to; damaged pipeline network and storage tanks/reservoirs leading to leaks and bursts on transmission and/or distribution mains, leakage and overflows at storage tanks and reservoirs and leakage on service connections up to consumer meters (Farley, M., Wyeth, G., Ghazali, Z., Istandar, A. & Sher, S., 2008). “Leaks and bursts occur due to poor quality materials that cannot sustain pressures (pipes, valves and fittings), old dilapidated infrastructure and poor network” (Shilehwa, 2012). During maintenance the pipeline has to be drained completely to enable repair works to be done and after repair flushing of pipeline is required to avoid water contamination and clogging of pipeline with mud/debris and clogging of consumer meters due to mud/debris (AWA, 2013)

Shilehwa (2012) states that leaks and bursts on Transmission and/or distribution mains and especially transmission mains are primarily large events; they are visible, reported and normally repaired quickly. By using data from the repair records, the number of leaks on mains repaired during the reporting period can be calculated, an average flow rate estimated and the total annual volume of leakage from mains calculated as follows: number of reported bursts x average leak flow rate x average leak duration (say 2 days) and then a certain provision for background losses and so far undetected leaks on mains can be added. Leakage and overflows at storage tanks are usually known and can be quantified Leakage on service connections up to point of customer metering. By deducting mains leakage and storage tank leakage from the total volume of real losses, the approximate quantity of service connection leakage can be calculated. This volume of leakage includes reported and repaired service connection leaks as well as hidden (so far unknown) leaks and background losses from service connections (Shilehwa, 2012). Although the water balance is an important tool for understanding inflows, consumption, and losses, the general lack of data leads to problems.

"Data gaps make it difficult to quantify commercial losses and to pinpoint the nature and location of physical losses" (Shilehwa, 2012). However, it always has to be kept in mind that the water balance might have errors and thus the real losses are verified by either of the following two methodologies (i) Component analysis and (ii) Bottom-up real loss assessment. With Component Analysis, Liemberger and Farley (2005), lists the key data required for a real loss component analysis of a water distribution system as; Total length of pipe network and number of service connections, average service connection length between curb-stop and customer meter, total number of distribution mains repairs per year (reported and unreported) and total number of service connection repairs per year (reported and unreported). The others are; Average system pressure across the entire network, estimates of the time periods for awareness, location and repair duration and estimates of utility storage tank leaks and overflows. Calculation of losses from reported and unreported bursts; reported bursts are those events that are brought to the attention of the water utility by the general public or the water utility's own staff. A burst or a leak that under normal conditions manifests itself at the surface will normally be reported to the water utility. Unreported bursts are those that are located by leak detection teams as part of their normal everyday active leakage control duties. After collecting the annual numbers of reported bursts on mains and service connections, flow rates and durations have to be established in cases where the utility has not investigated average leak flow rates. Total annual volume of leakage from mains = Number of reported bursts x Average leak flow rate x Average leak duration (Liemberger and Farley, 2005).

After calculating the volume of reported and unreported bursts, estimates for background losses and excess losses (current undetected leaks) are added. Background losses are individual events (i.e. small leaks and weeping joints) that flow at rates too low for detection by an active leak detection survey. They are finally detected either by chance or after they have worsened to the point that an active leak detection survey can discover them. Excess Losses = Physical losses from water balance - known physical loss components. The volume of excess losses represents the quantity of water lost by leaks that are not being detected and repaired with the leakage control policy in existence (Liemberger and Farley, 2005).

On the other hand there is Bottom-up Real Loss Assessment. This includes 24 Hour Zone Measurements; Working on the assumption that no DMAs are established, areas of the distribution network are selected which are temporarily isolated and supplied from one or two inflow points only. Suitable areas are selected in various parts of the distribution system, with the objective of obtaining a representative sample of the system. In these areas, 24 hour inflow measurements are carried out with portable flow measurement devices. The flow measurements are always done along with pressure measurements where pressures are recorded at the zone inlet point(s), at the average pressure point and at the critical pressure point. Generally the more the amount of water lost in bursts and leaks, the lesser the water sale and the higher the nonrevenue water (Liemberger and Farley, 2005).

2.7 Theoretical framework

This study was modelled on the theory of water balance advanced by International Water Association (IWA). The theory has been used widely in the water sector and recommended by WASREB the WSP regulating body in Kenya. The theory is also included in the Standard NRW Manual for Kenya's 77 WSPs. The theory postulates that system water input is divided into two components namely authorized consumption and Water losses. The theory further breaks down authorized consumption into billed authorized consumption and unbilled authorized consumption. Water losses are divided into apparent (commercial) losses and real losses. The theory further suggests for billed authorized consumption to be revenue water while the total sum of unbilled authorized consumption, apparent losses and real losses to form non-revenue water. This theory is part of the study for factors influencing NRW Kimilili water supply, Bungoma County.

2.8 Conceptual Frame Work

This study had two main variables as illustrated in the conceptual framework (Figure 2.1), which shows independent and dependent variables. The independent variable was broken into sub-variables mechanical condition of water meters, unmetered connections, customer base and water bursts and leak while dependent variable is non-revenue water. The level of non-revenue water was expressed as percentage of water loss against water supplied indicating water loss.

Independent Variable **Moderating Variable** **Dependent Variable**

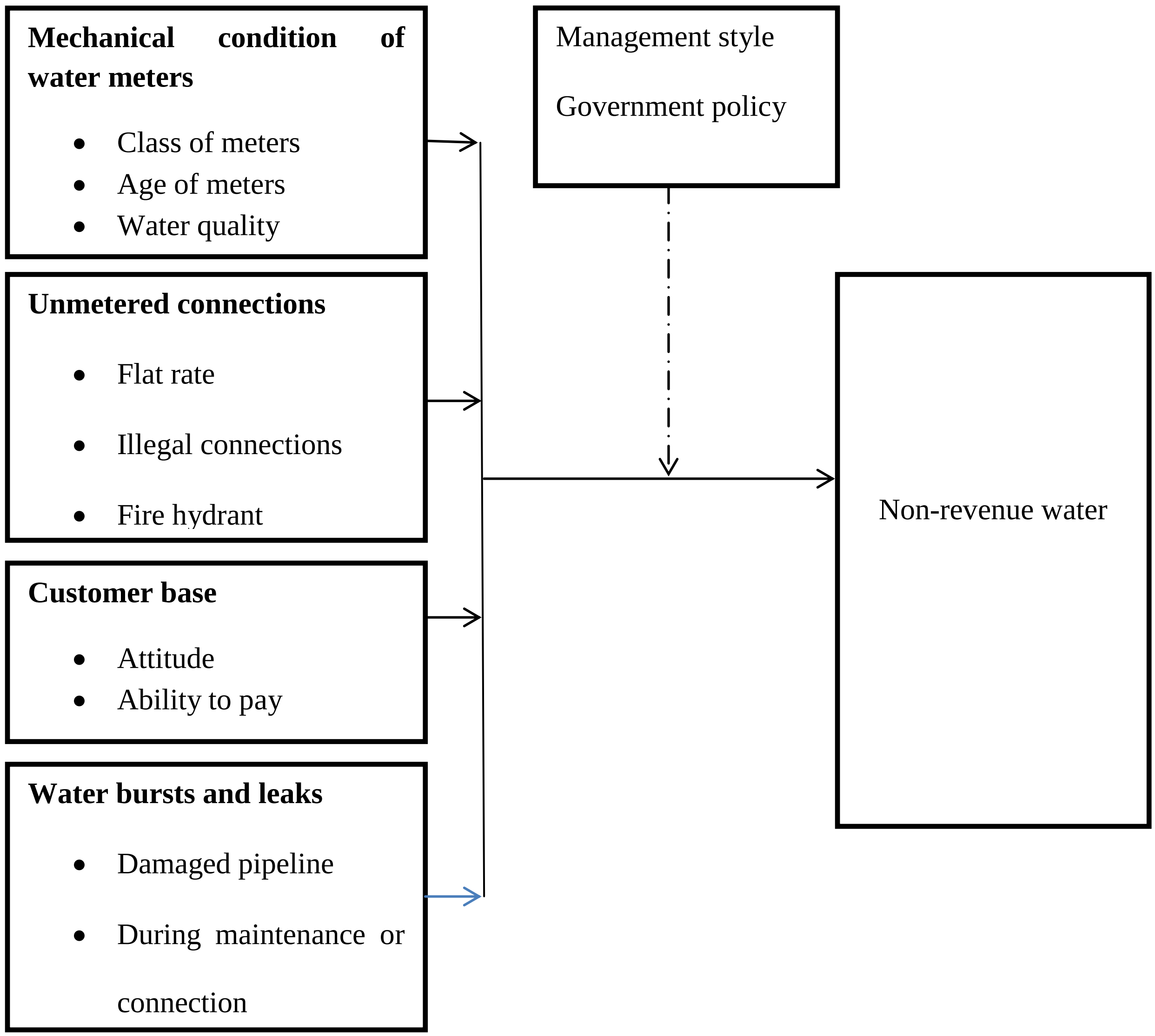

Figure 2.1: Source: Author (2015)

2.9 Knowledge gap

The knowledge gap of this research study was based on analytical gap. There was need to determine the indicators level of influence on non-revenue water in Kimilili water supply in order to determine which one had more influence. The research study knowledge gap also was knowledge based as there is little analysis on the influence of the customer base attitude and paying ability on non-revenue water. There is need for Kimilili water supply to develop non-revenue water (NRW) strategy as per the manual developed and launched in 2013 by the Ministry of Environment, Water and Natural Resources. In order for WSP to develop NRW strategy, there was the need to study and establish in-depth the current indicators to be able to develop workable strategies. The missing management focus involves establishing and maintaining an effective NRW program is, besides all other difficulties, a managerial problem. Physical loss reduction is an ongoing, meticulous activity with few supporters among the following: (a) Politicians: there is no “ribbon cutting” involved. (b) Engineers: it is more “fun” to design treatment plants than to fix pipes buried under the road. (c) Technicians and field staff: detection is done primarily at night, and pipe repairs often require working in hazardous traffic conditions. (d) Managers: it needs time, constant dedication, staff, and up-front funding.

Nor is the reduction of commercial losses very popular among the following: (a) Politicians: unpopular decisions might have to be made (disconnection of illegal consumers or customers who don’t pay). (b) Meter readers: fraudulent practices might generate a substantial additional income. (c) Field staff: working on detecting illegal connections or on suspending service for those who don’t pay their bills is unpopular and can even be dangerous. (d) Managers: it is easier to close any revenue gap by just spending less on asset rehabilitation (letting the system slowly deteriorate) or asking the government for more money. Except for those customers who do pay their bills, it might appear that there is no support from any party.

Given this situation, a utility manager trying to establish an NRW program to reduce high levels of losses may face frustrating responses from his or her own staff and from the utility owners. Engineers and operational staff will assure him or her that the levels relate solely to commercial losses (that is, there is no leakage problem), while the commercial staff will say that it is all leakage.

WSP have different challenges which makes it impossible to automatically apply solutions from one WSP to another. The study established the factors influencing non-revenue water for Kimilili water supply which the Company can use to develop NRW strategy and attract funding from donors who have partnered with the GOK.

2.10 Summary of literature Reviewed

The literature review looked at mechanical conditions of water meters and non-revenue water. It can be seen that the mechanical condition of water meters can either under register, over register, fail to register or register correct readings. Also unmetered connections and non-revenue water was reviewed and it can be noted that unmetered connection does not give clear indication of water sale since it's not captured and could have impact on NRW level. Customer base and base non-revenue water was also review and it can be said that the number, ability to pay and attitude may have influence on NRW. Finally on water bursts and leaks and non-revenue water, we note that when data is captured properly and results acted upon through developed strategies the may influence NRW level.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

This chapter outlines the Research methodology that was used in the research study. It describes the research design, target population, sample design and size, data collection methods, instruments validity and reliability, data collection procedures and data analysis techniques.

3.2 Research Design

This study was conducted through descriptive survey research design. This design is most preferred when conducting research study to a large population since it allows generalization of results of the research sample to the larger target population. The research was to establish the influence and relationship of mechanical condition of water meters, unmetered connections, customer base and water bursts and leaks on non-revenue water without any manipulation. The research also describes and explains the factors as they were. Descriptive research design involves describing the characteristics of a particular individual, or a group. Descriptive research includes surveys and fact-finding inquiries of different kinds. This research design is applicable whereby the person conducting the research has no control over variables can only report what is happening and what has happened. The research study involves the use of questionnaires and interview guide to gather information (Kothari, 2004).

3.3 Target Population

The target population consisted of 2,136 registered customers under the Kimilili water supply and 27 water supply staff. The registered customers were categorised as Domestic, Institutions, Commercial and Kiosks. Target population includes all members of a real or hypothetical set of people, events or objects to which researchers wish to generalize the results of their research. It's the totality of cases of people, organization, or institutions which possess a certain common characteristics that is relevant to the study (Borg, Gall J. & Gall M., 2007).

The water supply had 2,136 registered customers as at 31st December, 2014 Nzoia Water Services Company Ltd. monthly report spread over Mt. Elgon District - Kamtiong area (Mt. Elgon Constituency), Bungoma East District - Lugulu, Misikhu areas (Webuye East Constituency & Webuye West Constituency) and Kimilili District – Bahai, Bituyu, Kamusinga areas (Kimilili Constituency) all in Bungoma County, Kenya. Staffs working under Kimilili Water Supply were twenty three and four make up the administration team. The staff were categorised as belonging to either commercial and finance section or technical section.

3.4 Sample Size and Sampling procedure

3.4.1 Sample size

This research study adopted the formula by Cochran (1963) to determine the sample size of household consumers at 7% level of significance as follows:

$$; n = \frac{N}{[1 + N(e^2)]}$$

Whereby n is the sample size

N is the target population (no of household consumers) =2,136

e is the level of significance = 0.07

$$\frac{2{,}136}{[1 + 2{,}136 * 0.07^2]} = 186\ \textit{Kimilili watersupply customers}$$

Systematic sampling was applied to the domestic stratum, whereby the targeted respondents were grouped into forty six (46) groups each consisting of thirty four (34) respondents, after which the 10^{th} , 20^{th} and 30^{th} members from each group were elected to form a sample of 138. Tables 3.1 show the respondents representation.

Table 3.1 Proportionate sampling of registered customers with Kimilili Water Supply

Stratum	Population	Sample size
Domestic	1,584	138
Commercial	398	34
Institution	148	13
Kiosks	6	1
Total	**2,136**	**186**

3.4.2 Sampling procedure

This study employed stratified sampling, systematic sampling, simple random sampling and purposive sampling. Sampling is the process by which a relatively small number of individual, object or event is selected and analyzed in order to find out something about the entire population from which it was selected. A sample is a small proportion of targeted population selected using some systematic format (Mugenda, 2008).

Stratified random sampling was used to select the one hundred and eighty six (186) registered customer respondents of Kimilili Water Supply. Stratified random sampling technique is a technique that identifies subgroups in the population and their proportions and select from each subgroup to form sample (Onen D. & Oso W. Y., 2009). It groups a population into separate homogeneous subsets that share similar characteristics and selects from each subgroup so as to ensure equitable representation with a view of accounting for the difference in subgroup characteristics. The customers target population was not uniform. This is because the customers used water for different purposes including domestic, commercial business, water kiosks and institutions and all this strata had different water tariff structures as per the 2010 gazette notice stated. Stratified random sampling technique was therefore used to ensure that the target population was divided into different homogenous strata and that each stratum was represented in the sample proportion equivalent to its size in the population. This ensured that each strata characteristic was represented in the sample thus raising the external validity of the study.

Systematic sampling was used to select the respondents under domestic category because it was easier and cheap to implement and respondents group were relatively wide. Simple random sampling was used to select respondents under institution, kiosks and commercial strata to avoid bias. This method also ensured each member has equal opportunity and independent chance of being included in the sample. Purposive sampling technique was used to select two (2) staff of Kimilili Water Supply and two key informants from the Administration (one from both commercial and technical sections). Purposive sampling was used to select who to include in sample based on their typicality in order to collect focused information. According to Airy et al (1972), a sample of 10 percent to 20 percent is acceptable, thus from a population of twenty seven (27) total staff, the research will work with a sample of 4 respondents representing 14.81 percent of the total staff population to avoid the biasness associated with small samples which tend not to be representative (Mugenda and Mugenda, 1999). Hence two from administration team and two from the staff list were interviewed.

3.5 Research instruments

Primary data was collected using questionnaires and interview guide. Secondary data was collected through document review and analysis. The selection for these tools was guided by the nature of data to be collected, time available as well as the objectives of the study. The overall aim of the study was to investigate the factors influencing non-revenue water in Kimilili water supply, Bungoma County, Kenya. According to Onen (2009) and Kothari (2004), descriptive research design employs observation, questionnaires, interview, examination of records and focus group discussions tools for collecting data. Questionnaires was used to collect data from the registered customer respondents while an interview guide was used to collect data from the water supply administration team and staff.

The questionnaire is a convenient tool especially where there are large numbers of respondents to be handled because it facilitates easy and quick derivation of information within a short time (Onen, 2009). The questionnaire included structured questions for closed-ended question and a few open ended questions. These types of questions were accompanied by a list of possible alternatives from which respondents are required to select the answer that best describes their situation. The main advantage of close ended questions is that they are easier to analyse since they are in an immediate usable form. They are also easy to administer because each item is followed by an alternative answers and is economical to use in terms of time saving. The questionnaire was arranged into five sections; section one dealing with general information, section two focusing on mechanical condition of water meters, section three to deal with unmetered connections, section four capturing information on customer base and finally section five capturing water bursts and leaks.

Personal interviews were employed to collect data from two key administration informants and the two staff of Kimilili water supply. This method was preferred because it allows face to face contact with the respondent and obtains in-depth information. Also it allows one to obtain information that can't be directly observed, gain the control over the line of questioning and to obtain historical information (Onen, 2009).

Document review is critical examination of public or private recorded information related to the issues under investigation Onen (2009). Document review list was used in the study to access past characteristics of non-revenue water levels, connected active water service users over a given period, illegal consumption cases, metering levels, dormant accounts, disconnection and reconnection rates, classes of meters used, water bursts and leaks records, maintenance schedules, pipeline characteristic and meter registration accuracy.

3.5.1 Piloting of the research instruments

Pretesting of the research instruments was done to establish the validity and reliability. This involved administering the research instruments to respondents at two separate times to determine the instruments' consistency hence reliability. This was done in one week's interval in Webuye water supply area to 10 respondents outside the study area. Pre testing involved testing the correctness of the research instruments through the research supervisor and research experts in order to ascertain correctness.

Pretesting of instruments was done to help in determining the appropriate data analysis techniques, to be familiar with the research site and to improve on the measurement scale. Pilot study as part of the pre testing procedure can be done within the study area but the subjects should not be part of the research study or can be done outside the study area. Pretesting assisted to plan well as it was possible to determine the time taken by the respondent on each research instrument.

3.5.2 Validity of the instruments

Validity refers to the degree to which results obtained from analysis of the data actually represent the phenomenon under study (Mugenda, 2008). The question of validity is raised in the context of the form of the test, the purpose of the test and the target population. Fraenkel, J.R and Wallen, F.N (2000), defines validity as the accuracy, soundness or effectiveness with which an instrument measures what it is purported to measure. It is the degrees to which results obtained from the analysis of data actually represent the phenomenon under study. The researcher assessed content validity by consulting five research experts including the supervisor, two professional experts and two peers to ensure that the instrument measured what it was intended to measure. The recommendations of the supervisor, research experts and peers was considered and incorporated in the final instrument.

3.5.3 Reliability of the instruments

Reliability is the degree to which a test consistently measures whatever it measures (Mugenda, 2008). Reliability is the ability to consistently yield the same results when repeated measurements are taken under the same conditions. Test– retest method was employed in the research study to ensure reliability of the research instruments and that the research instruments yield consistent results, pre-testing through piloting was done. This involved administering the research instruments to 10 respondents from Webuye Water Supply which was outside the study area at two separate times (one week's interval) to determine the instruments' reliability. Pearson product moment formula was used to calculate the reliability of the instrument, hence calculating the correlation coefficient to establish the relationship between the two sets of scores. A correlation coefficient (r) of +0.78 was obtained from the calculation. According to Kerlinger (1986), a correlation coefficient of at least 0.5 is considered high enough for the instrument to be used for the study. Thus the instrument (questionnaire) was used for the study.

3.6 Data collection method

The primary data for this study was obtained through questionnaires and interviews. The questionnaires were administered on sampled registered active water consumers served by Kimilili Water Supply 186. Meter readers guided the two research assistants since they understood the areas better. The interview guide was administered by the researcher personally on two members of the Administration team and two staff of Kimilili Water supply. The guide had four parts including mechanical condition of water meters, unmetered connections, customer base and water bursts and leaks.

The secondary data for this study was obtained by the researcher personally through document review on quarterly reports, annual reports, WASAN billing software, WARIS report and performance reports. The data reviewed included customer connections history, debts history, metering history, water bursts and leaks, maintenance programme, history of disconnections and reconnection rates, class/types of meters used, age of meters and illegal consumption records.

3.7 Data Analysis technique

Data analysis refer to systemic organization and synthesis of research data in order to gain information pertinent to a given research question. The returned questionnaires were checked for completeness and consistent answers before leaving the respondents. This step entailed close checking of the questionnaire items in order to identify the ones which have been left blank or incomplete, the legibility and any items wrongly responded to. Data was then coded to reduce the number of responses to classes and then classified according to the items in the questionnaire parts.

Non-revenue water MIS software developed by Vitens Evides International and launched in 2014 for WSPs to analyse and monitor NRW was used to analyse the correct non-revenue water values and the influence of the variables. The quantitative data generated was subjected to the descriptive statistics feature in IBM SPSS Version 20 to generate information which was presented using frequency and percentage tables. Correlation analysis between the dependent and independent variables was conducted to deduce their relationship. This facilitated the description and explanation of the findings of the study, of which conclusions were drawn and recommendations made based on the research findings.

3.8 Ethical Considerations

The research study had major concerns on informed consent, privacy and confidentiality, anonymity and researcher's responsibility. In this research study, the researcher sought permission to carry out the research from the National Council of Science, Technology and Innovation (NACOSTI), and Kimilili Water Supply through Management of Nzoia Water Services Company. The research process obtained informed consent from respondents and concerned authority before collecting data. More so, the research study kept all the information confidential and private to restrain inflicting psychological harm to the respondents. The study did not use names neither disclose Kimilili Water Supply's information obtained for any other purpose than academic research. Transmittal letter was used to seek consent of respondents. This was done by visiting the respondents and making appointments especially for the institutions like schools, hotels, hospitals and large business premises.

3.9 Operationalization of variables

The variables considered in this research study were two (dependent and independent). The dependent variable was non-revenue water (NRW), while independent variables were mechanical condition of water meters, unmetered connections, customer base and water bursts and leaks. The variables in this study were measured by use of nominal, ordinal and ratio scales .The measurement of the various variables in this study undertaken as shown in Table 3.2

Table 3.2 Operational definition of variables

Objectives	Variables Independent	Indicators	Measurement	Measurement scale
To assess the extent to which mechanical conditions of water meters influence non-revenue water in Kimilili water supply, Bungoma County.	Mechanical conditions of water meters	Class of meters	Type of meter used Durability Life span in field	Ordinal
		Age of meters	Years of usage Serviceability	Ordinal
To establish how unmetered connections influence non-revenue water in Kimilili water supply, Bungoma County.	Unmetered connections	Flat rate	Number Period	Nominal Ordinal
		Illegal connections	Number of illegal connections. Duration of existence Methods used Estimated consumption	Nominal Ordinal
		Fire hydrants	Number Estimate consumption	Nominal Ordinal

To examine how customer base influence non-revenue water in Kimilili water supply, Bungoma County.	Customer base	Attitude		Nominal
		Paying ability		Ordinal
To establish the extent to which water bursts and leaks influence non-revenue water in Kimilili water supply, Bungoma County.	Water bursts and leaks	Damaged pipeline	Causes	Nominal
			Number of repairs	Ordinal
			Frequency of repairs	Ordinal
		During connection or maintenance	Quantity of water loss	Ordinal
			Hours of connection or repair	
	Dependent Non-revenue water	Percentage of the volume of water unbilled to volume of water pumped into the distribution system		Ratio

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS, INTERPRETATION AND DISCUSSIONS

4.1 Introduction

This study investigated the factors influencing non-revenue water in Kimilili Water Supply, Bungoma County, Kenya. With the view of reducing water loss and improving efficiency, the study examined the influence of mechanical condition of water meters, unmetered connections, customer base and water bursts and leaks on non-revenue water. This was in the light of addressing the high level of non-revenue water (NRW) attributed to have direct impact on the financial sustainability of water utilities and service delivery to customers. The data collected was analyzed using tables, NRW MIS developed in 2014 by Vitens Evides International and IBM SPSS statistics Version 20. This chapter presents the results of the analysis and interpretation. Raw data was analyzed according to the objectives of the study.

4.2 Response Rate

The research study targeted total of 186 customer respondents' and four (4) from the Kimilili water supply categorized as two (2) from the administration team and two (2) staff. The response rate of the sampled administration and staff was 100% while from the customers was 80.12%. The research involved physically visiting the customer connections. The connection numbers are labelled at customer points which made it easier for confirmation and identification. The questionnaires administered to the customers of the water supply had the following return rates presented in Tables 4.1:

Table 4.1: Distribution of respondents

Category	Sample size	Respondents	Percentage Response	Frequency	Percentage of total
Domestic	138	108	78.26	108	72
Commercial	34	27	79.4	27	18
Institution	13	13	100	13	9
Kiosk	1	1	100	1	1
Total	**186**	**149**	**80.12**	**149**	**100**

According to Mugenda and Mugenda (1999), a response rate of 50% and above is adequate for analysis and reporting. The successes to high response rate by the customers were accredited to the proper field preparation done by the researcher and the two assistants, the ease of accessing the respondents through the support of five meter readers from Kimilili Water Supply and the easy identification of the connections since they were labeled at consumer points.

4.3 Demographic characteristics of the respondents

This section shows the respondent’s background information. The demographic characteristics of respondents on gender, age distribution and beneficiaries are presented in Tables 4.2 and 4.3

4.3.1 Respondents gender and age

The study sought to establish the respondents age and gender. The findings are presented in Table 4.2

Table 4.2: Gender and Age of customers' respondents

	Gender		**Age**		
	Male	**Female**	**18-35**	**36-55**	**Above 56**
Domestic	36	72	23	66	19
Commercial	12	15	5	16	6
Institution	7	6	3	10	
Kiosk	1				1
Percentages	37.58	62.42	20.81	61.74	17.45
Total	**56**	**93**	**31**	**92**	**26**

Table 4.2 shows that most respondents were female 62.42% while the male were 37.58%. Most respondents were women because most of them were found at residential places day time either tilling at the farm or while carrying out domestic chores. Dominant age group was 36 – 55 years mainly because this age group is well expected to be settled with families and developing infrastructures and investing well in real estates, projects and individual homes.

4.3.2 Number of beneficiaries of water connections

The study also sought to establish the number of beneficiaries of the water connections. The findings are presented in Table 4.3.

Table 4.3: water connection beneficiaries

Beneficiaries / Category	<5	5-10	10 - 20	20-100	> 100	Total
Domestic	49	44	15			108
Commercial			6	19	2	27
Institution			2	3	8	13
Kiosk				1		1
Percentages	32.89	29.53	15.44	15.44	6.7	100
Total	**49**	**44**	**23**	**23**	**10**	

The result in table 4.3 implies that most beneficiaries fall within the domestic category mainly representing the family unit both nuclear and extended. Where the beneficiaries were greater than 10 for domestic connections, it was noted mainly connections serving several tenants. Commercial institution serving greater than 20 people were the hotels, petrol stations, carwash and supermarkets while institutions were the schools, Non-Governmental Organizations, Government institutions and hospitals.

4.4 Mechanical conditions of water meters and non-revenue water in Kimilili Water Supply, Bungoma County, Kenya.

The first objective of this study was to assess the extent to which mechanical conditions of water meters influence non-revenue water in Kimilili water supply, Bungoma County. To achieve this objective the customers were asked to react to several statements intended to describe the status of their connection water meters' if any, history of installed meters, age of their water meters, class of water meters and water quality. Data collected was analyzed under the question how does mechanical condition of water meters influence non-revenue water in Kimilili water supply, Bungoma County? This section therefore presents findings on the relationship between mechanical condition of water meters and non-revenue water. Metered connections found on ground were 92.6% while unmetered connections were 7.4%. All customer connections under commercial, institutions and water kiosk were found with meters while domestic connections eleven (11) were found to have no meters on site. 79.2% had actual bills while 20.8% had estimated bills.

4.4.1 Class of water meters

The study sought to establish the various classes of water meters available within Kimilili water Supply. The results of meter class is summarized in table 4.4

Table 4.4: Class of water meters

Meter class	Frequency	Percentage
B (10 bars)	57	38.3
C (16 bars)	92	61.7
Total	**149**	**100**

Table 4.4 shows that there are two classes of meters in Kimilili Water Supply that were found on ground. Class C being the majority accounting for 61.7 % while Class B 38.3%. Initial water meters installation was done by contractors under programme funded by

World Bank and meters were purchased by Lake Victoria North Water Services Board. The company policy to provide water meters started in 2009. This has led to several meters being Class C though the consignment from LVNWSB was still being issued. According to AWWA (2013), the higher the pressures the meter can hold the safer as it will safeguard against unpredicted surges and un-predetermined pressure fluctuations

4.4.2 The age of water meters

The study sought to establish the age of water meters. Age of the water meters standing for the number of years each individual water meter has been working at customer point since the first day of installation. The findings are presented in Table 4.5

Table 4.5: Age of Customer Water Meters

Meter age yrs.	**Category of customer**				**Totals**	**Percentage**
	Domestic	Commercial	Institution	Kiosk		
0-1	12	6	2		20	13%
1 to 2	20	1			21	14%
2 to 3	16			1	17	11%
>3	60	20	11		91	61%
Total	108	27	13	1	149	100%

In Table 4.5 it can be noted that most meters found on ground were older than three years onsite making up 61% of the totals while less than 3 years were 39% found on site. This indicates that most customers are having old connections with the Kimilili Water Supply and have been beneficiaries for long. The old water treatment plant was commissioned in 1972. Rehabilitation, expansion and construction of new treatment plant started in 2010 and were completed in 2015. Table 4.6 summarizes the details on meter class and meter readings. AWWA (2013) recommends that meters should be replaced with age above three years though routine meter testing programme since meter accuracies deteriorate with age and lead to inaccurate meter readings.

4.4.3 Combined data on the meter class, water meter age and meter readings and effects on meter readings

The study also sought to establish jointly and compare the influence of water meter age and class on water meter readings. The findings are presented in Table 4.6.

Table 4.6: Combined results for meter class, meter age and meter readings

Meters age	**Frequency**	**Estimates**		**Total Estimates**	**Actuals**		**Total Actuals**
		Class B	**Class C**		**Class B**	**Class C**	
0 to 1	20	0		1	3	16	19
1 to 2	21	2	2	3	7	11	18
2 to 3	17	3	1	4	4	9	13
>3	91	22	1	23	16	52	68
Total	**149**	**27**	**4**	**31**	**30**	**88**	**118**

Analyses in table 4.6, it can be inferred that Class C meter give more actual accurate readings (74.57%) as compared to Class B meters (20.13%). It can also be noted that meters tend not to function well with age leading to estimate especially after 3 years. Interview response and document review indicated mechanical condition of water meters was determined by 88% physical examination during meter servicing and 12% carrying out simple volumetric tests on site. Faulty meters are repaired by replacing the faulty parts e.g. the counter/gears or replaced with new ones. New meters are not calibrated before installation. There was no programme to calibrate existing water meters. Pressure monitors were installed on pipelines network and information downloaded into computers. Mean water turbidity was 23 NTU. Meter testing was being done at Eldoret Water Sanitation Company ISO credited laboratory or Kenya Bureau Standards Kisumu Laboratory for large meters above 1½" using stationery meter testing bench while small size meters ½" to 1" are tested using fabricated meter testing bench and simple volumetric test on site. This is in agreement with AWWA (2013) that meters estimate with age.

The study therefore established that mechanical condition of water meter affect non-revenue water. This means that poor mechanical condition of meters increases the non-revenue water in the sense that failure for the meter registration to be accurate then the connections are estimated. The water supply can reduce its non-revenue water by improving the mechanical condition of the water meters. This is in terms of improved water quality to meet standards of less than 5NTU recommended by World Health Organization (WHO) and Kenya Bureau Standard (KEBS), water meter replacement with regard age considering meter life span and using recommended meter class depending on the water pressures. Lambert (2010), Shilehwa (2012) and AWWA (2013) confers that water meters should be replaced with age though proper routine meter testing programme and under-registration results in lower billing and loss of potential revenue while at the same time erroneously indicating an increased level of water lost from the system.

4.5 Unmetered connections and non-revenue water in Kimilili Water Supply, Bungoma County, Kenya

The second objective was to establish whether unmetered connections influence non-revenue water in Kimilili water supply, Bungoma County. To achieve this objective, respondent were asked to respond to several statements intended to describe the true status of their connections. Unmetered connections were described in form of unbilled authorized and authorized water consumption. Data collected was analyzed under the question to what extent do unmetered connections influence non-revenue water in Kimilili water supply, Bungoma County? This section therefore presents findings on the relationship between unmetered connections and non-revenue water. The study looked at flat rate connections, fire hydrants and illegal connections as some of the factors. Fire hydrants were established to be four (4) and were installed under World Bank project but have not been commissioned yet therefore not in use. It can be inferred that fire hydrants have no influence on non-revenue water in Kimilili Water Supply.

4.5.1 The number of unmetered connections

This research established the number of unmetered connections with regard to flat rates and illegal connections. The results of unmetered connections were summarized in table 4.7

Table 4.7: Unmetered connections

	Factor	Frequency	Percentage
1.	**Flat rates**		
	Domestic	11	7.38
2.	**Illegal connections**		
	Domestic	32	21
	Commercial	8	5
	Institution	3	2
	Kiosk	0	0
	Total	**43**	**35.38**

From the results in table 4.7 it can be noted that only domestic connections had flat rate connections and highest number of illegal connections. It means that the institutions, kiosk and commercial categories receive numerous routine visits even from senior staff hence anomalies are easily spotted and rectified. Information gathered from interview with staff and administration is that the domestic connections are sorely within the mandate of the meter readers while the institutions usually attract other parties because of the ties with general public and high revenue obtained from them. Kiosks target the poor hence attract close monitoring. This concurs with GIZ & SNV (2014) report which states that the utility's billing department should use water tracking monthly and customer spot-checks should be enhanced randomly to avoid routine practices that customers are accustomed to.

4.5.2 The reasons established for flat rate connections at customer points

The study also sought to establish the reasons why some connections had flat rate connections or had no water meters on site. The data was collected in this regard, analyzed and presented as shown in Table 4.8.

Table 4.8: Reason for lack of meter on site

Unmetered connections	**Flat rate installation**	**Arrangement with staff**	**Total**
Domestic Connections	9	2	11
Percentage	**81.82**	**18.18**	**100**

The results in table 4.8 suggest that most unmetered connections were flat rate connections which lead to estimation of consumption on the lower minimum of $6M^3$ paying Kshs 271 per month. Flat rates are billed on the minimum charges and consumption and are bound for misuse and negligence. This is in agreement with MEWNR (2014), report which indicated that all connections of flat rate contribute to non-revenue water and that they should be metered to be able to obtain actual billed amount in M^3 and Kshs since utilities are sustained by billed amount and pay levies to Water Resources Management Authority, Water Service Board based on billed amount. Water Research Foundation, (2014) agrees that all customer connections have to be metered in order to charge customers for what they use.

4.5.3 The water connections and whether all their water usage are metered

The study also sought to establish if all water usage by consumers were fully metered. The data was collected in this regard, analyzed and presented as shown in Table 4.9

Table 4.9: Connections and their water usage metered

Category		**Frequency**	**Percentage**
Domestic	Yes	76	51
	No	32	21.48
Commercial	Yes	19	12.75
	No	8	5.37
Institution	Yes	10	6.71
	No	3	2.01
Kiosk	Yes	1	0.67
Total	**Yes**	**106**	**71.14**
	No	**43**	**28.86**

The results in table 4.9 suggest that most connections had all their water passing though the meter making up 71.18%. The other 28.86% connections had some of their water connections unmetered hence their water bills were not accurate. The estimates signify relationship with non-revenue water since the water within connections whose water is not fully captured is water loss within the system. UN (2011) report on The Millennium Development Goals concurs with above results as it states that more 20% of customers in Sub-Sahara countries have illegal water consumption identified and unidentified which accounts for huge water loss.

4.5.4 The reasons why not all water usage are not captured

The study also sought to establish the reasons not all water consumption by customers are not captured through water meters. The data was collected in this regard, analyzed and presented as shown in Table 4.10

Table 4.10: Reason that not all water usage is metered

Factor	Frequency	Percentage
Illegal tapping	36	83.72
Improper connection	7	16.28
	43	**100**

The results in table 4.10 suggest that illegal tapings explains the water that is unmetered. Interview with staff suggested that most illegal tapings were deliberate efforts to escape genuine water bills. Private plumbers also lure customers into malpractice to evade genuine water bills. The findings were similar to a study carried out by Water Services Regulatory Board (2012), on reasons that not all water consumption is captured which indicated that illegal tapping's were observed to be the greatest challenge facing the non-revenue water and the main reason why most of water usage is not fully captured.

4.5.5 The mode of illegal water use

The study also sought to establish the main methods used by customers to obtain illegal water. The data was collected in this regard, analyzed and presented as shown in Table 4.11

Table 4.11: Mode of illegal water use

Factor	Frequency	Percentage
Illegal tapping of water	16	37.20
Bypassing water before meter	9	20.93
Self-turn on after disconnection	5	11.63
Illegal Private plumbers masquerading as staff	10	23.26
Meter removal	3	6.98
Total	**43**	**100**

The results in Table 4.11 suggest that illegal tapping and bypass account for most of illegal mode of water use. Illegal plumbers who pose as company staff were identified as staff who had worked as casuals and were laid off and students on attachments. The findings were similar to a study carried out by GIZ & SNV (2013), on the method of illegal water usage which indicated that illegal tapping of water, bypass before meter and private plumbers masquerading as staffs were the main factors related to illegal connections. World Bank, (2010) and OFWAT (2008) both states that major mode for illegal use are due to poor monitoring practices of customers and field staff leading to high rate of illegal tapping of water and growth of private plumbing works.

4.5.6 Causes of illegal connections

The study also sought to establish the main causes of illegal water usage. The data was collected in this regard, analyzed and presented as shown in Table 4.12

Table 4.12: Causes of illegal connections

	Frequency	**Percentage**
Corrupt staff	42	28.19%
Private plumbing	65	43.62%
Slow connection process	10	6.71%
High tariff	32	21.48%
Total	**149**	**100.00%**

The results in table 4.12 suggest that private plumbing is the major cause of illegal connection. From the interviews it was suggested that there are several technical institutions within hence there alumni of this institutions are part of the private plumbers. This is in agreement with WASREB (2013), report which cautions water utilities against high rate on non-revenue due to private plumber and corrupt staff and insists that staff and the general public should be sensitized. This is also in agreement with Farley (2013), whose findings on no-revenue water international best practice indicated that private plumbers earn their living through connecting customers illegally by luring customers that they shall evade monthly bill payment hence demand heft bribes from them.

The study therefore established that unmetered connections affect non-revenue water in relation to flat rates and illegal connections. This means that water loss through illegal connections and flat rates increases the non-revenue water. The water supply can reduce its non-revenue water by ensuring that all flat rate connections are metered and illegal connections unearthed, regularized and metered. This concurs with WRC (2012) which advised that utilities should identify mechanisms to handle illegal water use. This finding also is in agreement with Ministry of Environment Water and Natural Resources (2014) research stating that "A non-paying customer is a customer that hurts the utility's bottom line and other customers in the long run". Unmetered connections could be unmetered billed consumptions e.g. consumer flat rates or unbilled unmetered consumption e.g. illegal connections, firefighting equipment usage by the county government fire department (Water Research Report, 2012). Hence Kimilili Water Supply should consider devising friendly harmonious ways of unearthing the illegal connections and regularizing them and ensuring that all customer connections are metered and captured in the system.

Dealing with non-revenue water will also require motivating the staff who are installing some of the illegal connections and also sensitizing the customers to avoid using private plumbers but seek assist from the office. The water supply four fire hydrants were not commissioned yet hence not in operation thus did not influence non-revenue water. The Water Supply should install water meters to capture water utilized at the fire hydrants as a cautionary measure. This will help capture the component of water losses. According to WASREB (2013), unmetered consumption promotes uneconomical water consumption contributing to increases in volumes of non-revenue water.

4.6 Customer base and non-revenue water in Kimilili Water Supply, Bungoma County, Kenya.

The third objective of the research study was to examine whether customer base influence non-revenue water in Kimilili water supply, Bungoma County. To achieve this objective, respondent were asked to respond to several statements intended to describe their attitude towards water services, general attitude towards paying for water services and ability to pay for the water services. Data collected was analyzed under the question to what extent does customer base influence non-revenue water in Kimilili water supply, Bungoma County? This section therefore presents findings on the relationship between customer base and non-revenue water.

4.6.1 Customer water bills payment rate

To determine the perception of the respondents on water bill payment, they were asked to state how frequent they pay their water bills. The responses are summarized in Table 4.13

Table 4.13: Customer water bill payment rate

Water bill payment rate	Frequency	Percentage
Monthly	29	19.5
in two months	31	20.8
Quarterly	1	0.7
Yearly	2	1.3
Not at all	2	1.3
Others	84	56.4
When disconnected	35	23.5
When bills have accumulated	49	32.9
Totals	**149**	**100**

The results of table 4.13 suggest that most customers were not paying bills monthly as required by their contractual agreement. While 80.5% paid at will with 32.9 paying when bills accumulate and 23.5% when disconnected. This suggests that they don't feel the urgency to pay water bills on time not knowing it affects the company operations since the company depends on the paid bills for continual sustenance. These results agree with findings by Jason Lemkim (2010) that attitude affects postpaid services as customers tend to pay later after settling other issues if they don't view as urgent. This is because they may consider it as right or as a normal routine service rendered not necessarily being bad service/good offered. WASREB (2012) suggested prepaid water meters as opposed to prepaid services like the communications industry.

4.6.2 Customer income levels

To determine the respondents' income levels, they were asked to state their monthly average incomes. The responses are summarized in Table 4.14

Table 4.14: Customer Income levels

Income Level	Frequency	Percentage
Below Kshs. 5,000	2	1.3
Kshs. 5,000 – 10,000	54	36.2
Kshs. 10,001 – 20,000	25	16.8
Kshs. 20,001 – 50,000	29	19.5
Above Kshs. 50,000	30	20.1
Others	9	6.0
No answer	2	1.3
Not sure	3	2.01
inconsistent	4	2.68
Total	**149**	**100**

Table 4.14 shows the number of respondents per income level. for The main commercial activities are selling of new second hand clothes, hardware, education, health and social welfare. Agricultural produce is sold in open air market stalls. There are a number of small scale/jua kali type industrial activities within town. The customers below Kshs. 10,000 (37.5%) earning per month had arrears and sited high water tariff close to 78% of them. Institutional revenue was within the following ranges 7.69% for Kshs.20, 000 – Kshs. 50,000 (1 No.), 15.38% for Kshs. 50,001 – Kshs. 100,000 (2 No.) and 76.92 for above Kshs. 100,000 (10 No.). High institutional revenue stream turnover of above Kshs. 100,000 is because most of them are schools, hospitals and government institutions accounting for 76.92%. The customer accounts which have ever been

disconnected were 77.85% explaining the attitude towards payment and delay to pay bills. There were 22.15% connections which have never been disconnected at any given time. From document review Government institutions had arrears as they were slow in payment due to bureaucratic procedures from their headquarters in Nairobi. World Bank (2010) estimates customers with earning below a dollar/day can pay bills at 2kshs/20litre.

The study therefore established that customer base in relation to attitude and paying ability affect the non-revenue water. This means that the Kimilili water supply can reduce non-revenue water by taking into account the customer paying ability within the rural set up in the tariff structure and working on customer perception through improvement in service delivery and sensitization. WASREB (2014), analysis indicate that water supplies with large number of customer base have low non-revenue water. WASREB (2014), analysis report stated that the best performing water service provider (WSP) are those with large number of connections grouped as Very Large WSPs including those with more than 35,000 connections, Large WSPs with 10,000 – 34, 000 connections, Medium WSPs with 5,000-9,999 and finally small WSPs with 1,000 – 4,999 connections . This finding is in agreement with view of Water Research Foundation (2014) who expresses same view. WASREB (2014) and GIZ (2013) also stated that companies with large number of customers have financial stability from the analysis of the monthly reports for all WSPs in Kenya.

4.7 Water bursts and leaks influence on non-revenue water in Kimilili Water Supply, Bungoma County, Kenya.

The fourth and final objective of the research study was to establish the extent to which water bursts and leaks influence non-revenue water in Kimilili water supply, Bungoma County. To achieve this objective, respondent were asked to respond to several statements intended to establish whether the number of bursts and leaks are to the magnitude to actually affect non-revenue water and also to assess the level of responsibility among the public when they come across them. Data collected was analyzed under the question how do water bursts and leaks influence non-revenue water in Kimilili water supply, Bungoma County? The results are summarized in table 4.15

4.7.1 Reported bursts and average water loss

To determine the water lost during water bursts and leakage document analysis and interview with respondents gave the number of bursts and leaks which was used to compute water loss. The responses are summarized in Table 4.15

Table 4.15: Reported bursts and average water loss

Location of Burst	Flow Rate for Reported Bursts [l/hour/m pressure]	Flow Rate for Unreported Bursts [l/hour/m pressure]	Frequency Unreported	Frequency Reported	Total Unreported M^3	Totals Reported M^3	Grand totals M^3
Mains	240	120	10	9	6,600	11,880	18,480
Service Connection	32	32	172	48	30,272	8,448	38,720
Totals							**57,200**

Table 4.15 shows the actual amount of water loss form the reported and unreported water bursts and leaks. The new connections were found to have negligible or minimal water losses since valves are closed before the installation of new connections. 53.69% responded to have ever reported bursts or leaks while 46.31 % indicated to have never reported. 29% indicated not being aware where to report to and 23% were disconnected hence did not bother while 14.5% stated the staff were slow to response. It can be inferred that there is need for staff and customer sensitization on handling visible bursts and leaks. Major cause of bursts and leaks were noted as 30% quality of pipes, 34% class of pipes, 16% depth of trenches and 20% high pressures form the document review on causes of water bursts and leaks. 70% of customers indicated that it took one

day for the staff to carry out repairs, 28% indicated within one hour while 2% indicated it took one month to repair.

50% of customers advised that that quality pipes should be used, 30% advised that pipelines should be depended while 20% advised that there should be speedy repairs of water leaks and bursts. Liemberger and Marin (2006) clarified that utility managers often do not pay enough attention to NRW because of weak internal policies and procedures, which contributes to rising NRW levels. Many utility managers do not have access to information on the entire network, which would enable them to fully understand the nature of NRW and its impact on utility operations, its financial health, and customer satisfaction. Water bursts and leaks can affected non-revenue water to as high as 35% while the other combination of factors can carry up to 40% combined.

This result establishes that water bursts and leaks are water losses which increase the non-revenue water. The mean response time for bursts was found to be 5.5 hours while for leaks was 7 hours. It can be inferred that bursts are attended to much faster because they tend to cause more havoc while leaks are slow hence tend to be attended to much later after the bursts. 90% of the responses' stated that their advice to Kimilili Water Supply was that response time should be beefed up. WASREB recommended response time is 4 hours for bursts and leaks less than 2" (<50 mm ø) and 5 hours for bursts and leaks above 2" (>50mm ø). According to Frauendorfer and Liemberger (2010), the main objective of a water utility is to satisfy customer demand. A high level of NRW has a severe and direct impact on the ability of utilities to meet this objective and therefore has a negative impact on customers. High physical losses often lead to intermittent supply, either because of limited raw water availability or because of water rationing, which may be needed to reduce supply hours (and therefore hours of water leakage) per day. In addition to substandard service, intermittent supply poses a significant health risk, as contaminated groundwater or even sewerage, can enter the leaking pipes during supply interruptions and very low pressure periods. The avoidance of this significant public health risk should be reason enough to reduce leakage to enable continuous supply. Shilehwa (2012) agrees that high leakages also increase flow rates in the pipe network, which can cause unnecessarily high pressure losses that affect customers and often lead to supply interruptions during peak demand hours. Intermittent supply will leave customers unsatisfied, resulting in low willingness to pay for improved service.

"Leaks and bursts occur due to poor quality materials that cannot sustain pressures (pipes, valves and fittings), old dilapidated infrastructure and poor network" (Shilehwa, 2012). Water losses during bursts and leaks can occur due to; damaged pipeline network and storage tanks/reservoirs leading to leaks and bursts on transmission and/or distribution mains, leakage and overflows at storage tanks and reservoirs and leakage on service connections up to consumer meters (Farley, M., Wyeth, G., Ghazali, Z., Istandar, A. & Sher, S., 2008). In the findings the bursts and leaks occurred due to shallowly laid pipeline, poor materials, slow response time, high uncontrolled pressures in the pipeline network and constant sabotage within slums where people cannot afford individual connections hence damage pipelines to obtain free water. WASREB (2014) indicated that water bursts and leaks form huge part of water loses for the water utilities and there should be proper and intensive leak detection programme and response time to bursts should be improved. Water loss during new connection installation was found to have no significant effect to non-revenue water since sluice and gate valves are closed at the time of installations as precautionary measures.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

Chapter five presents a summary of the findings, conclusions, recommendations of the study and suggestions for further studies. The chapter further summarizes the studies contribution to the existing body of knowledge

5.2 Summary of the research findings

The findings of the study are summarized and presented according to the four variables of study namely; mechanical condition of water meters, unmetered connections, customer base and water bursts and leaks. The study utilized a total of 149 respondents out of the targeted sample size of 186, representing 80.11% questionnaire response rate and reaching all the two administration and two staff representing 100% interview response rate.

The first objective was to assess the extent to which mechanical conditions of water meters influence non-revenue water in Kimilili Water Supply, Bungoma County, Kenya. Mechanical condition of water meter; age and class can both cause the water meter stall and not register any water flow or under register total consumption. Data analysis and interpretation of responses from the customer’s questionnaires and interview with the administration and staff and document review revealed that mechanical condition of water meters positively influence non-revenue water. Class C water meters have more actual meter readings represented by 74.58% as compared to Class B with

25.42%. Class C estimate readings are 12.9% as compared to Class B with 87.1% estimated readings. Class C meter can sustain pressure up to 16 bars while Class B can withhold pressure up to 10 bars only. Highest turbidity was 23 NTU meaning meter should be fitted with inbuilt strainers. 61% of meters were found to be above 3 years on ground hence requiring having meter testing and replacement schedule.

The second objective of this study was to establish whether unmetered connections influence non-revenue water in Kimilili water supply, Bungoma County. Data analysis and interpretation of responses from the customers' questionnaires and interview with the administration and staff and document review revealed that unmetered connections influence of non-revenue water. Domestic flats rates make up 7.38%. Illegal connections make up 28 %. Both illegal and flat rates make up 35.38%. There was no operational fire hydrants of the four found on pipeline network. The study discovered that 71.18% of all connection had all their water captured by meters while 28.86 % had uncaptured water usage.

The third objective was to examine whether customer base influence non-revenue water in Kimilili water supply, Bungoma County. Data analysis and interpretation of responses from the customers questionnaires and interview with the administration and staff and document reviews revealed that customer base influence the of non-revenue water. These findings indicate that customer base is significant to non-revenue water. From the study it was found that 19.5% customers paid their bills monthly. Most of the customers 56.4% paid when disconnected and when the bills accumulated. Domestic income levels had varied range from less than Kshs. 5,000 to above Kshs. 50,000. There was evident varying ability to pay. There are 27% of the total connections which are dormant connections for over 6 months due to huge bills as established from the interview with staff and administration and on records. New applications mean was 30 new connections per month. Unpaid bills had cumulated to 8.5M for the Kimilili Water Supply. Disconnection rate was 4.85% per month of the total connections which is quiet high above WASREB recommended 0.01%. Reasons for disconnection from the records suggested 62% was due to inability to pay, 26% was due to attitude and other reasons 2% e.g. disputed of bills of the total disconnected accounts.

The fourth objective was to establish the extent to which water bursts and leaks influence non-revenue water in Kimilili water supply, Bungoma County. Data analysis and interpretation of responses from the customers questionnaires and interview with the administration and staff and document revealed that water bursts and leaks influence the of non-revenue water. Water bursts on mains lost mean of 18, 480 M^3 and on service lines 38,720 M^3 monthly. Mean bursts and leaks repaired monthly equaled to 174. Major cause of bursts and leaks was noted as 30% quality of pipes, 34% class of pipes, 16% depth of trenches and 20% high pressures. Response time established by the study was average 5.5 hours for bursts and 7 hours for the leaks.

5.3 Conclusions of the study

This study investigated factors influencing non-revenue water in Kimilili Water Supply in Bungoma County, Kimilili. The study specifically sought to address the following objectives; to assess the extent to which mechanical conditions of water meters influence non-revenue water in Kimilili water supply, Bungoma County. To establish whether unmetered connections influence non-revenue water in Kimilili water supply, Bungoma County. To examine whether customer base influence non-revenue water in Kimilili water supply, Bungoma County. To establish the extent to which water bursts and leaks influence non-revenue water in Kimilili water supply, Bungoma County. The study sought to answer the following questions; how does mechanical condition of water meters influence non-revenue water in Kimilili water supply, Bungoma County? To what extent do unmetered connections influence non-revenue water in Kimilili water supply, Bungoma County? To what extent does customer base influence non-revenue water in Kimilili water supply, Bungoma County? And finally how do water bursts and leaks influence non-revenue water in Kimilili water supply, Bungoma County? In view of these findings, the study concludes that mechanical conditions of water meters, unmetered connections, customer base and water bursts and leaks were outstanding factors that determined non-revenue water in Kimilili Water Supply.

The study established that water meters functionality deteriorates with age hence a constant programme should be in place to rest the accuracy of meters with age and also a preplacement programme is required to be developed. Meters with age tend to under register the water consumption. It was also established that the water quality affects the functionality of the water meters. Hence there should be improved water treatment process to ensure turbidity is within acceptable limits. The study also found out that the meter class also affects meter registration where Class C was found to be more tolerant to high pressures.

It was concluded from the study findings that unmetered connections have a role to play in the level of non-revenue water. The study established that there were illegal connections which lead to water loss since their consumption is not known and captured in the system. Flat rate connections were also established to influence non-revenue water since they don't capture the actual consumption and were subject to abuse and misuse. It was established that the fire hydrants were not in use hence not affecting non-revenue water. As precautionary measure water meters should be installed at each fire hydrant as it will lead to unaccounted for water by the system hence non-revenue water.

It was concluded from the study findings that customer base has effect on non-revenue water. The study established that ability to pay the water bills and the customer attitude have considerate influence on the bills payment which in return affects the customer base. If customers cannot be able to pay for services offered will be disconnected end up dormant hence reduce customer base. Kimilili water supply should consider having separate water traffic structure for domestic connections, commercial, water kiosks and also the medium level and low level income earners. This cannot also be affected through installing prepaid water waters where one only consumes as per his/her pocket can allow.

It was concluded from the study findings that water bursts and leaks have huge influence on non-revenue water. Improvement on the response time to bursts and leaks will reduce much water loss. The study established that effective leak detection, use of proper pipe materials, sinking of shallow pipeline and construction of water kiosk to cater for the underprivileged will reduce water loss hence reducing non-revenue water.

5.4 Recommendations of the study for policy and practice

Based on the findings of this study, the following recommendations were made;

Firstly, mechanical conditions of water meters influence non-revenue water. In order to reduce the NRW levels at Kimilili Water Supply, the management and staff should develop and implement a NRW reduction strategy at Kimilili Water Supply which should include mechanical condition of water meters. Water meter' class, water quality and age significantly influences mechanical condition of water meters registration accuracy, hence the need of developing aged water meters replacement program besides replacing all class 'B' water meters with class 'C' ones. The company should also adopt use of magnetic water meters as they are more durable and have higher accuracy as compared to displacement water meters and multi-jet velocity water meters the company is using.

Secondly, unmetered water consumption has influence on non-revenue water at Kimilili water supply, thus there is need for management and staff at Kimilili Water Supply to ensure that they meter all unmetered consumer connections and carry out regular servicing and calibration of consumer water meters at Kimilili Water Supply. The management and staff should carry out periodic customer base audit by reconciling office consumer database with field connections. Kimilili Water Supply should sensitize its staff on influence of illegal consumption on the sustainability of the company and its reflection on the integrity of the staffs. Besides carrying out public awareness campaigns against illegal water consumption, the company should also issue an amnesty period for all illegal water users to legalize their consumption failure to which the company should take legal action against all defaulters to be tracked.

Thirdly, customer base has influence on non-revenue water at Kimilili water supply, thus there is need for management and staff at Kimilili Water Supply to ensure that they sensitize the staff under Kimilili Water Supply. The Kimilili Water Supply should also embrace the use of pre-paid meters to reduce on arrears. Kimilili Water Supply also should encourage the customers to enter into a flexible agreement in order to pay in installments as they consume water. Kimilili Water Supply also should consider the water tariff should also take into consideration that Kimilili area is a rural set up.

Fourthly, on the other hand, water bursts and leaks has influence on non-revenue water at Kimilili water supply, thus there is need for management and staff at Kimilili Water Supply to ensure that they carry out repairs on time. There should also be proper measures for leak detection. Kimilili Water Supply should constitute and operationalize a NRW team to oversee and enforce implementation of NRW reduction activities on daily basis at Kimilili Water Supply.

5.5 Contributions to the Body of Knowledge

The contributions made by this study to the body of knowledge are as indicated in table 5.1.

Table 5.1: Contributions to the Body of Knowledge

	Objectives	**Contribution to the body of knowledge**
a.	To assess the extent to which mechanical conditions of water meters influence non-revenue water in Kimilili water supply, Bungoma County.	Improvement on the mechanical conditions of water meters will reduce non-revenue water.
b.	To establish whether unmetered connections influence non-revenue water in Kimilili water supply, Bungoma County.	Metering of all unmetered connections will reduce non-revenue water.
c.	To examine whether customer base influence non-revenue water in Kimilili water supply, Bungoma County.	Improvement of customer base will reduce non-revenue water.
d.	To establish the extent to which water bursts and leaks influence non-revenue water in Kimilili water supply, Bungoma County.	Reduction of water bursts and leaks will reduce non-revenue water.

5.6 Suggestions for further research

The research covered only part of the factors influencing non-revenue water in Kimilili Water Supply, Bungoma County in Kenya; the following areas are suggested for further study;

i.) A research to be carried out in-depth on the on the influence of system pressure on non-revenue water.

ii.) Secondly, research to be carried out on the influence of billing system errors on non-revenue water which is under commercial losses.

ii.) Lastly, it is also suggested that an analysis be carried out on influence of staff attitude on non-revenue water.

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APPENDICES

APPENDIX I: LETTER OF TRANSMITTAL

Theodora Madara

P.O Box 321-50241

Kipkarren River.

Kenya.

Dear Sir/Madam,

REF: REQUEST FOR PARTICIPATION IN RESEARCH STUDY

I am a student studying at the University of Nairobi pursuing Degree in Master of Arts Project Planning and Management. I am carrying out a research project on Factors Influencing the level of Non-Revenue Water Kimilili Water Supply, Bungoma County, Kenya.

I will appreciate if you could kindly take part in the research study. Your identity will be treated with outmost confidentiality and anonymity. Thank you.

Yours faithfully,

Theodora Madara

L50/73528/2014

APPENDIX II: KEY INFORMANTS INTERVIEW GUIDE

INTERVIEW GUIDE FOR KIMILILI WATER SUPPLY ADMINISTRATION TEAM AND STAFF

FACTORS INFLUENCING THE LEVEL OF NON-REVENUE WATER IN KIMILILI WATER SUPPLY, BUNGOMA COUNTY, KENYA	
Part a: General information	**Response**
Instructions	**Tick response if in list provided otherwise clearly write responses**
Interview time and date	
Part b: Mechanical condition of water meters	
1.) How do you determine the water meters mechanical conditions as either appropriate/inappropriate in relation to required standards?	Physical examination Meter testing Volume registration monitoring Customer complaints Age Others………………………….
2.) What action is taken when a meters' mechanical condition has been discovered to have problem?	Repair Remove and replace Ignore Others………………………
3.) What affects the mechanical conditions of customer meter within your water supply area?	Age Type/Class Water quality Water pressure Other specify…………………………
4.) Does your water supply implement a program to test all system meters at regular intervals?	Yes No
5.) Water meters tend to deteriorate with age, resulting in inaccurate readings, do you have meter replacement schedule?	Yes No
6.) Meters may be damaged on site, what are the major causes and how do you handle such water meters?	
7.) Have you experienced meters which do not record water use at all? What could be the reasons and how do you handle those water meters?	
8.) Please give an average number of water meters identified monthly categorically with their mechanical conditions not up to required standards.	
9.) Are metered connections with poor mechanical conditions billed?	Yes No
10.) Which criteria is used to bill a connection with mechanical condition problem	Standard procedure to estimate Imaginary figures

	Assumed figures Consult with customer Others…………………………
11.) How much is averagely estimated monthly due to meters whose mechanical conditions are not up to standard?	M^3...........................
12.) Are all your meters calibrated?	Yes No
Part c: Unmetered connection	
13.) How many billed metered consumption does your water supply have?	No. M^3
14.) Billed unmetered consumption (flat rates)	No. M^3
15.) Unbilled metered consumption	No M^3
16.)Unbilled unmetered consumption (fire hydrants)	No M^3
17.)Unauthorized consumption (illegal connections)	No. M^3
18.) Please explain why the water supply has billed unmetered connections	
19.) Kindly give the number of illegal connections unearthed monthly.	No.
20.) How does each category affect the water supply?	
Part d: Customer base	
21.) Does your water supply have dormant connections which have not been in use for over one year and please give the average number of dormant connections?	Yes No Number
22.) How do dormant accounts arise within your supply area?	
23.) What is the rate of new applicants per month?	No.
24.) How can you rate the new applications number compared to population within the supply area?	Very low Low Average High Very High
25.) How much is the pending cumulated unpaid bills within your water supply?	Kshs.
26.) How does the unpaid bills compare to the paid bills?	
27.) What could be the reason for unpaid bills in your opinion?	Ability to pay Attitude Others specify…………………
28.) What is the monthly disconnection rate for unpaid bills?	No.
Part e: Bursts and Leaks	
29.) How many bursts do you repair per month averagely?	½" - 2" 2" – 4" 6" -12"

30) How many leaks do you repair per month averagely?	½" - 2" 2" – 4" 6" -12"
31.) What are the causes for leaks & bursts?	Quality of pipes Class of pipes Depth of trenches Others specify…………………
32.) What is the average response time to attend to leaks and bursts?	
33.) What is the quantity of water averagely lost monthly through bursts and leaks?	M^3
34.) What are the challenges you experience in dealing with bursts and leaks?	
35.) Which other factors do you think have effects on Kimilili water supply NRW?	
THANK YOU SO MUCH FOR TAKING YOUR VALUABLE TIME TO PARTICIPATE IN THIS INTERVIEW.	

APPENDIX III: RESEARCH QUESTIONNAIRE

QUESTIONNAIRE FOR REGISTERED KIMILILI WATER SUPPLY CUSTOMERS

Instructions

The questionnaire seeks to gather information from the registered Kimilili water supply customers. Please tick in the appropriate spaces and also fill in the blank spaces provided for those questions where elaborate answers are required. Please do not include your name on the questionnaire. Participation will be voluntary and information will be used for research only. Kindly spare your time to provide answers as honestly and objectively as possible.

(Section A): Background

1. What is your gender Male ( ) Female ( )

2. What is your age 18-35 ( ) 36-55 ( ) 56 and above ( )

3. Please indicate by ticking (√) the duration you have had a water connection with Nzoia water

Services Company, Kimilili water supply.

Less than 1 Year ( ) 1 year ( ) 2years ( ) 3 years ( ) More than 3 years ( )

4. Please indicate by ticking (√) the type of water customer that best describes you.

Domestic consumer ( )

Commercial consumer ( )

Industrial consumer ( )

Institution of learning ( )

Private institution ( )

Water Kiosk ( )

Other

(Specify)………………………………………………………………………………………

5. Kindly indicate the number of people benefiting from the water connection *(please including everybody even infants, babies, people living with disability)* ……………………………………

(Section B): Mechanical condition of water meters

1. Kindly state whether currently you have a metered water connection.

Yes ( ) No ( )

2. Please indicate if your meter is registering actual or estimate consumption

Actual ( ) Estimate ( )

3. Please indicate the age of your meter.

0-1 year ( ) 1-2 years ( ) 2-3 years ( ) above 3 years ( )

4. Please indicate the class of your meter

Class B ( ) Class C ( ) Other ……………………………………………

(Section c): Unmetered connections

1. Has your connection ever been unmetered?

Yes ( ) No ( )

2. Please give reasons why your connection was not metered.

Flat rate installation ( ) Meters not available ( ) Arrangement with staff ( )

3. Is all the water being billed on your connection passing through the meter?

Yes ( ) No ( )

5. Please give reason why not all your consumption is being billed……………….………

…………………………………………………………………………………………………

7. By any chance might you have had any illegal water use/connection/tapping that was later on legalized?

Yes ( ) No ( )

8. Please indicate how you were obtaining unbilled water

Illegal tapping of water ( ) Bypassing water before meter ( )

Self-turn on after disconnection ( ) New connection by Nzowasco not in system ( )

Other (specify) ………………………………………………………………………………

9.) In your own opinion, what do you think is the cause of illegal water consumption and how do you advise Nzoia Water Company over the same…………………………………

Section (d) Customer base

1. How often do you pay for your water bills for Nzoia Water Company?

Monthly ( ) After two months ( ) Quarterly ( ) Annually ( ) Not at all ( )

Other (specify) ……………………………………………………………………

2. Kindly indicate the average monthly income of the household by ticking (√) the appropriate category.

Below Kshs. 5,000 ( ) Kshs. 5,000 – 10,000 ( )

Kshs. 10,001 – 20,000 ( ) Kshs. 20,001 – 50,000 ( )

Above Kshs. 50,000 ( )

3. What is the most important source of income of this household?

Agriculture or fishery ( ) Permanent employment( )

Temporary employment ( ) Business ( )

Other (Specify)………………………………………………………………………

4. Kindly indicate the average monthly revenue for the institution. Revenue (Kshs)……

5. Has at any time your water connection ever been disconnected for the last two years due to non-payment of water bill?

Yes ( ) No ( )

6.) What was the outstanding water bill on disconnection? Kshs …………………………

7.) What are you able to pay comfortably per month when with quality and sustainable water supply per month? Kshs. …………………………………………………………

8. Do you think it is really necessary to pay for treated / piped water?

Yes ( ) No ( ) Don't know/ No opinion ( )

Section (e): Water bursts and leaks

1. Have you ever reported a pipe burst or water leakage to Nzoia water services Company?

Yes ( ) No ( )

2. If you have never reported any water burst/leak please circle or indicate why

I don't know where or who to report to ( ) I have no interest ( )

I have no water connection ( ) My water was disconnected ( )

The staff never takes action ( ) I have never come across ( )

3. How long did they take to respond to your reported cases?

1 hour ( ) 1 day ( ) 1 month ( ) No action ( )

4. In your opinion, how would you advice Kimilili water supply on water bursts and leaks……………………………………………………………………………….

Thank you for your cooperation and taking your valuable time to fill this questionnaire.

APPENDIX IV: DOCUMENT REVIEW GUIDE

Item	Unit	Description	Period
NRW	%		
Mechanical condition of meters	Years.	Age of meters	
		Class of meters	
	Inch	Sizing	
	Horizontal/ Vertical	Installation	
Unmetered connections	No. M^3	Flat rates	
	No. M^3	Illegal connections	
	No. M^3	Fire hydrant	
Customer base	Kshs.	Arrears/debts	
		Paying ability (patterns of payments)	
		Attitude	
Water bursts and leaks	No. M^3	Damaged pipeline	
	No. M^3	During maintenance	
	No. M^3	New Connections	

APPENDIX V: RESEARCH PERMIT

CONDITIONS

1. You must report to the County Commissioner and the County Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit
2. Government Officers will not be interviewed without prior appointment.
3. No questionnaire will be used unless it has been approved.
4. Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.
5. You are required to submit at least two(2) hard copies and one(1) soft copy of your final report.
6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice

REPUBLIC OF KENYA

NACOSTI

National Commission for Science, Technology and Innovation

RESEARCH CLEARANCE PERMIT

Serial No. A 5434

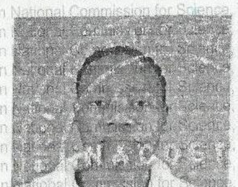
CONDITIONS: see back page

THIS IS TO CERTIFY THAT:
MS. THEODARA OMUNYERERE MADARA
of UNIVERSITY OF NAIROBI, 1017-3200
kitale,has been permitted to conduct
research in *Transnzoia County*

on the topic: *FACTORS INFLUENCING NON-REVENUE WATER IN KIMILILI WATER SUPPLY, BUNGOMA COUNTY, KENYA*

for the period ending:
6th November,2015

Permit No : NACOSTI/P/15/7595/6008
Date Of Issue : 19th June,2015
Fee Recieved :Ksh 1,000



....
Applicant's
Signature

....
Director General
National Commission for Science,
Technology & Innovation

APPENDIX VI: RESEARCH AUTHORIZATION

NACOSTI

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone: +254-20-2213471, 2241349, 310571, 2219420
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Email: secretary@nacosti.go.ke
Website: www.nacosti.go.ke
When replying please quote

9th Floor, Utalii House
Uhuru Highway
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No.

Date: **19th June, 2015**

NACOSTI/P/15/7595/6008

Theodara Omunyerere Madara
University of Nairobi
P.O Box 30197-00100
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Factors influencing non-revenue water in Kimilili Water Supply, Bungoma County, Kenya,"*** I am pleased to inform you that you have been authorized to undertake research in **Bungoma and Trans Nzoia Counties** for a period ending **6th November, 2015.**

You are advised to report to **the County Commissioners and the County Directors of Education, Bungoma and Trans Nzoia Counties** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

SAID HUSSEIN
FOR: DIRECTOR-GENERAL/CEO

Copy to

The County Commissioner
Bungoma County.

The County Director of Education
Bungoma County.

National Commission for Science, Technology and Innovation is ISO 9001: 2008 Certified