FACTORS INFLUENCING WATER SUPPLY’S NON REVENUE WATER: A CASE OF WEBUYE WATER SUPPLY SCHEME

BY

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DECLARATION

This research project report is my own original work and has never been presented for award of any degree in any other University.

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

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DEDICATION

This work is dedicated to my parents Mrs Rita Ayuma Shilehwa and the late Mr. Fredrick Ukondo Shilehwa for their tireless and selfishness effort to educate me, to my spouse Nelius Kariuki for her sincere love, understanding, commitment and support, to my brother Telesphorus Matekwa and my sister Electine Shilehwa for their support.

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ABBREVIATIONS AND ACRONYMS

AWWA – American Water Works Association

DMAs – District Metered Areas

FCR – Full Cost Recovery

GI – Galvanized Iron

GPM – Gallons per Minute

IWA – International Water Association

JICA – Japan International Corporation Agency

KWDN – Kampala Water Distribution Network

LVNWSB – Lake Victoria North Water Services Board

MDGs – Millennium Development Goals

NGOs – Non Governmental organizations

NRW – Non Revenue Water

NZOWASCO – Nzoia Water Services Company Limited

OECD – Organization for Economic Co-operation and Development

Rs – Rupees (Indian)

SABESP – Saneamento Básico do Estado de São Paulo

SIV – System Input Volume

SPSS – Statistical Package for Social Sciences

UFW – Unaccounted for Water

WAC – Water for Asian Cities

WASREB – Water Services Regulatory Board

WASH – Water Sanitation and Hygiene

WSPs – Water Service Providers

ABSTRACT

This study was carried out to examine the factors influencing water supply's non revenue water (NRW): a case of Webuye water supply scheme of Nzoia Water Services Company Limited (NZOWASCO). The study was conducted under guidance of the following objectives; To assess the extent to which meter registration inaccuracy influence non revenue water at Webuye water supply scheme. To establish how unmetered consumption influence non revenue water at Webuye water supply scheme. To examine how illegal consumption influence non revenue water at Webuye water supply scheme. To evaluate the influence of water tariff on non revenue water at Webuye water supply scheme. The study sought to ascertain the following hypothesis; There is no significant relationship between meter registration inaccuracy and non revenue water at Webuye water supply scheme. There is no significant relationship between unmetered consumption and non revenue water at Webuye water supply scheme. There is no significant relationship between illegal consumption and non revenue water at Webuye water supply scheme. There is no significant relationship between water tariff and non revenue water at Webuye water supply scheme. The study employed ex-post facto descriptive survey research methodology with both quantitative and qualitative research designs. The study targeted a population of 1658 registered water consumers of Webuye water supply scheme whose composition was; domestic consumers, institutional consumers, commercial consumers and water kiosk operators. Yamane, T. (1967) formula was applied at 93 percent confidence level to obtain a sample size of 183 consumer connections and 183 consumer water meters. The primary data for the study was obtained through questionnaires and field observations. The questionnaire was pilot-tested using a sample of ten (10) respondents from Bungoma water supply scheme after which its reliability was determined using pearson product moment correlation coefficient (r) and obtained $r = +0.68$. Field observations were made using a portable clamp on ultrasonic flow meter and a stationary meter test bench. The secondary data for the study was obtained through document review. The sample for registered water consumers and consumer meters was determined through stratified sampling in accordance with the classification of the consumers, then systematic sampling and finally random sampling. The final data analysis was done using Statistical Package for Social Sciences (SPSS). From the study's findings, hypothesis tests revealed that; There was significant positive relationship between meter registration inaccuracy and non revenue water at 1% level of significance at Webuye water supply scheme. There was significant positive relationship between unmetered consumption and non revenue water at 1% level of significance at Webuye water supply scheme. There was significant positive relationship between illegal consumption and non revenue water at 1% level of significance at Webuye water supply scheme. There was no significant relationship between water tariff and non revenue water at Webuye water supply scheme. Based on the study findings it is suggested that; NZOWASCO should develop and implement a NRW reduction strategy at Webuye water supply scheme which should include water meter registration accuracy enhancement. There is need for NZOWASCO to meter all unmetered consumer connections and carry out regular servicing and calibration of consumer water meters at Webuye water supply scheme. To suppress illegal water consumption, NZOWASCO should carry out periodic customer base audit by reconciling office consumer database with field connections. NZOWASCO should constitute and operationalize a NRW team to oversee and enforce implementation of NRW reduction activities on daily basis at Webuye water supply scheme. The study suggested for further research as follows; A research to be carried out on the influence of unbilled authorized consumption on non revenue water. An in depth analysis be carried out on the influence of billing system errors on non revenue water. Further, it is also suggested that an analysis be carried out on influence of management style on non revenue water.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The efficient and sustainable supply of high quality water to commercial, industrial and domestic users, at an acceptable pressure and with the minimum loss through leakage is a key objective for all water supply and distribution utilities. Globally, water demand is rising and resources are diminishing. It is expected that in 2030, 47 percent of the world population will live in regions with severe water stress. The growing pressure on water has led this resource to be considered scarce and must therefore be managed efficiently. Obviously, this need is greater in the regions with more pronounced water stress (Organisation for Economic Co-operation & Development (OECD, 2008a).

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). The World Bank has estimated the total cost of NRW to utilities worldwide at US$14 billion per year. Reducing by half the current levels of losses in developing countries, where relative losses are highest, could generate an estimated US$ 2.9 billion in cash and serve an additional 90 million people further investment (*en.wikipedia.org/wiki/Non-revenue water*). It takes on a new dimension in developing countries, where poor infrastructure is the major source of high water losses. Yet not all losses are the result of poor infrastructure and leaking pipes. 'Apparent' losses from the network, and excessive use or misuse of water, are often the result of local customs, combined with low tariff structures or inadequate metering policies (Farley, 2003). According to WASREB (2012), non revenue water is the difference between amount of water produced for distribution and the amount of water billed to consumers. NRW constitutes of real losses (physical) through leaks, bursts, reservoir overflows, apparent losses (commercial) through illegal connections, water theft, metering inaccuracies and unbilled authorized consumption.

Water loss from the pipe network, has long been a feature of operations management, even in countries with well developed infrastructure and good operating practices. Of particular importance is the need for economic and environmental reasons to stem the loss of water from the system that contributes to excessive levels of non-revenue water. The rehabilitation of aging sections of the network is central to achieving this (Farley, 2003).

Non revenue water is typically measured as the volume of water "lost" as a share of net water produced. However, it is sometimes also expressed as the volume of water “lost” per km of water distribution network per day or volume of water “lost” per connection per day. According to Kerry& Tarma (2012), non revenue water levels of some selected countries expressed in percentage terms were 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. According to WASREB (2012), in kenya, the NRW levels for various water utilities (urban water service providers) expressed in percentage of water produced for financial year 2011/2012 were Nairobi 44, Eldoret 27, Nyeri 26, Kisumu 49, Nzoia 52, Embu 41, Kitui 68, Mandera 37, Murang’a 44, Isiolo 48, kirinyaga 78 and Sibo 60.

In order to meet Millennium Development Goal (MDG) 7.C: ‘reducing by half the proportion of people without sustainable access to safe drinking water and basic sanitation, in the period 2000 to 2015’, based on the last updates it can be said that the world is on track to meet the drinking water part of this goal. This fact has motivated governments, non-governmental organizations

(NGOs) and other entities to invest in safe water supplies for urban and rural areas. Recent report released by Water Services Regulatory Board impact, issue no.5 (WASREB, 2012) 'A performance Review of Kenya's Water Service Sector – 2010/11' about the sustainability of water service providers (WSPs) show that only 67 percent of the large WSPs were more likely to be viable while 39 percent of the small WSPs were more likely to be viable, with the less viable WSPs being associated with high amounts of NRW as compared to the more likely viable ones. The average NRW as a percentage of total water injected into the distribution system was 45 percent translating to financial losses of Ksh 9.5 billion annually. The factors influencing NRW levels resulting to high financial losses and low viability of Kenyan WSPs is the subject of this research report with the case of Webuye Water Supply Scheme.

1.2 Statement of the Problem

The implementation of Water Act 2002, which led to privatization of the water sector in Kenya resulting to formation of Water Service Providers (WSPs) was meant to improve on the quality of water and sanitation services that were being offered to the citizens, thus the WSPs were expected to be self sustaining through generation of revenues from services they offered. The surplus earnings were to be reinvested through further extensions of water and sanitation infrastructure, thus contributing towards meeting Millennium Development Goal 7(C). Contrary to the above expectation, the situation where infrastructure for water service providers is in place but not viable is being experienced in Kenya even after having implemented the Water Act 2002 for ten years. According to WASREB, (2012), it has been reported that 41percent of the existing pumping scheme WSPs in Kenya are not viable, with non revenue water (NRW) being considered to be one of the major causes of non viability of WSPs in Kenya. Only 67 percent of the large WSPs were more likely to be viable while 39 percent of the small WSPs were more likely to be viable, with the less viable WSPs being associated with high amounts of NRW as compared to the more likely viable ones. The national average NRW as a percentage of total water injected into the distribution system was 45 percent translating to financial losses of Ksh 9.5 billion annually.

Focusing on Webuye water supply scheme of Nzoia Water Services Company (NZOWASCO), the scheme is supposed to meet all its operation and maintenance costs by generating its own revenue from the water and sanitation services it offers to citizens. This is not practically reflected on the ground as the scheme is reported to record the highest NRW of 56 percent compared to the other three schemes managed under NZOWASCO cluster. The NRW levels for Kitale, Bungoma and Kimilili schemes of Nzoia water Services Company limited are 42 percent, 40 percent and 44 percent respectively. As a result of the high NRW levels, Webuye water scheme is reported to have attained the lowest cost coverage estimated at 65 percent as compared to Kitale, Bungoma and Kimilili whose cost coverage are 123 percent, 104 percent and 101 percent respectively (NZOWASCO 2011/2012 report). If the above trend of NRW for Webuye water supply scheme continues, it is feared that the schemes cost coverage will further drop leading to deterioration of infrastructure in place hence poor quality service offer, which will derail achievement of MDG 7(C).

Based on the above observations, there was need of carrying out research on the factors influencing the high NRW levels at Webuye water scheme with the aim of developing and implementing a NRW reduction strategy based on the findings of the study, hence leading to the topic of this research report “factors influencing water supply’s non revenue water: a case of Webuye Water Supply Scheme”.

1.3 Purpose of the Study

The purpose of the study was to establish factors influencing Non Revenue Water at Webuye water supply scheme.

1.4 Objectives of the Study

The study was guided by the following objectives;

1. To assess the extent to which meter registration inaccuracy influence non revenue water at Webuye water supply scheme.
2. To establish how unmetered consumption influence non revenue water at Webuye water supply scheme.
3. To examine how illegal consumption influence non revenue water at Webuye water supply scheme.
4. To evaluate the influence of water tariff on non revenue water at Webuye water supply scheme.

1.5 Research Hypothesis

The study sought to ascertain the following hypothesis;

1. There is no significant relationship between meter registration inaccuracy and non revenue water at Webuye water supply scheme.
2. There is no significant relationship between unmetered consumption and non revenue water at Webuye water supply scheme.
3. There is no significant relationship between illegal consumption and non revenue water at Webuye water supply scheme.
4. There is no significant relationship between water tariff and non revenue water at Webuye water supply scheme.

1.6 Significance of the Study

It is hoped that the findings of the study in this report will be important for the following reasons; By establishing the factors influencing NRW levels at Webuye water supply scheme, the water utility management team will be able to use the information to develop a NRW reduction strategy giving priority to the critical factors hence being able to tackle the real issues instead of trial and error. Therefore understanding the real issues to tackle will lead to preparation of a more focused NRW reduction strategy thus saving on both time and finances.

The water utility management team will use the findings of the study as a justification for preparing a report for NRW reduction which will be presented to the utility Board of Directors' for approval before being implemented. It is only by establishing the level of NRW at which the water utility will be able to attain financial sustainability (economic level of NRW) that the target for level of NRW to be attained for the water utility will be set, thus determining the financial implications (budget).

Through implementation of NRW reduction strategy based on the study findings, reducing the NRW to the levels of financial sustainability of the water utility, will lead to increase of both financial resources and the water available to utilities which will guarantee provision of services that will meet the current and future needs for the lowest costs possible (Farley, 2008). This will be a contribution towards meeting Millennium Development Goal 7.C: 'reducing by half the proportion of people without sustainable access to safe drinking water and basic sanitation'.

The findings of the study will be used by other scholars and researchers to carry out more research in the related fields.

1.7 Basic Assumptions of the Study

The study was based on the following basic assumptions.

First and foremost it was assumed that the respondents to the questions would be objective and cooperative to enable the study to be carried within the scheduled time frame. Further it was assumed that the meter samples testing results would give true replication of the ground facts in the entire water supply scheme. It was also assumed that the climatic conditions would favor data collection hence the study would be carried within the stipulated time frame.

Lastly the researcher assumed that the factors meter registration inaccuracy, unmetered consumption, illegal consumption and water tariff influenced non revenue water levels at Webuye water supply scheme.

1.8 Limitations of the Study

Testing of water meters was costly and due to the limited funds that were available for the study, the researcher sought financial support from NZOWASCO for financing of sample meter testing. NZOWSACO had provision for the same in its 2012/2013 annual budget.

Time scheduled for the study was not adequate to carry out field illegal consumption sampling, thus the researcher gathered required data through document review of NZOWASCO's records.

1.9 Delimitations of the Study

The study was only focused on four factors (meter registration inaccuracy, unmetered consumption, illegal consumption and water tariff) influences on NRW levels in NZOWASCO's water utility. It was confined to Webuye water supply scheme and only covered schemes performance for the period between 1st July 2010 to 30th June 2012. The scheme was chosen because it was reported to be registering the highest levels of NRW and not able to financially sustain itself in the NZOWASCO cluster hence the need of carrying out a study to investigate the causes of high NRW (NZOWASCO 2011/2012 report).

1.10 Definition of Significant Terms Used in the Study

Water act 2002: This 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.

System Input Volume: This is the annual volume of water input to that part of the water supply system.

Authorized Consumption: Refers to the annual volume of both metered and un-metered water taken by registered customers, the water supplier, and others who are implicitly or explicitly authorized to do so (e.g. water used in government offices or fire hydrants). It includes exported water and the leaks and overflows after the point of customer metering.

Non Revenue Water: This is the difference between the volume of water injected into a water utility's pipeline network system and the volume of water billed for consumption.

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

System Pressure: Refers to the force (in pounds) exerted per square inch by water on the internal wall surface of pipeline. Also measured in bars (1 bar = 10 meters head).

Water Balance: Refers to a schematic chart showing the different components of volume of water supplied into the distribution system as well as volume of water lost and/or used within the distribution system.

Water Audit: It is a periodic exercise of determining the volume of water supplied, consumed and lost in the distribution system thus providing a utility with information to make effective operation and maintenance as well as investment decisions.

Water tariff: Refers to the price structure assigned to water supplied by a public water utility through a piped network to its customers.

1.11 Organization of the Study

This research project contains five chapters. Chapter one is the introduction and includes the background information of the study, statement of the problem, purpose of the study, the research objectives and research hypothesis that guided the study. It also covers the significance of the study, basic assumptions of the study, limitations and delimitations of the study. Operational definition of significant terms used in the study is given under this chapter.

Chapter two is the literature review of studies done by scholars related to factors influencing water supply's non revenue water. Under this section, literature review was discussed under causes of water meter registration inaccuracies, unmetered water consumption, illegal water consumption and effects of water tariff on non revenue water. The objective of this discussion was to highlight in general the various causes of non revenue water in water utilities. At the end of the chapter, the conceptual framework of the study was provided.

Chapter three is a description of the Research Methodology used to conduct the study. The research design and target population are explained. There is also a description of the sample size and sample selection. A description of the research instruments used and their validity and reliability are also included. There is also an elaboration of data collection procedures, operational definition of variables and ethical considerations that were observed.

Chapter four is data analysis, presentation, interpretation and discussions of the findings of the research study. The findings of the study as per the study objectives are presented in the form of tables and interpretation, explanations and discussions of the same provided after each table.

Chapter five summarizes the findings of the study, concludes and gives recommendations based on the study's findings. Finally, suggestions of areas for further research are provided at the end of this chapter.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter provides a review of works carried out by other scholars and researchers relevant to the problem of the study both globally and regionally. It focuses on relevant information from previous studies which have focused on components of NRW and the factors influencing NRW in different water utilities in the world. The chapter also has the conceptual framework of the study.

2.2 The Concept of Non Revenue Water (NRW)

Juan (2008), defines non revenue water as the difference between water produced and the amount of water sold to all customers. It is represented with the following formula:

$$\text{NRW} = \left(\frac{(\text{Water Produced m}^3 - \text{Water Billed m}^3)}{\text{Water Produced m}^3}\right)\text{X}100$$

There are two main components of water losses, technical and commercial. The first of them lies on physical failures on the distribution system (pipe leaks), being some of them easily identified and corrected. On the other hand, there is a commercial component that 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.

According to WASREB (2012), non revenue water is the difference between amount of water produced for distribution and the amount of water billed to consumers. NRW constitutes of real losses (physical) through leaks, apparent losses (commercial) through illegal connections, water theft, metering inaccuracies and unbilled authorized consumption.

NRW is typically measured as the volume of water "lost" as a share of net water produced. However, it is sometimes also expressed as the volume of water “lost” per km of water distribution network per day or volume of water “lost” per connection per day.

2.3 Influence of Meter Registration Inaccuracy on Non Revenue Water

Meter under-registration means that, the meter only reads portion of the water that passes through it and therefore, the consumer is only billed for that portion.

Rizzo (2008), associated meter under-registration in water utilities with; meter wear and tear, incorrect meter installation practice, lack of meter maintenance or calibration and incorrect meter sizing.

Water meter inaccuracies are considered to be the most significant and hardest to quantify. Water meter errors are amplified in networks subjected to water scarcity, where users adopt private storage tanks to cope with the intermittent water supply. According to a study carried out to analyse water meter age and the private storage tank effect on meter performance in Palermo (Italy), it demonstrated that the impact on apparent losses from the meter starting flow rapidly increased with meter age. Private water tanks, usually fed by a float valve, overstate meter under-registration, producing additional apparent losses between 15 percent and 40 percent for the users analysed in the study (Criminisi et al., 2009).

According to Kingdom et al. (2006), in 1999 Saneamento Básico do Estado de São Paulo (SABESP), a water utility that served the São Paulo Metropolitan Region in Brazil tendered a series of turnkey contracts for meter replacement. The project target was to replace the meters of 27,000 large revenue accounts identified by SABESP, which was aimed at increasing large customer meter accuracy. Five 36 months contracts were put in place and by the end of the contract period (36 months), the results of the contract were remarkable. The total volume of metered consumption increased by some 45 million cubic meters over the contract's three year duration, while revenues increased by Brazilian Reais (R$) 172 million (US$72 million).

According to AWWA (2000), sub-metering was widely used as a tool to promote water conservation, notably in the USA. Water use reduction in the range of 10 to 30 percent was reported as a result of sub-metering. The term 'sub-metering' refers to any metering that occurs downstream of a water utility's master meter to measure individual resident water usage in apartments, condominiums, mobile home parks, and small mixed commercial properties. However, universal metering and sub-metering has not brought the much anticipated benefits to water utilities in developing countries, most likely due to metering inefficiencies.

AWWA (2000), found that non-revenue water (NRW) resulting from meter inaccuracies and poor water meter management could be reduced by assessing meters' performance and identifying the main causes of malfunction.

According to Male et al. (1985), 'calculating the optimum level of apparent losses due to water meter inaccuracies' research, it was concluded that 'the higher the amount of volume used at low flows (which increased the degradation rate of the weighted error since meters degraded in first place at low flows) the higher the optimum level of water meter error and the higher the consumption volume of the users the lower the V parameter (ratio of meter cost to the product of yearly consumption and water price) and the lower the optimum level of water meter error.

It is was widely acknowledged that mechanical water meter's metrology become more and more inaccurate during their operating life due to 'wear and tear' of the measuring components (Arregui et al., 2006b; Male et al., 1985).

According to Wright-Pierce 2011 Rochester municipal water supply system, NH Water Audit Report, 2000 Rochester audit report lead to water meters being installed on previously unmetered services, outdated positive displacement Neptune meters were replaced with state of the art electromagnetic sensus i-Perl meters for small commercial and residential customers while 29 industrial water meters were replaced with state of the art electromagnetic sensus omni meters. The improvements in metering led to increase in revenue water volume from 62 percent to 76 percent (14 percent increase) and decrease in metering inaccuracies and apparent losses from 9 percent to 2 percent (7 percent decrease) for 2000 and 2011 respectively. Also 153 water meters were tested in 2008 and 2009 for inaccuracies of which a few measured more water than the known volume, but most meters on average measured less. Several meters were "dead" and measured no water. The majority of the meters under registered water use, particular at the low flow range.

Because flow measurement accuracy varies based on flow rate, overall meter accuracies were determined by applying a weighting factor to three flow distributions, low (¼ gpm), medium (2 gpm) and high (10 gpm). A 2011 AWWA study found that in Louisville, Kentucky, 18 percent of the flow was in the low range, 73 percent in the medium range, and 9 percent in the high range. These weighting factors and the meter error were applied to the volume of flow measured by the approximately 1,500 Neptune meters that remain in the Rochester. From on-going bench testing being conducted by Rochester, under-registering in the low flow range was 19 percent, in the medium range was 3 percent and in the high range was 6 percent. The report further concluded that had the City not acted to address the 2000 non-revenue statistics, presumably meter inaccuracy would worsen over the ten year interval leading to decrease in volume of revenue water.

According to United Water New Rochelle non-revenue water study final report, United Water New Rochelle participated in a long term meter testing and replacement program (05th Feb 2007 to 21st July 2010), 13,303 tests were carried out, of which 29,381 meters were tested. Out of

29,381 meters tested, 1,387 recorded an average of 100.5 percent of the actual reading, 1,483 recorded an average of 100.0 percent of the actual reading and 2,6511recorded an average of 98.87 percent of the actual reading. Total under read water was 289,262 M^3/year translating to 1.46 percent of the system supply. There were an estimated 31,072 accounts, with an estimated 1,691 meters (5.4 percent) unaccounted for. Assuming that the meters under read at the same rate as the remaining meters, the total estimated apparent losses due to under read meters was 306,618 M^3/year translating to 1.54 percent of the system supply (Halcrow, Inc. 2012).

According to Mutikanga et al (2011), (Investigating water meter performance in developing countries: A case study of Kampala, Uganda) research finding, the following conclusions were drawn based on the analysis of performance of water meters in the Kampala water distribution network (KWDN).

Sub-metering reduced utility revenue water in Kampala by 18percent. This under-registration of sub-meters was due to individual ageing of sub-meters and low network pressures.

For single-family apartments with storage elevated tanks, about 25percent of water use occurred at flow rates between 0 and 35 l/h. The high percentage of water use at very low flows, where meters were least efficient, contributed significantly to metering errors. In addition the ball-valve effect of the private elevated storage tanks magnified the under metering of revenue water.

The volumetric positive displacement (piston-type) meters were not suitable for the KWDN due to the observed high failure frequency. They were probably more suitable for water networks with very good maintenance practices and no particulates in water.

Most studies carried out on metering have been based on water utilities of developed countries, with well-managed water distribution networks, notably the USA, Spain, France, and Italy (Arregui et al., 2006a; Criminisi et al., 2009; Pasanisi and Parent, 2004; Richards et al., 2010). Water meter performance in water systems of the developing countries, often with poorly managed networks and relatively lower water quality in the distribution system, is not very well understood. This research attempted to close the knowledge gap by investigating water utility metering problems in developing countries, the case of Webuye water supply scheme, Kenya.

2.4 Influence of Unmetered Consumption on Non Revenue Water

In 1998, it was found out that some of the non revenue water for city of Sequim was due to irrigating unmetered city parks, including Silberhorn Ball fields, Carrie Blake park and buildings, the high school football field bathrooms, fire hydrant flushing, fire department training, and water trucks used for dust control and street cleaning etc.

The city carried out an aggressive maintenance, reconstruction and meter replacement program over a short period of approximately 6 years. Within that timeframe, the non revenue water reduced from 30 percent down to approximately 9 percent.

The city installed new meters throughout the system and added meters in those places that had no meters such as Carrie Blake park and Dr Standard park.

The reduced use of unmetered potable water from fire hydrants for dust control, street washing, vehicle washing and landscape watering also provided a great reduction in the non revenue water (Sequim City Water System Improvement report, 2004).

According to Hailu et al, (2011), a survey carried out in 2010 on small scale water providers in Kenya indicated that, in Nairobi the unreliability of water supply could be reduced dramatically by controlling the high rates of non revenue water. In 2009, 40 percent of the water that entered Nairobi City Water and Sewerage company’s network was recorded as “non-revenue water” (WASREB, 2010). This figure measured not only water lost through leaks caused by the decay of infrastructure, but also water diverted through illegal connections, inaccurate metering of water use, and inefficient revenue collection due to low metering ratios and weak billing capacities.

According to Wright-Pierce 2011 Rochester municipal water supply system, NH Water Audit Report, 2000 Rochester audit report lead to Water meters being installed on previously unmetered services, outdated positive displacement Neptune meters were replaced with state of the art electromagnetic sensus i-Perl meters for small commercial and residential customers while 29 industrial water meters were replaced with state of the art electromagnetic sensus omni meters. The improvements in metering led to increase in volume of revenue water from 62 percent to 76 percent (14 percent increase) and decrease in metering inaccuracies and apparent losses from 9 percent to 2 percent (7 percent decrease) for 2000 and 2011 respectively.

2.5 Influence of Illegal Consumption on Non Revenue Water

Illegal consumption is also known as unauthorized water usage. This may include illegal water withdrawal from hydrants, illegal connections, illegal reconnections and bypasses to consumption meters. Reduction of illegal consumption reduces non revenue water.

Illegal consumption is categorized into;

Meter by pass, where the consumer is a legal customer with a meter. The customer has an alternative pipe taping water before the meter.

Illegal Connection where by the consumer is not even a customer to the water supply system consumer data base. He / she simply connects himself / herself to the network without the knowledge of the water supply operator.

Fetching water at a point before the meter - the customer consumes water that is not metered by closing the stop cork, removing the meter then connects a horse pipe to the network and fetches water. After fetching water, the meter is reinstalled in its normal position.

Meter reversal, this is a situation where by customers install meters in reverse order so that they count backwards to desired readings. When satisfied they turn the meters to the correct position. Meter reversal may entail reversing the meter readings manually. (Uganda National Water and Sewerage Corporation, 2008).

According to Balkaran and Wyke (2003), there were significant numbers of illegal users of water. Water and sewerage authority estimated that 40,000 households (1992 figure) did not pay water rates but received water from its distribution system. As a consequence, they contributed significantly to apparent losses and revenue loss to the Authority. These connections were often poorly laid just a few inches below the surface and would break easily resulting in real losses taking place in the form of leakage. Illegal consumption were therefore of major concern.

According to Rizzo (2008), Water theft (illegal consumption) 'is probably the easiest to conceptualise although sometimes may be very difficult to eliminate'. According to Butler and Memon (2006), apart from loss of water to the water supply system, illegal consumption also played a major role in limiting the water system's ability to increase its level of service. Illegal consumption or water theft is where someone deliberately bypasses the water meter to get water for a period of time. Some of the causes for water theft were; water scarcity, poor management, lack of awareness, inappropriate tariff system and refusal to allow individuals to have house connection. Several factors accounted for the difficulties for water utility staff to try to stamp out illegal connections in a water system. Some of the factors were;

The assumption that water was a basic human need and therefore should not be charged for.

The involvement of politicians who try to win public support at the expense of sustainability.

According to Hailu et al. (2011), a survey carried out in 2010 on small scale water providers in Kenya indicated that about 62 percent of fixed-point vendors declared that they had a legal connection to the water utility network. About 35 percent seemed to be reselling water from illegal connections: 24 percent were illegally connected to someone else's formal piped connection, and 11 percent declared "another piped connection" that assumed consisted chiefly of illegal connections to the main water grid, given the exclusion of other legal alternatives presented in the survey questionnaire. 2 percent sold water from a borehole and 1 percent of vendors did not reveal the water source. The survey also indicated that, in Nairobi the unreliability of water supply could be reduced dramatically by controlling the high rates of non revenue water. In 2009, 40 percent of the water that entered Nairobi City Water and Sewerage company's network was recorded as "non-revenue water" (WASREB, 2010). This figure measured not only water lost through leaks caused by the decay of infrastructure, but also water diverted through illegal connections, inaccurate metering of water use, and inefficient revenue collection due to low metering ratios and weak billing capacities. Illegal connections, therefore, were both a cause and effect of water rationing: because if supply was unreliable, underserved households turned to the market for small-scale water provision. These types of providers, in turn, relied on a variety of sources, including illegal connections. The illegal diversion of water increased NRW rates, leading to further rationing. Inefficient billing and revenue collection similarly contributed to exacerbated NRW level. Lost revenues entailed downward pressure on investment capital to carry out critical maintenance work on a decaying water-supply infrastructure.

2.6 Influence of Water Tariff on Non Revenue Water

According to international news on water supply, sanitation and hygiene-WASH (2011), a TaKaDu research paper showed the connection between water prices and water network efficiency. Based on information from 42 urban water networks all over the world, the research found that higher water tariffs were associated with lower water loss and a more sustainable outcome. In most cities where the price of water was very high or very low, low and high NRW rates were observed respectively. In the research, the top eight cities in terms of NRW rates (Utrecht, Adelaide, San Jose, Paris, Sydney, Vienna, San Diego and Copenhagen), which demonstrated NRW<10%, of which water tariffs were significantly higher than the median (Median =$2.12/m^3). Looking at Europe only, urban networks that used lower water tariffs, like Dublin, Sofia, Bucharest and Naples, suffered from higher NRW rates while Paris, Vienna and

Copenhagen that used very high water tariffs had low NRW rates. This holds true across different countries and regions and even cities. Manila East and Manila West for instance had two different private sector operators, Manila West scored 12 percent non revenue water while Manila East scored 53 percent non revenue water.

According to Farley (2003), most countries had some form of household metering or other charging structure for water used. However, water companies in many developing countries set low or flat rate tariffs, water rates which were subsidized by government, or provided free water. Although this was frequently in the interests of low-income customers, to maintain health and hygiene, it tended to become the expected norm, and was frequently a politically sensitive issue, especially during local elections. However, there were severe disadvantages to water utilities of allowing zero or low rated tariff structure and not charging an economic rate for water; It did not encourage sensible use, it did not encourage the mending of customer leaks, The water utility had no incentive to install an active metering and meter replacement policy and insufficient revenue was generated to provide a sustainable operation, maintenance and repair programme.
Often, even on low tariffs, customers (both household and non-household) would vandalise or by-pass meters to save paying. Liemberger and Marin (2006), are also in support of the view that unsuitable tariff structure influences the scope of managing NRW, the lower the tariff structure the less investment in infrastructure maintenance hence the higher the NRW.
According to Water for Asian Cities (WAC) Programme, policy paper I (2006), the prevailing water tariffs for Asian cities were generally below the actual cost of water supply. The existing tariff structure needed to be rationalized to address cost recovery principles. The full cost recovery (FCR) for water services primarily covered all costs associated with operating, maintaining and financing the capital cost of expansion of the municipality's water system. The concept implied that revenues from water sales, primarily through tariffs, were equal to or exceeded the amount required to cover all costs related to obtaining, processing and distributing

water to the corporation's consumers. Clearly, achieving full cost recovery could be an important determinant of a utility's ability to improve on operational efficiency and expand service / infrastructure. Attainment of full cost recovery enabled water utilities to reduce non revenue water levels by;

Both maintaining and hiring of competent staff hence having a competent and motivated human resource for developing and implementing non revenue water reduction strategies. Keeping well maintained water infrastructure including measuring devices hence reducing on both physical and apparent losses. Embracing modern technologies for managing non revenue water among them including pressure management, geographical information systems (GIS) and intelligence metering.

According to Gwalior Water Demand Management Strategy and Implementation Plan (2006), the water tariff rates that existed in Gwalior by then had been implemented as from April 2002. Prior to which the domestic water tariff was 60 Rupees (Rs) per month which had increased from Rs. 9 per month in 1997. According to inputs from senior Gwalior Municipal Corporation officials, the number of illegal water connections had risen consistently in the past few years, especially amongst the domestic consumers which had largely been attributed to the sharp water tariff hike, introduced in 1997-1998 and 2002-2003 (from Rs.9 to Rs.60 and subsequently to Rs. 80). Therefore, any further tariff changes were to be orchestrated based on implications of revenue realization and willingness to pay parameters.

2.7 Empirical Literature

According to Brundland Commission (1987), studies carried out show that non revenue water 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.

Financial sustainability of water utilities is important because; only financially sustainable water utilities can guarantee provision of services that will meet the current and future needs. Lack of financial sustainability of water utilities means operating with looses and permanent cash flow deficit leading to degradation of infrastructure and resulting in worst quality services. Water utilities that are financially sustainable have wider access to external funds including grants and loans from international finance institutions. Financially sustainable water utilities are the most effective and efficient utilities providing their clients with services that meet their needs for the lowest possible cost (Frauendorfer and Liemberger, 2010).

The Nzoia Water Services Company Ltd (NZOWASCO) was established as a limited liability company under the Companies Act (CAP 486) on 4th February 2004 and became operational a year later on 9th February 2005 following the enactment of Water Act 2002 that ushered in reforms in the water sector in the country. The shareholders are the Municipalities of Kitale, Bungoma, Webuye and Kimilili. Its headquarters is situated in Webuye behind Masinde Muliro University Webuye campus in Bungoma East district, Bungoma County. Currently, the company is managed by a 9 member Board of Directors and 8 senior management staff overseeing a total workforce of 200 staff.

Nzowasco is licensed and mandated by Lake Victoria North Water Services Board to provide water and sewerage services within the councils of Kitale, Bungoma Webuye, Kimilili and Malaba. The company has got an active customer base of 15,000 and serves an average of 263,000 out of the total population of 248,360 within the operational area. Currently NZOWASCO operates a cluster of five water schemes within Kitale, Bungoma, Webuye, Kimilili and Malaba councils within Bungoma, Trans Nzoia, Busia and Kakamega counties.

Kitale, Bungoma and Webuye are urban schemes while Kimilili and Malaba-Kocholia are more of rural schemes. All the supplies have river sources with full conventional water treatment facilities. Kitale – Kapolet, Kimilili and Malaba-Kakoli spring supplies are gravity schemes while Kitale-Nzoia, Bungoma (Matisi), Webuye (Nabuyole) and Malaba- Malakisi supplies are pumping schemes. The NRW levels for Kitale, Bungoma, Webuye and Kimilili schemes are 42 percent, 40 percent, 63 percent and 44 percent respectively (NZOWASCO annual report, 2011/2012).

Webuye water supply scheme treatment plant is located in western part of Kenya, Bungoma County, Bungoma East district next to Broderick Falls (Nabuyole falls) on river Nzoia. The system was initially constructed in 1972 and has been augmented three times. The water is abstracted from Nzoia River at Broderick Falls and treated in a fully conventional treatment plant. Treated water is pumped to a balancing reservoir from where it is gravitated to Webuye Town. The scheme currently supplies treated piped water to estimated 50,000 people living within Webuye Municipality. The plant was augmented in 2010 after which the NRW rose to 69 percent from 48 percent. The schemes infrastructure is characterized by new well maintained treatment works and transmission lines, and old dilapidated distribution and service lines with high pressures. The metering ratio stands at 67 percent with an average revenue collection efficiency of 94 percent. The schemes' major challenges are; High levels of NRW (63 percent), high operation and maintenance costs with electricity costs accounting for 2/3 of the costs, high chemical consumption due to high turbidity of the raw water, and vandalism and theft of brass water meters, GI pipes and other appurtenances.

2.7.1 Impacts of Non Revenue Water

(i) The Vicious and Virtuous Circles

According to Farley et al (2008), the 'Vicious Circle' of NRW has been considered as one of the key reasons for water utility's poor performance and results in both physical and commercial losses. Physical losses or leakages divert precious water from reaching customers and increase operating costs. They also result in larger investments than necessary to augment network capacity. Commercial losses, caused by customer meter inaccuracies, poor data handling, and illegal connections, reduce income and thereby financial resource generation.

According to Frauendorfer and Liemberger (2010), "no business can survive for long if it loses a significant portion of its marketable product", but that is exactly what is happening with many water utilities. High levels of NRW lead to low levels of efficiency. When a utility's product (treated water) is lost, water collection, treatment and distribution costs increase, water sales decrease, and substantial capital expenditure programs are often promoted to meet the ever-increasing demand. In short, the utility enters into a vicious cycle that does not address the core problem. The challenge for water utility managers is to transform the Vicious Circle into the 'Virtuous Circle'. In effect, reducing NRW releases new sources of both water and finances. Reducing excessive physical losses results in a greater amount of water available for consumption and postpones the need for investing in new sources. It also lowers operating costs. Similarly, reducing commercial losses generates more revenues (Farley et al, 2008).

(ii) Impacts of Non Revenue Water on Customers

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. 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. This will discourage local governments to approve tariff increases that could help improve the situation, and the vicious NRW management cycle will be reinforced. In the long run, high levels of NRW may lead to unnecessarily high tariffs (if tariffs are properly set). In these cases, high water tariffs can in effect, represent a subsidy borne by paying customers to cover NRW. If tariffs are not high enough, the water utility will remain financially weak and will not be able to provide appropriate service to its customers.

In water systems characterized by unsatisfied demand and limited coverage, a high level of NRW is often the main reason why the system cannot be improved. In many cases, the population is then forced to use alternative water sources, which are often of poor quality and high in cost. There are two reasons for this situation;

First, where raw water is limited, the volume of water that is physically lost is often required to supply unserved areas. Second, poor financial performance that results from high NRW makes it difficult to finance distribution network expansion.

2.7.2 Addressing Non Revenue Water

Liemberger and Marin (2006), clarified that: although minimising non-revenue water should be a priority for water utilities, many still struggle to achieve acceptable NRW levels. The reasons NRW strategies fail range from not understanding the magnitude of the problem to lack of financial or human resource capacity. In addition, utility managers often do not pay enough attention to NRW because of weak internal policies and procedures, which contributes to rising NRW levels. NRW management is not a one-off activity, but one requiring a long-term commitment and involvement of all water utility departments. 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. Underestimating NRW's complexity, and the potential benefits of reducing NRW, often lead to reduction programmes' failure. Successful NRW reduction is not about solving an isolated technical problem, but is instead tied to overall asset management, operations, customer support, financial allocations and governance. However, utility managers' understanding of the institutional dimension of NRW is growing, new methodologies that quantify physical and commercial losses more accurately are emerging to support sustainable NRW reduction (Liemberger and Marin, 2006).

Liemberger and Marin (2006), have identified factors that influence the scope for managing water losses and demand, and affect the pace of change as follows; Rapid urbanization, environmental pollution, outdated infrastructure, diminishing water supply, poor operations and maintenance policy, including ineffective record-keeping systems, inadequate technical skills and technology and greater financial constraints, including unsuitable tariff structure and/or revenue collection policy. The other contributors also include; political, cultural, and social influences, work ethic and level of industriousness, ability to make do with available resources and materials and level of staff motivation for developing potential technical capacity

According to JICA (2011), step wise process of addressing of NRW follows three main steps; (1) Identifying the causes of non revenue water and quantifying them (Water balance), (2) prioritizing target NRW components and developing a reduction strategy and (3) implementation of the NRW reduction strategy by involving all stake holders. This study was limited to factors influencing NRW (causes).

The key to developing a water loss strategy is to gain a better understanding of the reasons for losses and the factors which influence them. Then techniques and procedures can be developed, and tailored to the specific characteristics of the network and local influencing factors, to tackle each of the causes in order of priority. It is only by quantifying NRW and its components, calculating appropriate performance indicators, and turning volumes of lost water into monetary values, that the NRW situation can be properly understood and the required actions taken.

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. Typical questions to be asked are; (i) How much water is being lost? (ii) Where are the losses occurring? (Where is it being lost from?) (iii) Why is it being lost? (iv) What strategies can be introduced to reduce losses and improve performance? (v) How can we maintain the strategy and sustain the achievements gained?

The first two questions, the components of NRW, and the priority areas of the network for investigation, can be determined by conducting a water balance calculation. The planning and implementation of the NRW strategy addresses the remaining three questions. As explained earlier, this study dealt with the third question but for the purpose of understanding table 2.1 summarizes the tasks required to address each of the five questions.

Table 2. 1: NRW Levels for Selected Kenyan WSPs

Question	Task
1. How much water is being lost?	Water Balance
➢ Measure components	▪ Improved estimation/measurement techniques ▪ Meter calibration policy ▪ Meter checks ▪ Identify improvements to recording procedures
2. Where is it being lost from?	Network audit
➢ Quantify leakage	▪ Leakage studies (reservoirs, transmission mains, distribution network)
➢ Quantify apparent losses	▪ Operational/customer investigations
3. Why is it being lost?	Review of network operating practices
➢ Conduct network and operational audit	▪ Investigation of; - historical reasons - poor practices - quality management procedures - poor materials/infrastructure - local/political influences - cultural/social/financial factors
4. How to improve performance?	Upgrading and strategy development
➢ Design a strategy and action plans	▪ Update records systems ▪ Introduce zoning ▪ Introduce leakage monitoring ▪ Address causes of apparent losses ▪ Initiate leak detection/repair policy ▪ Design short-medium-long-term action plans
5. How to maintain the strategy?	Policy change, training and O&M.
	▪ Training: - Improve awareness. - Increase motivation.

- Transfer skills.
- Introduce best practice/technology.

- O&M:
  - Community involvement
  - Water conservation and demand management programmes.
  - Action plan recommendations.
  - O&M procedures.

Source: Liemberger et al. (2005)

2.7.3 The Water Balance Concept

According to Liemberger and Farley (2005), the first step in reducing NRW is to develop an understanding of the 'big picture' of the water system, which involves establishing a water balance. In the United States, water balance is also called a 'water audit'. This process helps in understanding the magnitude, sources, and cost of NRW (quantity of water being lost). The International Water Association (IWA) developed a standard international water balance structure, a concept that has been adopted by national associations in many countries across the world (table 2.2).

According to Lambert (2001), international report on 'Water Losses Management and Techniques', he prioritized the IWA standard water balance and definitions as the basic and essential first step in management of Water Losses, then followed by the assessment and management of unbilled authorised consumption which is part of non revenue water, but not part of water losses in the IWA definitions. Next followed the assessment and management of components of apparent losses.

Table 2. 2: Standard IWA water balance structure showing NRW components

System Input Volume	Authorized Consumption	Billed Authorized Consumption	Billed metered consumption	Revenue Water
			Billed unmetered consumption	
		Unbilled Authorized Consumption	Unbilled metered consumption	Non-Revenue Water
			Unbilled unmetered consumption	
	Water Losses	Apparent Losses	Unauthorized consumption	
			Metering inaccuracies and data handling errors	
		Real Losses	Leakage on transmission and/or distribution mains	
			Leakage and overflows at utility's storage tanks	
			Leakage on service connections up to point of customer metering	

Source: Farley et al. (2008)

Non-revenue water (NRW) is equal to the total amount of water flowing into the water supply network from a water treatment plant (the ‘system input volume’) minus the total amount of water that consumers are authorised to use (the ‘authorised consumption’). NRW = system input volume - billed authorised consumption.

This equation works on the assumptions that; (i) Any known errors for system input volume are corrected and (ii) Customer billing records for metered consumption period are consistent with the system input volume period.

2.7.4 Systematic Determination of the Non Revenue Water Components.

Where are the losses occurring?

Farley et al. (2003), outlined in his book 'Losses in Water Distribution Networks' the following five steps as a guideline for determination of NRW components. The guideline was also supported by (Farley et al. 2008).

Step 1 – Determining System Input Volume

Annual system input volume is equivalent to the summation of the metered system input measurement for an entirely metered system. Ideally the accuracy of the input meters is verified, using portable flow measuring devices. If discrepancies between meter readings and the temporary measurements are discovered, the problem has to be investigated and, if necessary, the recorded quantity has to be adjusted to reflect the real situation.

For existence of any unmetered sources, the annual flow has to be estimated by using any (or a combination) of the following: (i) temporary flow measurements using portable devices, (ii) reservoir drop tests or (iii) analysis of pump curves, pressures and average pumping hours.

Step 2 – Determining Authorized Consumption

According to Lambert (2001), authorised consumption includes items such as fire fighting and training, flushing of mains and sewers, cleaning of suppliers' storage tanks, filling of water tankers, water taken from hydrants, street cleaning, watering of municipal gardens, public fountains, frost protection, building water etc. These may be billed or unbilled, metered or unmetered, according to local practice.

a. Billed Metered Consumption

The calculation of the annual billed metered consumption goes hand in hand with the detection of possible billing and data handling errors, information later on required for the estimation of apparent losses. Consumption of the different consumer categories (e.g. domestic, commercial, industrial) have to be extracted from utility's billing system and analyzed. Special attention shall be paid to the group of very large consumers.

b. Billed Unmetered Consumption

Billed unmetered consumption can be obtained from the utility's billing system. In order to analyse the accuracy of the estimates, unmetered domestic customers are identified and monitored for a certain period, for example by measuring a small area with a number of unmetered customers.

c. Unbilled Metered Consumption

According to Lambert (2001), unbilled authorized consumption is normally only a small component of the water balance. The volume of unbilled metered consumption has to be established similar to that of billed metered consumption.

d. Unbilled Unmetered Consumption

Unbilled unmetered consumption, traditionally including water used by the utility for operational purposes, is very often seriously overestimated. This might be caused by simplifications (a certain percentage of total system input) or overestimates on purpose to 'reduce' water losses. Components of unbilled unmetered consumption are identified and individually estimated, for example: (i) Mains flushing: how many times per month? for how long? how much water? (ii) Fire fighting: has there been a big fire? how much water was used?

2.7.5 Quantifying Real and Apparent Losses

Once the volume of non revenue water is known it is necessary to break it down into real and apparent losses, which is always a difficult task.

Step 3 – Estimating Apparent Losses

According to Lambert (2001), apparent losses consist of unauthorized consumption (theft and illegal use), metering and data handling errors. Calculations of these volumes are preferably based on structured sampling tests, or estimated by a robust local procedure (which should be defined for audit purposes). Some quoted figures for apparent losses in the country reports (as percentage of system input volume (SIV) are; Malaysia apparent losses 9 percent of SIV, Korea apparent losses 9.2 percent of SIV in 1998 and Australia apparent losses 1-3 percent of SIV.

Lambert (2001), further recommended for each utility to attempt to assess and manage the components of apparent losses for its own system(s) instead of assuming that apparent losses are some nominal percentage of system input volume, based on figures for other utilities.

a. Unauthorized Consumption

It is difficult to provide general guidelines of how unauthorized consumption is estimated.

The estimation of unauthorized consumption is always a difficult task and is done in a transparent, component based way so that the assumptions can later easily be reviewed.

According to Frauendorfer and Liemberger (2010), unauthorized consumption can be determined by subtracting the sum volume of unbilled authorised, real losses and metering inaccuracies from the volume of non revenue water.

b. Customer Meter Registration Inaccuracies and Data Handling Errors

The extent of customer meter registration inaccuracies, namely under or over registration, has to be established based on tests of a representative sample of meters. The composition of the sample shall reflect the various brands and age groups of domestic meters. Based on the results of the accuracy tests, average meter inaccuracy values (as percentage of metered consumption) are established for different user groups. Data handling errors sometimes form substantial component of apparent losses.

Step 4 – Calculating Real Losses

Real losses are calculated as volume of NRW minus sum volume of apparent losses and authorized unbilled, this figure is useful for the start of the analysis in order to get a feeling which magnitude of real losses can be expected. Confidence limits of 95 percent are applied to all water balance data. This define the boundaries within which utility managers can be 95 percent sure that the true value for that particular component lies.

Step 5 – Estimating Real Loss Components

Detailed component analysis is used to accurately split real losses into its components. However, a first estimate can be made using a few basic estimates.

a. Leakage on Transmission and /or distribution mains

Leaks and bursts on distribution 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.

b. Leakage and overflows at utility's storage tanks

Leakage and overflows at storage tanks are usually known and can be quantified.

c. 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.

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. However, it always need 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.

(i) Component Analysis

Liemberger and Farley (2005), listed 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.

a. 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, it is recommended to use the figures from table 2.3.

Total annual volume of leakage from mains = Number of reported bursts x Average leak flow rate x Average leak duration.

Table 2. 3: Flow rates for reported and unreported bursts

Location of Burst	Flow Rate for Reported Bursts [l/hour/m pressure]	Flow Rate for Unreported Bursts [l/hour/m pressure]
Mains	240	120
Service Connection	32	32

Source: IWA Water Loss Task Force (2003)

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. Table 2.4 shows background losses from various components of the network with average infrastructure condition.

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.

Table 2. 4: Calculating Background Losses

Location of Burst	**Litres**	**Unit of Measure**
Mains	9.6	Litres per km of mains per day per metre of pressure.
Service Connection – main to property boundary.	0.6	Litres per service connection per day per metre of pressure.
Service Connection – property boundary to customer meter.	16.0	Litres per km of service connection per day per metre of pressure.

Source: IWA Water Loss Task Force (2003)

(ii) Bottom-up Real Loss Assessment

a. 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. All relevant data on the zone are collected, such as; (i) length of mains, (ii) number of service connections, (iii) number of household properties and (iv) number and types of non-household properties.

2.8 Theoretical Framework

The study was based on the International Water Associations' water balance theory. This theory proposes that a water utility system input volume can be subdivided into two components namely authorized consumption and water losses. The theory further breaks down authorized consumption into billed authorized consumption and unbilled authorized consumption. The theory also suggests further breakdown of water losses into apparent (commercial) losses and real losses. Finally the theory suggest 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 which was the area of focus of this research report for Webuye water supply scheme.

2.9 Conceptual Framework

The study had two main variables; factors influencing (independent) and non revenue water (dependent). The independent variable was broken into sub-variables namely; meter registration inaccuracies, unmetered consumption, illegal consumption and water tariff. The factors were assumed to have effect on the day to day provision of water services hence influenced the level of Non Revenue Water at Webuye water supply scheme. The indicator for measuring the level of NRW was the percentage ratio of the volume of water unbilled to the volume of water injected into the distribution system or percentage volume of water "lost" as a share of net water produced. The relationship between these variables is shown in the conceptual framework of the study, figure 3.1.

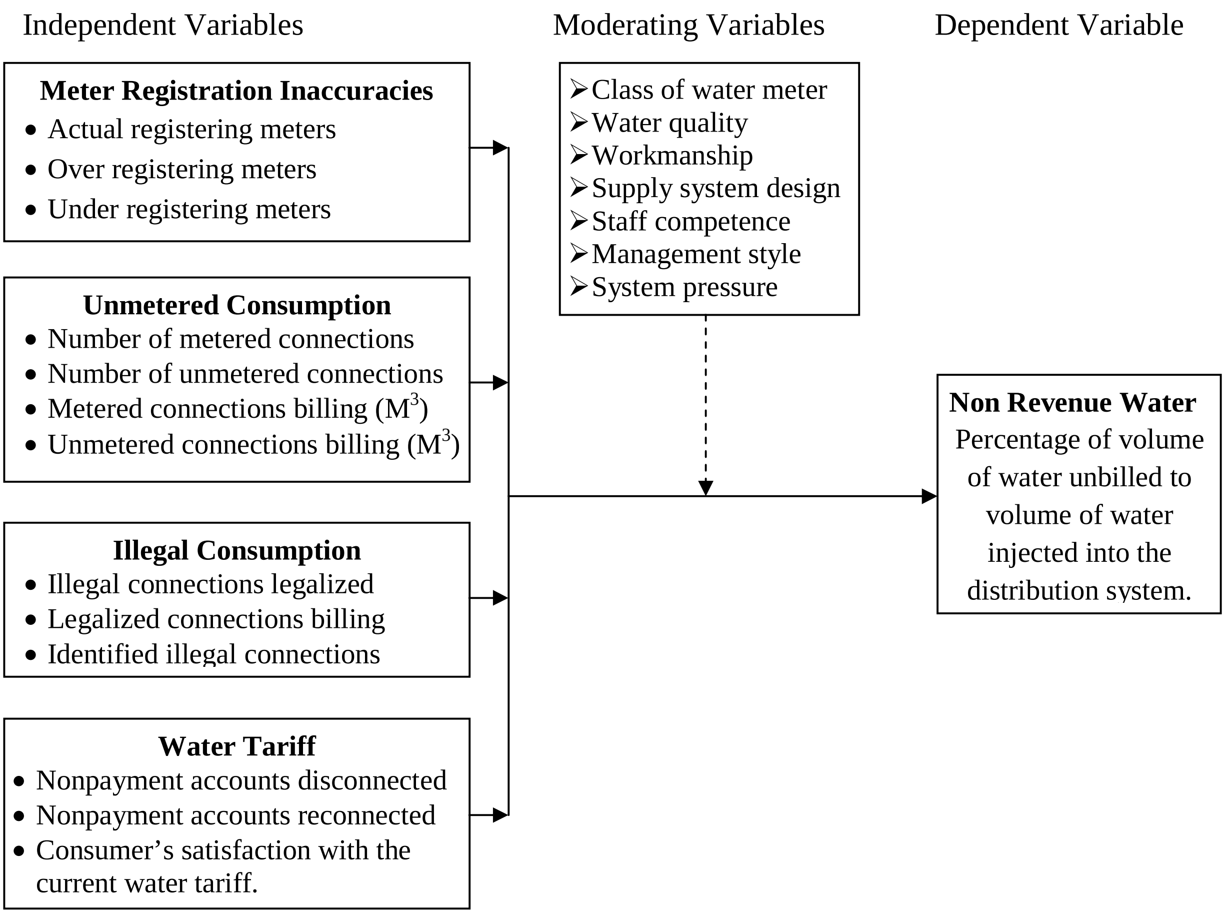

Figure 3.1: Perceived Conceptual Framework

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

Methodology refers to application of the principles of data collection methods and procedures in any field of knowledge. It is the system of methods or procedures used in sampling and collecting data required for a particular research. This chapter describes the research methodology that was adopted for this study. It provides details on the research design, target population, sample selection and sample size, the research instruments, instrument validity and reliability, data collection procedure and data analysis techniques applied.

3.2 Research Design

According to Mugenda (2008), research design is the conceptual structure within which research is conducted. It is the overall conception of the study including the description of all concepts, variables and categories, the relational propositions and the methods of data collection and analyses. This study employed an ex-post facto descriptive survey research methodology with both quantitative and qualitative research designs. This is a survey research design used to determine reasons or causes for the current status of the phenomenon under study. As a result of the cause-and-effect relationships, this research design does not permit the manipulation of the variables (Patton, 2002). This research design was adopted for the study because the cause (independent variables) was studied after they had exerted their effect on the dependent variable. Therefore, the researcher proceeded to investigate the independent variables in retrospect for their effect and possible relationship with the dependent variable.

The study was concerned with ascertaining the influence of the identified factors on Non Revenue Water levels at Webuye water supply scheme. Such influences are best investigated through survey research design (Kerlinger, 1986).

3.3 Target Population

According to Mugenda (2008), the target population comprises of all individuals, objects or things that the researcher can reasonably generalize his or her findings to. This study targeted a population of all the registered 1658 water consumer connections of Webuye water supply scheme as at 30th June 2012 (NZOWASCO 2011/2012 report).

According to Nzoia Water Services Company Limited 2011/2012 annual report, Webuye water supply scheme had a registered consumer base of 1658 consumers as at 30th June 2012. The composition of all the registered water consumer connections was 1540 domestic, 60 institutional, 51 commercial and 7 kiosks. Out of the 1658 registered water consumer connections, 1038 were billed based on actual meter readings and the rest (620) were estimated.

3.4 Sample Size and Sampling procedure

To determine the sample sizes for the registered water consumer connections, the researcher applied Yamane, T. (1967) formula at 93 percent confidence level.

Thus,

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

Where n = required responses.

N = sample size.

e^2 = precision level.

Thus the targeted sample size for registered water consumer connections was 183. According to Airy et al (1972), a sample of 10 percent to 20 percent is acceptable, thus from a population of 1658, the researcher worked with a sample of 183 respondents representing 11.03 percent of the total population, this was to avoid the biasness associated with small samples which tend not to be representative (Mugenda and Mugenda, 1999). The researcher did not use a sample size of more than 11 percentage as the study would have required more funding and time which were limited.

Taking time and financial factors in consideration for carrying out the research, the researcher adopted sampling approach. The sampling techniques the researcher adopted were; First, stratified sampling was applied whereby the researcher classified the respondents in four main strata (domestic, institutional, commercial and kiosks). This was to increase efficiency because it was important to treat homogenous parts of the population as populations in their own rights as a result of the population not being homogeneous. Second, systematic sampling was applied to the domestic stratum, whereby the targeted respondents were grouped into 70 groups each consisting of 22 respondents, after which the 3rd and 8th members from each group were selected to form a sample of 140. Third step involved carrying out random sampling on both institutional and commercial targeted respondents, out of which 20 institutional and 16 commercial were selected. Fourth, all the 7 kiosks targeted respondents were selected as they constituted only 0.42 percent of the targeted population.

Table 3.1 is the sampling frame for the registered consumer categories that were sampled and their sample sizes respectively.

Table 3. 1: Sampling Frame

	Stratum	Population	100% Sample / criteria	Respondents
1	Domestic	1540	9.1 (homogeneous)	140
2	Institutional	60	33	20
3	Commercial	51	32	16
4	Kiosks	7	100	7
	Total	**1658**	**11.03**	**183**

3.5 Data Collection Instruments

The core of the study was formed by both primary and secondary data that was collected from the field and from the company records respectively. They were important in providing the basis of the study and the conclusions. Primary data was collected through questionnaires and field observations while secondary data was obtained through document review. The questionnaire as a tool was used because was familiar to most people (Berdie et al. 1986). 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 (Kerlinger, 2004). The questionnaire was arranged into four sections; section one dealt with general information, section two focused on unmetered consumption, section three dealt with illegal consumption and section four captured information on water tariff. The questionnaire was administered through the support of four NZOWASCO metering officers from Webuye scheme. The document review was used to afford the researcher the opportunity to access the past characteristics of connected active water service users over a given period, illegal consumption cases filed and the corresponding non revenue water levels, while field observations enabled the researcher to gain first hand information of the consumer meters registration accuracy.

3.5.1 Validity of Research Instrument

Fraenkel and Wallen (2000), defined validity as the accuracy, soundness or effectiveness with which an instrument measures what it is purported to measure. It is the degree to which results obtained from the analysis of data actually represent the phenomenon under study. Content validity refers to how representative the items on the instrument are in relation to the content measured (Kathuri & Pals, 1993). Mehrens, et al. (1987), refers face validity to whether the test looks valid “on the face of it”. This research adopted the content validity technique to measure the validity of instruments that were to be used. In constructing the instruments, simple English language that the respondents easily understood was used. Content validity of the instrument was established in two stages. First, the researcher critically considered each item in the instrument to see if it contained a real representation of the desired content and if it could measure what it was supposed to measure after considering the constructs to be measured. Secondly, the instrument was presented to two research experts then to the supervisor who evaluated the applicability and appropriateness of the content, clarity and adequacy of the of the instrument construction from a research perspective. They indicated by tick or cross for every item in the questionnaire if it would measure what it was expected to measure or not. The recommendations of the research experts and the supervisor were considered and incorporated in the final instrument.

3.5.2 Instrument Reliability

Mugenda and Mugenda (2002), defines reliability as the degree to which a research instrument yields constant results or data after repeated trials. It is concerned with the internal properties of a measure and indicates the accuracy or precision of the research instrument. Koul (1993), states that the reliability of a test refers to the ability of that test to consistently yield the same results when repeated measurements are taken of the same individual under the same conditions.

To ensure reliability of the research instruments and that the research instruments yielded consistent results, pre-testing through piloting was done. This involved administering the research instruments to 10 respondents from Bungoma water supply scheme which was outside the study area at two separate times (two weeks interval) to determine the instruments' reliability. A Pearson product moment formula was used to calculate the reliability of the instrument by calculating the correlation coefficient to establish the relationship between the two sets of scores.

$$r = \frac{\sum xy - n\bar{x}\bar{y}}{\sqrt{\sum x^2 - n(\bar{x})^2}\sqrt{\sum y^2 - n(\bar{y})^2}}$$

Where r = Correlation coefficient

n = Paired sample size,

When $r = 1$, a perfect positive correlation exists between the variables,

$r = 0$, no linear correlation exists between the variables,

$r = -1$, a perfect negative correlation exists between the variables.

A correlation coefficient (r) of +0.68 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 Procedure

The primary data for this study was obtained through questionnaires and field observations. The questionnaire was administered on sampled registered active water consumers served by Webuye water supply scheme. The questionnaire research instrument was entitled 'Webuye water supply non revenue water questionnaire'. It helped to capture the respondents' connection status, water consumption and payment behavior. The field observation research instrument was called 'Webuye water supply consumer meters accuracy'. Field observations were used to assess the accuracy of water consumer meters by measuring water flow using FLEXIM FLUXUS® ADM 6725 ultrasonic flow meter. The FLEXIM FLUXUS® ADM 6725 meter is a clamp-on (non-intrusive) type allowing measurement of the discharge without disruption of flow in the pipe. The accuracies of sampled consumer meters less than 38mm diameter were determined through the use of meter test bench at Eldoret water and sanitation company Ltd.

The secondary data for this study was obtained through document review. The data reviewed included consumer billing history, metering history and illegal consumption case records. The sample for registered water service users and consumer meters was determined through stratified random sampling techniques which according to Kombo et al. (2006), involves dividing the population into homogeneous subgroups and then taking a simple random sample in each subgroup. The researcher classified the registered water users into four main strata as follows; domestic users, institutional users, commercial users and kiosk users. Each stratum was subjected to random sampling of which summation of all the samples from the four strata gave sample sizes of 183 registered water consumers and 183 consumer water meters.

3.7 Data Analysis Techniques

Data is a collection of facts and figures (Mugenda and Mugenda, 2003). The raw data collected was classified, coded, summarized and presented for analysis. Descriptive statistics was used in the analysis of the data to enable the researcher to meaningfully describe phenomena using few indices (Singleton 1993), this was facilitated by use of SPSS (Statistical Package for Social Sciences). The quantitative data generated was subjected to the descriptive statistics feature in SPSS 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 besides carrying out hypothesis testing. 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 Operational Definition of Variables

The variables that were considered in this study were two (dependent and independent). The dependent variable was non revenue water (NRW), while independent variables were meter registration inaccuracies, unmetered consumption, illegal consumption and water tariff. The variables in this study were measured by use of nominal, ordinal and ratio scales as illustrated in table 3.2.

Table 3. 2: Operational Definition of Variables

Variable	Indicator (measurement)	Measurement scale
Dependent:		
Non Revenue Water	Percentage of the volume of water unbilled to volume of water pumped into the distribution system.	Ratio
Independent:		
Meter registration inaccuracies	Number of meters which registered actual readings	Ordinal
	Number of meters that over registered	Ordinal
	Number of meters that under registered	Ordinal
Unmetered consumption	Number of metered connections	Nominal
	Number of unmetered connections	Nominal
	Volume billed on metered connections	Ordinal
	Volume billed on unmetered connections	Ordinal
Illegal consumption	Number of illegal connections legalized	Nominal
	Volume billed on illegal connections legalized	Ordinal
	Number of illegal connections identified	Nominal
Water tariff	Number of accounts disconnected due to water bill nonpayment.	Nominal
	Number of accounts reconnected after disconnection due to water bill nonpayment.	Nominal
	Number of consumers comfortable with the current water tariff.	Nominal

3.9 Ethical Considerations

In this study, the researcher sought permission to carry out the research from Nzoia Water Services Company. Utmost caution was exercised while administering questionnaires to avoid any mistrust between the respondents and the researcher. Both NZOWASCO and the respondents in the study were assured of confidentiality of the information they provided.

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION, INTERPRETATION AND DISCUSSIONS

4.1 Introduction

This chapter deals with data analysis, presentation, interpretation and discussions. Data has been organized, analyzed, presented, interpreted and discussed as per the objectives of the study and demographic information of respondents handled comprehensively.

4.2 Questionnaire Return Rate

A total of 183 water consumer connection units within Webuye Water Supply scheme were sampled. Questionnaires were administered to them. Out of 183 questionnaires that were presented to the consumer connection units, 164 were returned dully filled representing 89.60% and 19 were not returned as shown in table 4.1.

Table 4. 1: Questionnaire Return Rate

Questionnaires	Number	Percentage
Returned	164	89.60
Not returned	19	10.40
Total issued	183	100.00

The study also targeted a total of 183 consumer meters from all the four category of consumers from Webuye water supply scheme. During the study, 180 consumer meters were successively tested representing 98.36% response rate. The successes were accredited to the proper field preparation done by the researcher and easy of accessing the respondents through the support of four metering officers from Webuye water supply scheme.

4.3 Respondents Demographic Characteristics and Consumer Water Meter Characteristics

The study sought to find out the background information of the demographic characteristics of the respondents. This was meant to provide the basis of understanding the composition of the respondents and to determine their gender, age brackets and consumption category. The study also sought to find out the characteristics of consumer water meters that included the class, brand, size, material and period of service.

4.3.1 Distribution of Respondents by Gender

The first demographic characteristic that the study explored was gender. An analysis of the gender distribution of the respondents was carried out and presented in a gender distribution as shown in table 4.2. Knowing the gender of respondents was important in establishing whether the study was representative of all the gender and therefore not biased.

Table 4. 2: Gender of the Respondents

Gender	Frequency	Percentage
Male	62	37.80
Female	102	62.20
Total	**164**	**100.00**

The results reveal that 37.80% of the respondents were male while 62.10% were female. The number of female respondents was higher than the male respondents due to the fact that the questioners were administered on week days during working hours (8.30am to 4.30 pm), thus most of the men were out of the households working unlike most of the women who were taking care of the households. Some of the men found in the homes felt that it was the women who knew more about water issues as they were left to most of them to handle in most homes.

4.3.2 Distribution of Respondents by Age

The second demographic characteristic that the study explored was age. An analysis of the age distribution of the respondents was carried out and presented in an age distribution as shown in table 4.3.

Table 4. 3: Respondents Age Distribution

Respondents' Age	Frequency	Percentage
18 – 30 yrs	51	31.10
31 – 40 yrs	68	41.50
41 – 55 yrs	38	23.20
Above 55 yrs	7	4.20
Total	**164**	**100.00**

Table 4.3 results indicate that respondents who fell between 18 - 30 years were 51 (31.10%), those between 31- 40 years were 68 (41.50%), those between 41 - 55 years were 38 (23.20%) and those over 55 years were 7 (4.20%). Majority of the respondents fell between ages 31 – 40 years. From these results it is clear that the study followed a normal distribution whereby there are fewer respondents in the lower and higher age segments and more respondents in the middle age segments. From this it can be inferred that the study sample was representative of the population.

4.3.3 Distribution of Respondents by Consumer Category

The study sought to find out more about consumer category as a third characteristic. An analysis of the consumer category of the respondents was carried out and presented in a consumer category distribution as shown in table 4.4. Knowing the consumer category of respondents was important in establishing whether the study was representative of the entire consumer category and therefore not biased.

Table 4. 4: Distribution of the Respondents by Consumer Category

Respondents' Consumer Category	Frequency	Percentage
Domestic	124	75.60
Institution	19	11.70
Commercial	14	8.50
Kiosk	7	4.20
Total	**164**	**100.00**

The results from table 4.4 above indicate that respondents who fell in domestic category were 124 (75.60%), those from institution category were 19 (11.70%), the ones from commercial category were 14 (8.50%) and those from kiosk category were 7 (4.20%). Majority of the respondents fell in the domestic category. From this it can be inferred that in deed the study sample was representative of the entire population.

4.3.4 Distribution of Consumer Water Meters by Class

Further, the study investigated consumer water meter by class and the findings were as presented in table 4.5. Knowing the meter class was important in ascertaining accuracy of the meters based on the meter classes.

Table 4. 5: Distribution of the Consumer Meters by Class Category

Meter class	Frequency	Percentage
B (10 bars)	57	31.70
C (16 bars)	123	68.30
Total	**180**	**100.00**

The results indicated that 57 (31.70%) were class 'B' meters and 123 (68.30%) were class 'C' meters. The researcher analysis along the class line revealed that more of the class 'C' meters had been in use for a shorter period as compared to the class 'B' ones, this was as a result of the company (NZOWASCO) providing 'C' meters to the consumer connections and no consumer was allowed to buy a water meter for him/herself as from July 2009.

4.3.5 Distribution of Consumer Water Meters by Brand

The study also sought to find out the sampled water meters brands. The results were as presented in table 4.6. Knowing the meter brand was important in ascertaining accuracy of the meters based on the meter branding.

Table 4. 6: Distribution of Water Meters by Brand Category

Meter Brand	Frequency	Percentage
Kent	91	50.60
LXSG-15S	39	21.70
Younso	50	27.70
Total	**180**	**100.00**

Study results in table 4.6 shows that majority of the meters were of Kent brand 91 (50.60%), then followed by Younso brand 50 (27.70%) and the minority brand was LXSG-15S 40 (21.70%).

4.3.6 Distribution of Consumer Water Meters by Size

The study further investigated the distribution of sampled consumer water meter by sizes and the results were as tabulated in table 4.7.

Table 4. 7: Distribution of Consumer Water Meters by Size

Meter size (inches)	Frequency	Percentage
½	132	73.30
¾	18	10.00
1	11	6.10
1½	10	5.60
2	9	5.00
Total	**180**	**100.00**

The table 4.7 on cross tabulation indicates that ½ inch size meters were the majority 132 (73.30%) all of them being of domestic connections, ¾ inch size meters 18 composed 10.00% of the sampled meters which belonged to 5 domestic, 6 commercial and 7 kiosk connections. A total of 10 in number 1 inch meters were sampled of which 7 belonged to the commercial and 3 to the institution connections respectively. 1 of the sampled 1½ inch meters was from a commercial connection while 8 of them were from the institution connections. Finally all the 2 inch (9no) meters were from the institution connections. From this it can be inferred that the sample was representative of the entire population.

4.3.7 Distribution of Consumer Water Meters by Material

The study also investigated the distribution of sampled consumer water meter by material and the results obtained were as tabulated in table 4.8. Data on meter material was important so as to determine whether there was a relationship between meter registration error (accuracy) and the material of the meter.

Table 4. 8: Distribution of Consumer Water Meters by Material

Meter Material	Frequency	Percentage
Brass	76	42.20
Plastic	104	57.80
Total	**180**	**100.00**

Results in table 4.8 revealed that plastic meters were the majority 104 (57.80%) while brass meters were the minority 76 (42.20%). The brass meters were more expensive besides being susceptible to theft as compared to plastic ones, thus the need of NZOWASCO intensifying use of plastic ones.

4.3.8 Distribution of Consumer Water Meters by Age

The study also sought to establish age of the consumer meters sampled, results presented in table 4.9. This was to determine whether there was a relationship between meter registration error (accuracy) and meter age.

Table 4. 9: Distribution of Consumer Water Meters by Age

Meter Age (Months)	Frequency	Percentage
Below 6	10	5.56
6 – 12	36	20.00
13 – 24	45	25.00
25 – 36	51	28.33
Above 36	38	21.11
Total	**180**	**100.00**

From table 4.9 above, it can be observed that 21.11% of the meters were in use for more than 36 months, 28.33% were in use for 25 – 36 months, 25.00% were in use for 13 – 24 months, 20.00% were in use for 6 – 12 months while 5.56% were in use for less than 6 months.

4.4 Meter Registration Inaccuracies and Non Revenue Water

The first objective of the study sought to assess the extent to which water meter registration inaccuracies-related factors such as meter class, meter brand, meter age and meter material influenced non revenue water at Webuye water supply scheme of Nzoia Water Services Company Limited. This section therefore presents findings on the relationship between water meter registration inaccuracies-related factors and non revenue water.

Water meter registration inaccuracies-related factors were evaluated based on field observation tool items i, ii, iv, v and x (Appendix 2). For meter sizes ½ inch, ¾ inch and 1 inch, field observations were made from the field consumer connection points using a clamp on FLEXIM FLUXUS® ADM 6725 ultrasonic flow meter while for meter sizes 1½ inches and 2 inches, observations were made at Eldoret Water and Sanitation Company laboratory using a stationary meter test bench and recorded as item ix (volume recorded). Table 4.10 shows the distribution of the meter registration errors (inaccuracies).

Table 4. 10: Meter Registration Inaccuracies Distribution

Meter registration inaccuracy	Frequency	Percentage
–9 and below	28	15.56
–9+ to –6	21	11.67
–6+ to –3	20	11.10
–3+ to –0	88	48.89
0	6	3.33
0+ to 3	12	6.67
3+ to 6	2	1.11
6+ to 9	1	0.56
Above 9	2	1.11
Total	**180**	**100.00**

It was observed that meters that under registered between –3+ to –0 were the majority 88 (48.89%), then followed by –9 and below bracket 28 (15.56%), then –9+ to –6 bracket 21 (11.67%), –6+ to –3 bracket 20 (11.10%) and 0+ to 3 bracket 12 (6.67%). The remaining brackets had less that 5% each. 6 (3.33%) meters registered actual volumes while 17 (9.44%) meters over registered. The majority of the meters 157 (87.22%) under registered. From the proportion of under registered meters as compared to over registered meters, it can be inferred that majority of the meters were under registering which may have contributed to high NRW levels at Webuye water supply.

4.4.1 Meter Brand and Metering Inaccuracies

The study further sought to find out the influence of consumer meter brand on meter registration inaccuracies. The meter brands investigated were Kent, LXSG-15S and Younso. Table 4.11 shows the comparison of the meter brands inaccuracies observed.

Table 4. 11: Meter Brand and Metering Inaccuracies

Meter registration inaccuracy	Kent		LXSG-15S		Younso	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
–9 and below	17	18.68	3	5.13	9	16.00
–9+ to –6	11	12.06	3	7.69	7	14.00
–6+ to –3	10	10.99	4	10.26	6	12.00
–3+ to –0	45	49.45	23	58.97	20	40.00
0	3	3.30	0	0.00	3	6.00
0+ to 3	3	3.30	5	12.82	5	10.00
3+ to 6	1	1.10	1	2.56	0	0.00
6+ to 9	0	0.00	0	0.00	1	2.00
Above 9	1	1.10	1	2.56	0	0.00
Total	**91**	**100**	**39**	**100**	**50**	**100.00**

The results in table 4.11 show that majority of the meters under registered between –3+ to –0 for all the meter brands Kent 49.45%, LXSG-15S 58.97% and Younso 40.00%. The slight variations in meter registration inaccuracies within the error range brackets for all the meter brands would imply that there was no significant influence on the meter registration inaccuracies.

4.4.2 Meter Class and Metering Inaccuracies

The study investigated the influence of consumer meter class on meter registration inaccuracies. The meter classes investigated were class B and class C. Table 4.12 shows the comparison of the meter classes inaccuracies observed.

Table 4. 12: Meter Class and Metering Inaccuracies

Meter registration inaccuracy	**Class B**		**Class C**	
	Frequency	**Percentage**	**Frequency**	**Percentage**
–9 and below	11	18.97	19	15.57
–9+ to –6	7	12.07	14	11.48
–6+ to –3	6	10.34	14	10.66
–3+ to –0	30	51.72	58	47.54
0	0	0.00	6	4.92
0+ to 3	3	5.17	10	6.56
3+ to 6	0	0.00	2	1.64
6+ to 9	0	0.00	1	0.82
Above 9	1	1.72	1	0.82
Total	**58**	**100**	**122**	**100.00**

Table 4.12 results reveal that majority of the meters under registered between –3+to –0 bracket for both the classes B 51.72% and C 467.54%. However it was noted that higher percentages (93.10%) of class B meters under registered as compared to class C meters (86.10%). More percentages of class C meters (13.90%) both registered actual values and over registered as compared to class B meters (6.90%). The variations in meter registration inaccuracies within the

inaccuracy range brackets between the two meter classes would imply that there was significant influence on the meter registration inaccuracies.

4.4.3 Meter Age and Metering Inaccuracies

An investigation was carried out to establish the likely influence of consumer meter age on meter registration inaccuracies and the results were as tabulated in table 4.13.

Table 4. 13: Meter Age and Metering Inaccuracies

Age in Months	**Below 6**		**6 - 12**		**13 - 24**		**25 - 36**		**Above 36**	
Meter registration inaccuracy	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
–9 and below	0	0.00	4	10.80	4	8.89	9	18.00	9	24.32
–9+ to –6	2	18.18	4	10.80	1	2.22	7	14.00	10	27.03
–6+ to –3	0	0.00	5	13.50	20	44.44	17	34.00	9	24.32
–3+ to –0	3	27.27	17	45.90	13	28.89	11	22.00	7	16.22
0	5	45.45	2	5.50	3	6.67	0	0.00	1	2.70
0+ to 3	1	9.09	4	10.80	1	2.22	1	2.00	0	0.00
3+ to 6	0	0.00	1	2.70	0	0.00	3	6.00	2	5.41
6+ to 9	0	0.00	0	0.00	2	4.44	0	0.00	0	0.00
Above 9	0	0.00	0	0.00	1	2.22	2	4.00	0	0.00
Total	**11**	**100.0**	**37**	**100.0**	**45**	**100.0**	**50**	**100.0**	**37**	**100.0**

Table 4.13 reveals that majority 5 (45.45%) of the sampled meters below 6 months registered actual readings, for meters of age 6 – 12 months majority of them 17 (45.90%) under registered between –3+ to –0 bracket while for 13 – 24 months age majority of them 20 (44.44%) under registered between –6+ to –3 bracket. The general trend of the meters registration accuracies indicated that as the meters aged, the more they under registered, this would imply that they had a significant influence on the meter registration inaccuracies.

A pearson correlation coefficient was computed to examine the relationship between meter registration inaccuracies and related factors. The findings of the respective correlation coefficients (*r*) were as presented in table 4.14.

Table 4. 14: Correlation Between Meter Registration Inaccuracy and Related Factors

Factors	**Meter Registration Inaccuracy**		
	N	**P-value**	**Pearson rho**
Meter class	180	.000	.692**
Meter Brand	180	.816	–.017
Meter Age	180	.000	.377**
Meter Material	180	.250	.086

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

The values in table 4.14 show that there were significant, positive relationships ($p<0.05$) between meter registration inaccuracy and meter class (rho=0.692). For Meter age (rho=0.377), the correlations were of moderate strengths, implying that meter registration inaccuracies were to a moderate extent positively associated with these factors.

On the other hand, there was no significant relationship between metering inaccuracies and meter brand (rho= –0.017: $p>0.05$), meter material (rho=0.086: $p>0.05$) indicating that meter registration inaccuracies were not influenced by meter brand and meter material.

A pearson correlation coefficient was further computed to establish the relationship between meter registration inaccuracies and non revenue water. The finding of the respective correlation coefficient (*r*) was as presented in table 4.15.

Table 4. 15: Correlation Between Meter Registration Inaccuracy and Non Revenue Water.

Meter registration inaccuracy	Non Revenue Water		
	N	P-value	Pearson rho
	180	.000	.872**

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

The correlation between meter registration inaccuracy and non revenue water was 0.872 with a p - value of 0.00, since the p - value was a value less than 0.05, then we conclude that at 1% level of significance, meter registration inaccuracy had positive influence on non revenue water.

4.5 Unmetered Consumption and Non Revenue Water

The second objective of the study sought to establish how unmetered consumption influenced non revenue water at Webuye water supply scheme of Nzoia Water Services Company Limited. The study investigated the individual water consumption trends before metering and after metering, then related to non revenue water levels at the respective times. A correlation between the unmetered consumption and respective non revenue water levels was carried out to establish their relationship. This section therefore presents findings on the relationship between unmetered consumption and non revenue water.

Water consumption data before and after metering was obtained using items in part II (unmetered consumption) of 'Webuye Water Supply Non Revenue Water Questionnaire' tool appendix 1. The researcher administered the tool to the respondents who were required to fill the questioners as per what the items required. The items used included consumer metering status, the monthly consumption before metering and after metering and vise visa. The difference in consumption was coded as follows; 1= less than –10%, 2 = equal to or greater than –10% and less than –5%, 3= equal to or greater than –5% and less than 0, 4 = 0%, 5 = greater than 0 and equal to or less than 5%, 6 = greater than 5% and equal to or less than 10%, and 7 = greater than 10%. The non revenue water levels were obtained through document review from NZOWASCO billing system database and recorded in 'Non Revenue Water' tool appendix 3 as item (v).

4.5.1 Metered and Unmetered Connections

An investigation was carried out to establish the samples' proportion of metered and unmetered connections, the results were as tabulated in table 4.16.

Table 4. 16: Metered and Unmetered Connections

Connection Status	Frequency	Percentage
Metered	107	65.20
Unmetered	57	34.80
Total	**164**	**100.00**

Metered connections were the majority commanding 65.20% of all the 164 connections sampled. With 34.50% of the sampled connections being unmetered, there was likelihood of more water being supplied to the consumers but less being billed as a result of under estimating the consumption. According to Farley (2003), unmetered consumption promotes uneconomical water consumption contributing to increases in volumes of non revenue water.

4.5.2 Consumption Before Metering and After Metering

The study sought to find out the trends of water consumption both before metering and after metering to establish the influence of metering on consumption for 47 connections that were initially unmetered and then finally metered as per the administered questionnaire. The results were as presented in table 4.17.

Table 4. 17: Consumption Before and After Metering

Change in consumption (%)	Frequency	Percentage
$X < -10$	5	10.64
$-10 \leq X < -5$	7	14.89
$-5 \leq X < 0$	4	8.51
$X = 0$	1	2.13
$0 \leq X < 5$	8	17.02
$5 \leq X < 10$	13	27.66
$X > 10$	9	19.15
Total	**47**	**100.00**

The results reveal that there was increase in consumption reported for majority of the 47 connections 30 (63.80%). Only 1 connection (2.13%) reported no change in amount of water consumed while 17 (36.20%) reported decrease in amount of water consumed. This implied that 63.80% of the 47 connections were under billed when not metered as compared to the time when they were metered, thus the difference of 63.80% and 36.20% may be associated with non revenue water.

4.5.3 Consumption On Metering and After Un-metering

The study sought to find out the trends of water consumption both on metering and after un-metering to establish the influence of metering on consumption for 7 connections that were initially metered and then finally un-metered as per the administered questionnaire. The results were as in table 4.18.

Table 4. 18: Consumption On Metering and After Un-metering

Change in consumption (%)	Frequency	Percentage
$-10 \leq X < -5$	0	0.00
$-5 \leq X < 0$	0	0.00
$X = 0$	6	85.8
$0 \leq X < 5$	1	14.2
$5 \leq X < 10$	0	0.00
Total	**7**	**100.00**

The results indicate that there was no change in water consumed for 85.80% of the connections while only 14.20% of the connections had an increase of less than 5% in water consumption after initially metered connections were unmetered due to meter failure. Further investigation on the slight change in water consumption after un-metering revealed that the connections whose meters had failed were billed on estimate based on the average of previous consecutive three months metered consumption, thus there might be no significant influence on non revenue water.

The study further sought to establish the influence of unmetered consumption on non revenue water at Webuye water supply by computing a correlation between unmetered connections recorded per month for the entire water supply scheme against respective non revenue water values recorded for financial years 2010/2011 and 2011/2012 as established from Webuye water supply scheme billing system data base. Pearson correlation coefficient was computed and the findings were as presented in table 4.19.

Table 4. 19: Correlation Between Unmetered/Metered Consumption and Non Revenue Water

Factors	Non Revenue Water		
	N	P-value	Pearson rho
Unmetered Consumption	24	.000	.733**
Metered Consumption	24	.000	–.856**

**Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed).

The findings indicate that there was significant strong positive relationship ($p<0.05$) between non revenue water and unmetered consumption (rho=0.733) while on the other hand, there was significant strong negative relationship between non revenue water and metered consumption (rho = –0.856). Since the p - value was a value less than 0.05, then we conclude that at 1% level of significance, unmetered consumption had positive influence on non revenue water.

4.6 Illegal Consumption and Non Revenue Water

The third objective of the study sought to examine how illegal consumption influenced non revenue water levels at Webuye water supply scheme of Nzoia Water Services Company Limited. During the study, respondents opinion on issues related to illegal water consumption were analyzed and conclusions were made based on the frequency of opinions made per item in relation to non revenue water. Further correlation analysis was made on illegal water consumption cases recorded per months for 24 successive months (July 2010 – June 2012) against the respective non revenue water levels recorded. This section therefore presents findings on the relationship between illegal water consumption and non revenue water.

The respondents opinion were obtained using 'Webuye Water Supply Non Revenue Water Questionnaire' tool appendix 1. The researcher administered the tool to the respondents who were required to fill the questioners as per what the items required. Items in part III (illegal consumption) of the tool were used to obtain data concerning the third objective of this study. Data on illegal water consumption cases and NRW levels for the period July 2010 – June 2012 was obtained through review of the company documents (NZOWASCO 2010/2011 and 2011/2012 reports) using items (i), (iv) and (v) of the non revenue water tool appendix 3.

4.6.1 NZOWASCO Water Bills Receipt Rate.

An investigation was carried out to establish the rate at which the respondents were receiving water bills from Nzoia Water Services Company Limited. This was meant to estimate the illegal consumption (connections) from the 160 respondents' sample. The results were as tabulated in table 4.20.

Table 4. 20: Water Bill Receipt Rate

Bill receipt rate	Frequency	Percentage
Monthly	133	83.13
Bimonthly	13	8.12
Quarterly	8	5.00
Annually	4	2.50
Not at all	2	1.25
Total	**160**	**100.00**

The results indicated that majority of the respondents 133 (83.13%) were receiving water bills from NZOWASCO on monthly basis, 13 (8.12%) were receiving after two month, 8 (5.00%) quarterly, 4 (2.50%) annually and 2 (1.25%) had not received at all. According to NZOWASCO

201/2012 report, water usage non payments were being disconnected after 14 days from the day of the water bill production. In cases were bills receipt by consumers were delayed due to postage delays, extension of upto 30 days from the bill production date were allowed for disconnection to be effected. Based on this the study allowed for a maximum of two months as period for receipt of water bills and beyond two months was interpreted as illegal consumption, hence based on the result obtained, only 146 (91.25%) of the respondents consumed water legally while 14 (8.75%) were illegal water consumers. We then conclude that the 8.75% (illegal consumption contributed to increase in non revenue water at Webuye water supply.

4.6.2 NZOWASCO Water Bill Payment Rate

The study further explored Nzoia Water Services Company limited water bill payment rate by the consumers, which was meant to estimate illegal consumption (connections) from the 160 respondents' sample. Table 4.21 presents the findings.

Table 4. 21: Water Bill Payment Rate

Bill payment rate	Frequency	Percentage
Monthly	128	80.00
Bimonthly	19	11.87
Quarterly	11	6.88
Annually	2	1.25
Not at all	0	0.00
Total	**160**	**100.00**

The results reveal that majority of the respondents were paying for NZOWASCO water bills on monthly basis, 19 (11.87%) on two months basis, 11 (6.88%) quarterly and 2 (1.25) annually. Adopting 4.61 water bill receipt rate ideology above, any payment beyond two months period was interpreted as illegal consumption, hence 147 (91.87%) of the respondents were legal water consumers while 13 (8.13%) were illegal water consumers, thus the 8.13% (illegal consumption) had contributed to increase in non revenue water at Webuye water supply scheme.

4.6.3 Illegal Consumption Legalized

The study also sought to establish primarily illegal consumptions that had been legalized at last, this was based on the respondents' answers. The findings were as in table 4.22.

Table 4. 22: Illegal Consumption Legalized

Illegal consumption legalized	Frequency	Percentage
Yes	17	10.63
No	143	89.37
Total	**160**	**100.00**

The results indicated that majority 143 (89.37%) of the respondents had never consumed water illegally while 17 (10.63%) had consumed water illegally after which their consumption were legalized, thus the 10.63% (illegal consumption) had contributed to increase in non revenue water at Webuye water supply.

4.6.4 Illegal Consumption Cases and Non Revenue Water Levels.

The study also evaluated the correlation between illegal consumption cases and non revenue water by computing a correlation between illegal consumption cases per month for the entire water supply scheme against respective non revenue water values recorded for financial years 2010/2011 and 2011/2012 as established from Webuye water supply scheme billing system data base and 2010/2011 – 2011/2012 reports. Pearson correlation coefficient was computed and the results were as presented in table 4.23. This was meant to examine the relationship between illegal water consumption and non revenue water at Webuye water supply scheme.

Table 4. 23: Correlation Between Illegal Consumption and Non Revenue Water

Factor	Non Revenue Water		
	N	**P-value**	**Pearson rho**
Illegal Consumption	24	.024	.460**

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

The findings indicate that there was significant moderate positive relationship ($p<0.05$) between non revenue water and illegal consumption (rho=0.460). Since the p - value was a value less than 0.05, then we conclude that at 1% level of significance, illegal water consumption had positive influence on non revenue water.

4.7 Water Tariff and Non Revenue Water

The fourth objective of the study sought to evaluate the influence of water tariff on non revenue water levels at Webuye water supply scheme of Nzoia water Services Company limited.

Liemberger and Marin (2006), observed that unsuitable tariff structure influences the scope of managing NRW, the lower the tariff structure the less investment in infrastructure maintenance hence the higher the NRW. WASH (2011) and Farley (2003) also agreed with the above observation. During the study, respondents opinion on water tariff impact related issues were analyzed and conclusions were made based on the frequency of opinions made per item in relation to water tariff. Further correlation analysis was made on two different water tariff regimes (1^{st} July 2010 – June 2011, 2^{nd} July 2011 – June 2012) against the respective non revenue water levels recorded. This section therefore presents findings on the relationship between water tariff and non revenue water.

4.7.1 Illegal Connections in Relation to Water Tariff.

The study sought to find out whether water tariff had influence on illegal connections (which are part of the causes of NRW) from the opinions presented by the respondents. The respondents opinion were grouped into four main categories (low staff pay, High water tariff, staff lack of integrity, others). The findings were as presented in table 4.24.

Table 4. 24: Illegal Connections in Relation to Water Tariff

Causes	Frequency	Percentage
Low staff pay	35	21.34
High water tariff	17	10.37
Staff's lack of integrity	43	26.22
Others	69	42.07
Total	**164**	**100.00**

The results indicated that majority of the respondents 69 (42.07%) either did not know or were unable identify the causes of illegal connections, while 43 (26.22%) of them attributed illegal connections to lack of integrity by NZOWASCO staff. 35 (21.34%) related to low pay to field staff while the minority 17 (10.37%) attributed it to high water tariff.

4.7.2 Disconnections Due to High Water Tariff

The study further explored to find out the proportion of the respondents whose water connections had been disconnected due to nonpayment of water bill resulting from high water tariff. Presented in table 4.25 are the results of the findings.

Table 4. 25: Disconnections Due to High Water Tariff

Status	Frequency	Percentage
Yes	52	31.58
No	112	68.42
Total	**164**	**100.00**

The results reveal that majority of the respondents' 112 (68.42%) water connections had not been disconnected as a result of nonpayment of water usage bill as an effect of high water tariff while minority of them 52 (31.58%) had had their water connections disconnected due to water bill nonpayment resulting from high water tariff. This may imply that the possibility of having illegal connections (consumption) as a result of illegal reconnections due to high water tariff were minimal, hence the influence of water tariff on NRW could not be significantly noticed.

4.7.3 Water Tariff Rating

An evaluation on the respondents' rating of the existed water tariff was carried out in order to establish its contribution to NRW. The tariff was rated as cheap, average and expensive, of which the findings were as in table 4.26.

Table 4. 26: Water Tariff Rating

Status	Frequency	Percentage
Cheap	0	0.00
Average	95	57.90
Expensive	69	42.10
Total	**164**	**100.00**

The findings therefore indicate that the majority of the respondents 95 (57.90%) rated the water tariff as average while 69 (42.10%) rated it as expensive. On the contrary, none of respondents rated the water tariff as cheap. Rating of the tariff as average by the majority of the respondents may imply that most of the respondents were satisfied with the water tariff, thus the possibility of them having illegal connections would be minimal hence the influence of water tariff on NRW could not be significantly categorized.

4.7.4 Water Tariff and Non Revenue Water

The study further sought to establish the relation between water tariff and NRW by computing correlation between NRW recorded and the two water tariff structures that were operational within the period of this study (July 2010 – June 2012). Table 4.27 presents the results.

Table 4. 27: Correlation Between Water Tariff and Non Revenue Water

Factor	Non Revenue Water		
	N	P-value	Pearson rho
Water Tariff	24	.189	–.278

The findings indicate that there was weak negative relationship between non revenue water and water tariff (rho= – 0.278, p>0.05). Since the p - value was a value greater than 0.05, then we conclude that there was no significant relationship between water tariff and non revenue water.

4.8 Hypothesis Testing

This section presents the summary of four hypothesis that were tested in the study namely: to test for the significance of the relationship between meter registration inaccuracies and non revenue water for Webuye water supply scheme of Nzoia Water Services Company; to test whether there was significance relationship between unmetered consumption and non revenue water for Webuye water supply scheme of Nzoia Water Services Company; to test for the significance of the relationship between illegal consumption and non revenue water for Webuye water supply scheme of Nzoia Water Services Company and to test whether water tariff had some effect on non revenue water for Webuye water supply scheme of Nzoia Water Services Company.

Hypothesis 1

Null hypothesis (H_0): There is no significant relationship between meter registration inaccuracy and non revenue water at Webuye water supply scheme.

Alternative hypothesis (H_1): There is significant relationship between meter registration inaccuracy and non revenue water at Webuye water supply scheme. In testing hypothesis 1, the study employed a Pearson correlation analysis as shown in table 4.28.

Table 4. 28: Correlation Between Meter Registration Inaccuracy and Non Revenue Water

Meter registration inaccuracy	Non Revenue Water		
	N	P-value	Pearson rho
	180	.000	.872**

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

The correlation between meter registration inaccuracy and non revenue water was 0.872 with a p - value of 0.00, since the p - value was a value less than 0.05, then at 1% level of significance, we reject null hypothesis and accept the alternative hypothesis that there is significant relationship between meter registration inaccuracy and non revenue water at Webuye water supply scheme.

Hypothesis 2

Null hypothesis (H_0): There is no significant relationship between unmetered consumption and non revenue water at Webuye water supply scheme.

Alternative hypothesis (H_1): There is significant relationship between unmetered consumption and non revenue water at Webuye water supply scheme. In testing hypothesis 2, the study employed a Pearson correlation analysis as shown in table 4.29.

Table 4. 29: Correlation Between Unmetered Consumption and Non Revenue Water

Factor	**Non Revenue Water**		
	N	P-value	Pearson rho
Unmetered Consumption	24	.000	.733**

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

The correlation between unmetered consumption and non revenue water was 0.733 with a p – value of 0.000. Since the p - value was a value less than 0.05, then at 1% level of significance, we reject null hypothesis and accept the alternative hypothesis that there is significant relationship between unmetered consumption and non revenue water at Webuye water supply scheme.

Hypothesis 3

Null hypothesis (H_0): There is no significant relationship between illegal consumption and non revenue water at Webuye water supply scheme.

Alternative hypothesis (H_1): There is significant relationship between illegal consumption and non revenue water at Webuye water supply scheme. In testing hypothesis 3, the study employed a Pearson correlation analysis as shown in table 4.30.

Table 4. 30: Correlation Between Illegal Consumption and Non Revenue Water

Factor	**Non Revenue Water**		
	N	**P-value**	**Pearson rho**
Illegal Consumption	24	.024	.460**

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

The correlation between illegal consumption and non revenue water was 0.460 with a p – value of 0.024. Since the p - value was a value less than 0.05, then at 1% level of significance, we reject null hypothesis and accept the alternative hypothesis that there is significant relationship between illegal consumption and non revenue water at Webuye water supply scheme.

Hypothesis 4

Null hypothesis (H_0): There is no significant relationship between water tariff and non revenue water at Webuye water supply scheme.

Alternative hypothesis (H_1): There is significant relationship between water tariff and non revenue water at Webuye water supply scheme. In testing hypothesis 4, the study employed a Pearson correlation analysis as shown in table 4.31.

Table 4. 31: Correlation Between Water Tariff and Non Revenue Water

Factor	**Non Revenue Water**		
	N	P-value	Pearson rho
Water Tariff	24	.189	–.278

The findings indicate that the correlation between non revenue water and water tariff was -0.278 with a p – value of 0.189. Since the p - value was a value greater than 0.05, then we fail to reject the null hypothesis and conclude that there is no significant relationship between water tariff and non revenue water at Webuye water supply scheme.

4.9 Discussions

The first objective of the study was to assess the extent to which meter registration inaccuracy influenced non revenue water at Webuye water supply scheme. The study examined the influence of meter registration inaccuracies-related factors (meter age, meter brand, meter class and meter material) on non revenue water at Webuye water supply scheme. The study found out that there were significant, positive relationships ($p<0.05$) between meter registration inaccuracy and meter class (rho = 0.692); Meter age (rho = 0.377). The correlations were of moderate strengths, implying that meter registration inaccuracies were to a moderate extent positively associated with these factors. On the other hand, there was no significant relationship between metering inaccuracies and meter brand (rho= –0.017, $p>0.05$), meter material (rho=0.086: $p>0.05$) indicating that meter registration inaccuracies were not influenced by meter brand and meter material. The study also revealed that at 1% level of significance, meter registration inaccuracy had positive influence on non revenue water. The correlation between meter registration inaccuracy and non revenue water was 0.872 with a p - value of 0.000. The findings justifies AWWA (2000), AWWA (2011), Kingdom et al. (2006), Rizzo (2008) and Criminisi et al. (2009) opinions that metering inaccuracies have direct influence on utilities non revenue water levels.

The second objective of the study was to establish how unmetered consumption influence non revenue water at Webuye water supply scheme. It was found out that metered connections were the majority 65.20% of all the 164 connections sampled while unmetered were 34.50%. According to Farley (2003), unmetered consumption promoted uneconomical water consumption contributing to increases in volumes of non revenue water. It was found out that 63.8% of the 47 connections that were initially unmetered and then finally metered were under billed when not metered as compared to the time when they were metered, thus unmetered connections were being under billed. A correlation between unmetered connections recorded per month for the entire water supply scheme against respective non revenue water values recorded for financial years 2010/2011 and 2011/2012 revealed that there was significant strong positive relationship between non revenue water and unmetered consumption (rho = 0.733, p = 0.000) while on the other hand, there was strong significant negative relationship between non revenue water and metered consumption (rho = –0.856, p = 0.000). The findings were in support of Hailu et al, (2011), SCWSI (2004) and WASREB (2010) point of view that increase in unmetered consumption increased non revenue water levels.

The third objective was to examine how illegal consumption influence non revenue water at Webuye water supply scheme**.** An investigation carried out to estimate the illegal consumption (connections) from the 160 respondents' sample revealed that majority of the respondents 133 (83.13%) were receiving water bills from NZOWASCO on monthly basis, 13 (8.12%) were receiving after two month, 8 (5.00%) quarterly, 4 (2.50%) annually and 2 (1.25%) had not received at all. According to NZOWASCO 201/2012 report, water usage non payments were being disconnected after 14 days from the day of the water bill production. In cases were bills receipt by consumers were delayed due to postage delays, extension of upto 30 days from the bill production date were allowed for disconnection to be effected. Based on this the study allowed for a maximum of two months as period for receipt of water bills and beyond two months was interpreted as illegal consumption, hence only 146 (91.25%) of the respondents consumed water legally while 14 (8.75%) consumed water illegally. On water bill payment it was found out that majority of the respondents were paying for NZOWASCO water bills on monthly basis, 19 (11.87%) on two months basis, 11 (6.88%) quarterly and 2 (1.25) annually. 147 (91.87%) of the respondents were legal water consumers while 13 (8.13%) were illegal water consumers. Correlation analysis findings further revealed that there was significant moderate positive relationship between non revenue water and illegal consumption (rho = 0.460, p = 0.024). The findings were therefore in consensus with, Balkaran and Wyke (2003), Butler and Memon (2006) and Rizzo (2008) findings.

The study also sought to evaluate the influence of water tariff on non revenue water at Webuye water supply scheme. Liemberger and Marin (2006), observed that unsuitable water tariff structure influenced the scope of managing NRW, the lower the tariff structure the less investment in infrastructure maintenance hence the higher the NRW. WASH (2011) and Farley (2003) also agreed with the above observation. Results for influence of water tariff on illegal water connections revealed that majority of the respondents 69 (42.07%) either did not know or were unable to identify the causes of illegal connections, while 43 (26.22%) of them attributed illegal connections to lack of integrity by NZOWASCO staff. 35 (21.34%) related illegal connections to low pay to field staff while the minority 17 (10.37%) attributed it to high water tariff.

For disconnections due to high water tariff, it was found out that majority of the respondents' 112 (68.42%) water connections had not been disconnected as a result of nonpayment of water usage bill as an effect of high water tariff while minority of them 52 (31.58%) had had their water connections disconnected due to water bill nonpayment resulting from high water tariff. Implied that the possibility of having illegal connections (consumption) as a result of illegal reconnections due to high water tariff were minimal. Further correlation analysis between water tariff structures and NRW established that there was weak negative relationship between non revenue water and water tariff ($rho = -0.278$, $p = 0.189 > 0.05$), hence there was no significant relationship between water tariff and non revenue water. The findings were in contradiction of WASH (2011) argument that lower water tariff encouraged increase in non revenue water and higher water tariff led to decrease in non revenue water.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The purpose of the study was to establish the factors influencing non revenue water at Webuye water supply scheme. This chapter therefore presents a summary of the findings, conclusion and recommendations. The chapter further summarizes the studies contribution to the existing body of knowledge and finally gives suggestions for further research with respect to the gaps identified in the course of carrying out this study.

5.2 Summary of the Findings

The study utilized a total of 164 respondents out of the targeted sample size of 183, representing 89% response rate and reaching at least more than half of each of the targeted respondents of the study. The study also utilized a total of 180 sample meters out of the targeted sample size of 183, representing 98% response rate.

Findings for study objective (1), to assess the extent to which meter registration inaccuracy influence non revenue water at Webuye water supply scheme, were that there was significant relationship between meter registration inaccuracy and non revenue water at 1% level of significance. The correlation between meter registration inaccuracy and non revenue water was 0.872 with a p - value of 0.000.

Study objective (2) was to establish how unmetered consumption influence non revenue water at Webuye water supply scheme. The findings were that there was significant relationship between unmetered consumption and non revenue water at 1% level of significance. The correlation between unmetered consumption and non revenue water was 0.733 with a p – value of 0.000.

The third objective of this study was to examine how illegal consumption influence non revenue water at Webuye water supply scheme. There was significant relationship between illegal consumption and non revenue water at 1% level of significance. The correlation between illegal consumption and non revenue water was 0.460 with a p – value of 0.024.

The fourth objective of this study was to evaluate the influence of water tariff on non revenue water at Webuye water supply scheme. The findings revealed that there was no significant relationship between water tariff and non revenue water. The correlation between water tariff and non revenue water was –0.278 with a p – value of 0.189.

5.3 Conclusion

The purpose of the study was to establish factors influencing non revenue water with focus on Webuye water supply scheme. The study found out that water tariff did not significantly influence non revenue water though it also influences non revenue water. Factors that significantly influenced non revenue water at Webuye water supply scheme were meter registration inaccuracies, unmetered consumption and illegal consumption.

The factor that had the highest influence on non revenue water was meter registration inaccuracy (rho = 872, p = 0.000). There was a strong positive correlation between meter registration inaccuracy and non revenue water. Increase in meter registration inaccuracy lead to increase in non revenue water almost at the same proportion.

The factor that had the second highest influence on non revenue water was unmetered consumption with a correlation coefficient of 0.733 and p-value of 0.000. There was a strong positive correlation between unmetered consumption and non revenue water. Increase in unmetered consumption lead to increase in non revenue water.

Illegal consumption had the third highest influence on non revenue water with a correlation coefficient of 0.460 and p-value of 0.000. There was a moderate positive correlation between illegal consumption and non revenue water. Water tariff had the least influence on non revenue water with a correlation coefficient of –0.278 with p-value of 0.189.

5.4 Recommendations

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

Meter registration inaccuracies have positive influences on non revenue water. In order to reduce the NRW levels at Webuye water supply, the management of Nzoia water Services Company should develop and implement a NRW reduction strategy at Webuye water supply scheme which should include meter registration accuracy enhancement. Water meter' class and age significantly influences meter 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.

Unmetered water consumption has significant positive influence on non revenue water at Webuye water supply scheme, thus there is need for NZOWASCO to meter all unmetered consumer connections and carry out regular servicing and calibration of consumer water meters at Webuye water supply scheme.

Illegal water consumption has significant positive influence on non revenue water at Webuye water supply scheme, the company should carry out periodic customer base audit by reconciling office consumer database with field connections. NZOWASCO 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.

NZOWASCO should constitute and operationalize a NRW team to oversee and enforce implementation of NRW reduction activities on daily basis at Webuye water supply scheme.

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
1. To assess the extent to which meter registration inaccuracy influence non revenue water.	Significantly there exists positive relationship between meter registration inaccuracy and non revenue water (rho = 0.872, p = 0.000).
2. To establish how unmetered consumption influence non revenue water.	Significantly there exists positive relationship between unmetered consumption and non revenue water (rho = 0.733, p = 0.000).
3. To examine how illegal consumption influence non revenue.	Significantly there exists positive relationship between illegal consumption and non revenue water (rho = 0.460, p = 0.024)
4. To evaluate the influence of water tariff on non revenue water.	Significantly there exists no relationship between water tariff and non revenue (rho = –0.278, p = 0.189).

5.6 Suggestions for Further Research

The research covered only a small portion of the factors influencing non revenue water, the following areas are suggested for further study;

1. A research to be carried out on the influence of unbilled authorized consumption on non revenue water.
2. An in depth analysis be carried out on the influence of billing system errors on non revenue water.
3. Further, it is also suggested that an analysis be carried out on influence of management style on non revenue water.

REFERENCES

Arregui, F., Cabrera, E., Cobacho, R. & Garcia, J. (2006a), *Reducing apparent losses caused by meters inacuracies*. Water pract. technol. **1** (4) doi: 10.2166/wpt.2006093.

Arregui, F., Cabrera, E. & Cobacho, R. (2006b), *Integrated water meter management*. IWA publishing, London.

AWWA (2000), *Water Sub Metering and Billing Allocation*: A discussion of issues and Recommended Industry Guidelines. An AWWA Draft White Paper, American Water Works Association, Denver, Colorado.

Balkaran, C. & Wyke, G. (2003), *Managing water loss*: Strategies for the Assessment, Reduction and Control of Non Revenue Water in Trinidad and Tobago.

Butler, D. & Memon, F. (Eds), (2006). *Water demand management*.

City water system improvement (2004), www.sequimwa.gov/index.aspx?NID_342. 04/03/2013.

Criminisi, A., Fontanazza, C.M., Freni, G. & La Loggia, G. (2009), *Evaluation of the apparent losses caused by water meter under-registration in intermittent water supply*. Water Sci. Technol. 60 (9) 2373-2382.

Degol, H., Rendtorff, S.S. & Tsukada, R. (2011), *Small scale water providers in kenya*: Pioneers or Predators, UNDP paper.

Farley, M. (2003), "*Non revenue water - international best practice for assessment, monitoring and control*" presented to 12th annual CWWA water, wastewater & solid waste conference 28nd September – 3rd October, 2003 - Atlantis, Paradise Island, Bahamas. Oxford shire UK Paper.

Farley, M., Wyeth, G., Ghazali, Z., Istandar, A. & Sher, S. "*The Manager's Non Revenue Water handbook*",(2008).http://warrington.ufl.edu/centers/purc/docs/resources_NRWManagersHandbook.pdf

Fraenkel, J.R. & Wallen, N. E. (2000). *How to Design and evaluate research in educa*tion, New York, NY: Mc Grawhill Companies Inc.

Halcrow, Inc. (2012), *Non revenue water study*, final report United Water New Rochelle. http:// www.rizzoconsultants.com/Hyperlinks/ApparentLossControl_Theory_Application.

Juan, C .B. (2008), *Non revenue water reduction programs in Colombia*. M.Phil. Thesis in System Dynamics, University of Bergen.

Kerlinger, F. N. (1986), *Foundations of behavioural research*. New York: Subject Publications.

Kerry, H. L & Tarma, J. M. (2012), *Utility's Water loss a global multi-million challenge*.

Kingdom, B., Liemberger, R. & Marin, P (December 2006), *The challenge of reducing non revenue water in developing countries*. A water supply and sanitation sector board discussion paper series, paper no.8.

Kombo, D.K. & Tromp, D.L.A. (2006), University of Nairobi, Unpublished.

Kumar, R. (1999), *Research methodology*, A Step-by-step Guide for Beginners. Sage Publications London, UK.

Lambert, A. (2008), *Managing pressure*. http://www.nzwwa.org.nz/ Waterloss08_11%20 Session11a&bAL.pdf, accessed on 21/01/2013.

Lambert, A., & Taylor, R. (2010), *Water loss guidelines*-Water New Zealand.

Male, J. W., Noss, R. R. & Moore, I. C. (1985), *Identifying and reducing losses in water distribution systems*. Noyes Publications, New Jersey.

Mehrens, W.A. & Lehmann, I.J. (1987). *Using standardized tests in education*. Longman. New York.

Mugenda, M.O. & Mugenda, G.A. (1999), *Research methods*: quantitative and qualitative approaches, Acts press, Nairobi Kenya pp90-147.

Mugenda, M.O. & Mugenda, G.A. (2003), *Research methods*: quantitative and qualitative approaches, Acts press, Nairobi Kenya.

Mugenda, M.O. & Mugenda, G.A. (2008), *Research meth*ods: quantitative and qualitative approaches, Acts press, Nairobi Kenya.

Mulusa, T & Worker, A.O. (1978), "*Training the youth for employment a report for a case study based on Gimomoi village polytechnic*" prepared for the SEPA seminar held in Monrovia, Liberia august 1978.

Mutikanga, H., Natongo, O., Wozei, E., Saroj, K., Sharma, S.K. & Vairavamoorthy, K. (2011), *Investigating the impact of utility sub-metering on revenue water in Kampala city*, Institute of water Engineering Netherlands.

Mutikanga, H. E., Sharma, S.K. & Vairavamoorthy, K. (2011), *Assessment of apparent losses in urban water systems*. Water Environ. J. **25** (3) 327-335.

National Water and Sewerage Corporation, external services, (2008) Uganda: *Illegal use reduction Operational Manual*.

Orodho, A. J. & Kombo, D. K. (2002), *Essentials of educational and social sciences,* Masola Publishers, Nairobi.

Richards, G. L., Johnson, M. C. & Barfuss, S. L. (2010) "*Apparent losses caused by water meter inaccuracies at ultralow flows*". Water Works Assoc. **105** (5) 123-132.

Rizzo, A. (2008), *Apparent water loss control*: Theory and application.

Sudman, S. (1976), *Applied sampling*. New York: Academic Press.

Water demand management, Strategy and implementation plan for Gwalior (2006), TERI Pvt. Lt

Water for Asian Cities (WAC) Programme, policy paper I (2006) "*Community Managed System for Operation, Billing & Collection of Water Charges*".

Water Services Regulatory Board, *Impact report Issue No. 3,* (2010).

Water Services Regulatory Board, *Impact report Issue No. 5*, (2012).

WASH news international , International news on water supply, sanitation and hygiene (WASH) washinternational.wordpress.com/2011/11/02/higher-water-tariff, accessed15/02/2013.

Wright Pierce (2011), *Rochester municipal water supply system*, NH Water Audit Report.

Wyatt, A.S. (2010), *Non revenue water*: Financial Model for Optimal Management in Developing Countries. RTI Press http://www.rti.org/pubs/mr-0018-1006-wyatt.pdf, accessed on 18/01/2013.

Yeboah, A.P. (2008), *Management of non Revenue Water*, a case study of the water supply in Accra Ghana http://www.switchurbanwater.eu/outputs/pdfs/W3-1_CACC_PHD_Management_of_Non-Revenue_Water_-_Case_study.pdf, accessed on 28/12/2012.

Yamane, T. (1967), *Statistics*: an introductory analysis, second edition, Description New York Harpen and Row.

APPENDICES

APPENDIX 1: QUESTIONNAIRE

WEBUYE WATER SUPPLY NON REVENUE WATER QUESTIONNAIRE

This questionnaire is aimed at collecting information on the factors influencing high non revenue water levels at Webuye Water Supply scheme of Nzoia Water Services Company Limited.

Please take a few minutes to complete this questionnaire. Your involvement in this study is essential and your honest answers will be completely anonymous and shall be used for this study only, but your views in combination with those of others are extremely important in helping Nzoia Water Services Company and other stakeholder to have a better understanding of the factors influencing high levels of non revenue water and as a result provide you with better water and sewerage services.

Please answer all questions as indicated by either filling in the blank or ticking the option that applies.

PART I: GENERAL INFORMATION

1. Your area of operation/residence______________________________________
2. Gender of respondent Male ☐ Female ☐
3. Age of respondent in years

   18 – 30 ☐ 31 – 40 ☐ 41 – 55 ☐ Above 55 ☐
4. Please indicate by ticking (√) the duration you have had a water connection with Nzoia water Services Company.

   Less than 1 year ☐ 1 year ☐ 2 years ☐ 3years ☐ More than 3years ☐
5. Please indicate by ticking (√) the type of water customer that best describes you.

   Industrial consumer ☐

   Commercial consumer ☐

   Domestic consumer ☐

   Institution of learning ☐

   Public institution ☐

   Kiosk operator ☐

   Other (Specify) ______________________

(Questions 6 to 7 to be answered by domestic consumers)

6. Kindly state by ticking (√) the sex (gender) of the head of this household:
   Male ☐
   Female ☐
7. Kindly indicate the number of persons living (staying) in this household? *(Emphasize that we would like to know the total number of persons, including babies*).
   Number of persons in household ___________________.

(Question 8 to be filled by all categories of customers except domestic customers)

8. Kindly indicate the average population being served? *(Emphasize that we would like to know the total number of persons, including babies*).

PART II: UNMETERED CONSUMPTION

1. Who is your **main** water supplier?
   Nzoia Water services company ☐
   Private operators/vendors ☐
   Community projects ☐
   Other (Specify)________________________________

2. If your main water supplier is Nzoia water company, kindly state whether currently you have a metered water connection. Tick (√).
   Yes ☐ No ☐

3. If yes in (2) above, on average what is your current **monthly** consumption in cubic meters (M^3)? _____________________.
4. If yes in (2) above, has your connection ever been unmetered for the **last two** years? _____.
5. If yes in (3) above, for how many months was your connection unmetered? ____________.
6. On average, what was your **monthly** consumption in cubic meters (M^3) the period your connection was unmetered as in (5) above? ____________.
7. If currently your connection is unmetered (if **No** in (2) above), on average what is your **current monthly** consumption in cubic meters (M^3)? __________.

8. If currently your connection is unmetered, has it ever been metered for the **last two** years? .. ________, and for how many months (if yes)? ____________.
9. In (8) above, on average what was your **monthly** consumption in cubic meters (M^3) when your connection was **metered?** __________________.

PART III: ILLEGAL CONSUMPTION

1. How do you access the water from your main source of water? (**Circle one**).
   i. Own house connection
   ii. Organizational connection (Including churches, government institutions, etc.)
   iii. Communal tap
   iv. Water kiosk
   v. Open well, Borehole
   vi. Stream, river, roof (rainwater harvesting)
   vii. Illegal connection
   viii. Leaks in the supply network
   ix. Tanker truck, Water reseller (donkey cart, push cart (*mkokoteni*) etc.)
   x. Other (Specify)________________________________

2. How often do you receive your water bills from Nzoia Water Company?
   Monthly ☐ After two months ☐ Quarterly ☐ Annually ☐ Not at all ☐
3. Lastly when did you receive your water bill? ________________________.
4. Is your piped water connection legalized? __________________________.
5. How often do you pay for your water bills for Nzoia Water Company?
   Monthly ☐ After two months ☐ Quarterly ☐ Annually ☐ Not at all ☐
6. Lastly when did you pay for your water bill? _______________________.
7. By any chance might you have had any illegal connection that was later on legalized? _____
8. Do you think it is really necessary to pay for treated / piped water?
   Yes ☐
   No ☐
   Don't know/ No opinion ☐
   Explain your answer. ____
   ____
   ____

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. ________________________________

____

____.

____.

____.

PART IV: WATER TARIFF

(Questions 1 to2 be filled by domestic customers only)

1. 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 ☐

2. What is the most important source of income of this household? Tick (√).
   Agriculture or fishery ☐
   Permanent employment ☐
   Temporary employment ☐
   Business ☐
   Other (Specify)____________________________

   (Question 3 to be filled by all categories of customers except domestic customers)

3. Kindly indicate the average monthly revenue for the institution.
   Revenue (Kshs)__________________________________

4. How much (on average) do you spend on piped water from Nzoia Water Company per day, per week or per month?
   Kshs. ______________Per day
   Kshs. ______________ Per week
   Kshs. ______________ Per month
   Free of charge ☐
   Don't know ☐

5. How much (on average) do you spend on water from your ***alternative sources of supply*** per day, per week or per month? *(Include all costs associated with obtaining water from the source, e.g. transportation, treatment, maintenance, etc)*

   Kshs. ______________Per day

   Kshs. ______________ Per week

   Kshs. ______________ Per month

   Free of charge ☐

   Don't know ☐

6. Has at any time your water connection ever been disconnected for the last two years due to nonpayment of water bill? _______________.
7. If yes in (6) above, what was the outstanding water bill on disconnection? Ksh ____________.
9. If you were supplied with good quality water in an accessible and clean environment, what would **you be able** to pay per month? Ksh______________________________________.
10. If you were supplied with good quality water in an accessible and clean environment, what would **you be willing** to pay per month? Ksh____________________________________.
11. Your average **monthly** water consumption in cubic meters (M^3).

    Previous tariff ☐ Current tariff ☐

12. How do you rate the current water tariff?

    Cheap ☐ Average ☐ Expensive ☐

THANK YOU FOR TAKING YOUR TIME TO FILL THIS QUESTIONNAIRE

APPENDIX 2: FIELD OBSERVATIONS

WEBUYE WATER SUPPLY CONSUMER METERS ACCURACY

		(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)
No.	Meter S/No.	Class	Brand	Size	Material	Months of service	STD Volume	Initial Volume	Final Volume	Recorded Volume	Error (%)
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											

APPENDIX 3: NON REVENUE WATER

WEBUYE WATER SUPPLY 2010/2011- 2011/2012 NRW LEVELS

	(i)	(ii)	(iii)	(iv)	(v)
FINANCIAL YEAR	**MONTHS**	**METERED CONNECTIONS (No)**	**UNMETERED CONNECTIONS (No)**	**ILLEGAL CONSUMPTION CASES (No)**	**NRW (%)**
2010 / 2011	July 2010				
	August 2010				
	September 2010				
	October 2010				
	November 2010				
	December 2010				
	January 2011				
	February 2011				
	March 2011				
	April 2011				
	May 2011				
	June 2011				
2011 / 2012	July 2011				
	September 2011				
	October 2011				
	November 2011				
	December 2011				
	January 2012				
	February 2012				
	March 2012				
	April 2012				
	May 2012				
	June 2012				

APPENDIX 4: LETTER OF TRANSMITTAL

Celsus M. Shilehwa
P. O. Box 1206 – 50205, WEBUYE.
06th May 2013

The Managing Director,
Nzoia Water Services Company Ltd,
P. O Box 1010 – 50205,
WEBUYE.

RE: PERMISSION TO CONDUCT RESEARCH

I am a post graduate student at the University of Nairobi pursuing a Master of Arts degree in Project Planning and Management. As part of the course, I intend to carry out a research study entitled " factors influencing non revenue water (NRW): the case of Webuye water supply scheme of Nzoia water services company limited". The study will entail field observations administering questionnaires and document review.

The purpose of this letter is to request for permission and goodwill to enable me successfully carry out the study. All the data collected will be treated with total confidentiality as this study is for academic purposes only.

It is my hope that the findings will be very vital in developing strategies that will enhance non revenue water reduction at Webuye water supply and if applicable to the entire Nzoia cluster.

Thank you in advance for your cooperation.

Yours Sincerely,

Shilehwa M. Celsus

APPENDIX 5: LETTER OF AUTHORIZATION

NZOIA WATER SERVICES COMPANY LIMITED

NZOWASCO

Telephone:
Landline: 055-41005
Wireless: 020-20-60554/536
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Mobile: 0727-495567, 0735-977756

HEAD OFFICE:
P.O. BOX 1010 – 50205,
WEBUYE,
Kenya.
Email: info@nzoiawater.or.ke

16th May 2013

Our ref: *NZOWASCO/HO/MD/Vol.1(34)*

Celsus M. Shilehwa
The University of Nairobi,
P. O. Box 1206 - 50205,
WEBUYE.

RE: RESEARCH AUTHORIZATION

The above matter refers;

This is in reference to your letter *'Ref: Permission to Conduct Research'* dated 06th May 2013 addressed to my office. I'm pleased to inform you that your request to carry out a NRW research at our organizations' Webuye Water Supply scheme has been granted.

During your research period, you will be expected to adhere to the company's' rules and regulations of which a copy can be obtained from our human resource office free of charge, any information obtained should be treated with utmost confidentiality. You are requested to liaise with our Regional Manager – Webuye Water Supply scheme for your research logistics.

Wishing you success in your research.

Thank you,

Eng. Patrick W. Munialo
MANAGING DIRECTOR

Cc: Regional Manager- Webuye Water Supply Scheme.