FACTORS INFLUENCING THE HIGH NON-REVENUE WATER IN GARISSA TOWNSHIP, KENYA

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DECLARATION

This research project is my original work and has not been submitted to any university for an award of a degree.

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(L50/65355/2010)

This Research Project has been submitted for examination with my approval as the University Supervisor:

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DEDICATION

This project is dedicated to my family members who have provided me the time, financial support and inspiration needed during the development of this project.

ACKNOWLEDGEMENT

I would like to express my appreciation to my university supervisor Dr. Kyalo who has continually shown me kindness and wisdom, and has offered countless constructive contributions to this project. Thank you my family members and special friends, who encouraged me whenever I ran out of steam. I consider the completion of this project a great accomplishment. As with all great accomplishments, I give the entire honor, credit and glory to God.

ABSTRACT

The overall objective of this study was to find out factors influencing Non-Revenue Water (NRW) in Garissa Township. The study population consisted of Garissa Water and Sewerage Company Limited (GAWASCO) field technical staff in Garissa Township. This study used primary data in the form of questionnaires, and secondary data from existing literature from articles, books, and internet sources. Quantitative data collected was analyzed using cross tabulations and frequency distributions. The main finding of this study was that the level of Non-Revenue Water was unreasonably high. The three key factors influencing NRW were found to be unbilled unmetered consumption, physical losses, and unauthorized consumption. Malfunctioning water meters was found to be the most commonly experienced case relating to meter reading inaccuracies and estimations that influences NRW. The three main strategies employed to reduce NRW were found to be implementing zoning, training staff on NRW management and installing consumer water meters although the first two were found not to be the most appropriate for the high level of non-revenue water. Public ignorance on NRW was found to be the key challenge facing reduction of NRW. From the findings, this study recommends 100% installation of water meters for all connected consumers, conducting public awareness, and improvement of billing and revenue collection to computerized system in order to reduce NRW in Garissa Township to below thirty percent. It is only after achievement of a level of 30% NRW, that any other additional strategy can be employed to reduce it further.

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LIST OF ABBREVIATIONS AND ACRONYMS

ADB	-	Asian Development Bank
f	-	Frequency
GAWASCO	-	Garissa Water and Sewerage Company Limited
IBNET	-	International Benchmarking Network for Water and Sanitation Utilities
IWA	-	International Water Association
KES	-	Kenya Shilling
MDGs	-	Millennium Development Goals
N	-	Number of respondents or responses
NRW	-	Non-Revenue Water
SEAWUN	-	South East Asian Water Utilities Network
TSM	-	Technical Services Manager, GAWASCO
UfW	-	Unaccounted for Water
UUC	-	Unbilled Unmetered Consumption
WASREB	-	Water Services Regulatory Board
WSP	-	Water Services Provider

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

Many a times, people have argued that water is a public good, that is, a good, on consumption, does not reduce the amount available for others to consume. Public goods possess two essential attributes, that is, they are “non-rivalrous and “non-excludable (Dyson, 2003). While this argument would have been true sometimes back, it is contestable as water scarcity grips all corners of the earth. Overall, only 140,800 cubic kilometers of the 35.2 million cubic kilometers global fresh water is renewable annually and available for human use. This quantity is unevenly distributed in space and time. In 1995, 3% (171 million) of the world population (estimated at 5.7 billion) experienced water scarcity while 5% (285 million) were water stressed (United Nations World Water Development Report, 2006), but come the year 2050, with the global human population expanding to 9.4 billion, it was predicted that the water situation will drastically change for the worse, for water scarcity will rise to 18% (1.692 billion), while water stress will affect another 24% (2.256 billion) people.

The challenge of water scarcity notwithstanding, the more daunting task is how to prudently use this resource; who gets what amount, how, when and why, and hence the need to reduce Non Revenue Water (NRW). NRW refers to the water produced that does not generate revenue for the water utility (Alegre et al., 2006). Strategies to reduce water losses have been developed and are practiced worldwide. Whilst developed countries have to cope mainly with physical losses, developing countries are also facing the issue of commercial losses including meter inaccuracies and water thefts. Significant steps have been made in developing both technical strategies (which include pressure management and flow monitoring) and operational management strategies but developing countries are still facing harder difficulties to cope with their water losses. Poor infrastructures and equipment that have been unmaintained for long periods, high unbilled water through fraud and illegal connection or public buildings that are still enjoying privileges in developing countries (Kingdom et al., 2006).

Kenya faces serious challenges with regard to water services. Despite the efforts of investments provided in the past by the Government and development partners, existing facilities have continued to deteriorate and fail to meet the demand of the increasing population, particularly in many rural areas and the very rapidly growing settlements of the urban poor. The result of the deteriorated facilities is extremely high levels of Unaccounted for Water (and hence high levels of NRW) reaching 60% on average. Safe water and sanitation must be regarded as a basic human right and should therefore be affordable and accessible to all .This is important in order to achieve the Millennium Development Goals (MDGs) and the national targets in the Economic Recovery Strategy for Wealth and Employment Creation (ERS-WEC). Sustainable access to safe water is around 60% in the urban setting and drops to around 20% in the settlements of the urban poor where half of the urban population lives. With a population growth of up to 10% in the low income urban settlements many 'hot spots' continue to develop in many municipalities and therefore sustainable access to safe water is declining. Sustainable access to safe water in the rural setting is estimated at 40% (National Water Management Strategy 2007-2015).

Average NRW has stagnated at 45% since 2009/10, remaining at a level almost double the minimum acceptable level of 25%. In fact only Meru town has been able to keep NRW at an acceptable level. Current NRW levels translate to financial losses of KES 9.5 billion annually, which is about a quarter of the annual water sector budget. The continuously high NRW levels threaten the financial sustainability of the water services sector (WASREB performance report, 2012). A high NRW level is normally a surrogate for a poorly run water utility that lacks the governance, the autonomy, the accountability, and the technical and managerial skills necessary to provide reliable service to their population (Kingdom et al, 2006)

1.2 Statement of the Problem

High NRW levels are detrimental to the commercial viability of water utilities as well as the quality of the water itself. NRW increased in Kenya from 43% in 2008/09 to 45% in 2009/10 with Garissa Water and Sewerage Company (GAWASCO), the only licensed WSP in Garissa Township, registering a NRW percentage of 58% (WASREB performance report, 2011). Simply put, despite the costly production process which involves use of expensive chemicals, GAWASCO did not generate revenue from 42 % of the water it produced that year. Consequently, it failed to recover its production costs on that quantity. The percentage of NRW registered was 54% for the period 2010/2011 according to WASREB performance report ,2012.These quantities were far above the acceptable water sector benchmark of at most 25% given on the same report. There seems to be no studies done to investigate the factors that have influenced the high NRW in Garissa Township.

1.3 Purpose of the Study

The main purpose of this study was to find out factors that influence the high NRW in Garissa Township.

1.4 Objectives of the Study

The four objectives of the study were:

i. To find out factors that influence NRW in Garissa Township.
ii. To find out strategies employed to reduce NRW in Garissa Township.
iii. To find out the challenges faced in reducing NRW in Garissa Township.
iv. To come up with possible recommendations to reduce non-revenue water in Garissa Township.

1.5 Research Questions

The study sought to answer the following four research questions.

i. Which factors influence NRW in Garissa Township?
ii. What strategies have been employed to reduce NRW in Garissa Township?

iii. What challenges are faced in reducing NRW in Garissa Township?

iv. What can be done to reduce NRW in Garissa Township?

1.6 Operational Hypothesis

H_0: There is a significant relationship between the level of NRW and the amount of water that is unbilled unmetered consumption.

H_1: There is no significant relationship between the level of NRW and the amount water that is unbilled unmetered consumption.

1.7 Significance of the Study

GAWASCO may use the findings of this study to increase revenue collection and assess the need for public sensitization measures on NRW. In addition, other WSPs may consider adopting the strategies suggested in this study to reduce NRW in their respective areas of jurisdiction. The Ministry of Water and Irrigation may also use the findings to formulate policies regarding management of NRW towards attaining the Millennium Development Goals (MDGs).The study would also add to the existing body of knowledge from which other researchers would base their studies.

1.8 Scope and Limitation of the Study

This study limited itself to GAWASCO field technical staff. Due to financial and time constraints the study focused on Garissa Township only.

1.9 Assumptions of the Study

This study assumed that the respondents would cooperate and respond accurately to the questionnaire administered to them.

1.10 Definition of Significant Terms

i) Non-Revenue Water (NRW) – The difference between the amount of water produced for distribution and the amount of water actually billed to consumers. The measure captures both physical losses (leakage) and commercial losses (illegal connections/water theft, unmetered public consumption, metering errors, unbilled metered consumption , and water use for which payment is not collected (WASREB performance report ,2012)

$$NRW = Amount\ of\ water\ produced\ for\ distribution - Amount\ of\ water\ consumed\ and\ billed\ to\ consumers$$

NRW refers to the water produced that does not generate revenue for the water utility (Alegre et al., 2006).

ii) Unaccounted for Water (UfW)- The difference between net production (the volume of water delivered into a network) and consumption (the volume of water that can be accounted for by legitimate consumption, whether metered or not)

iii) Unbilled unmetered consumption – water used by a water supply utility for operational purposes such as cleaning/backwashing the treatment plant..

iv) Unauthorized consumption –Illegal use or consumption (or theft) of water supplied by a water supply utility.

v) Transmission lines – Pipelines that transport raw water (untreated water) from its source to a water treatment plant, then to the distribution grid system.

vi) Distribution lines – Those facilities used from the transmission lines to the service lines. They include water pipelines, water storage tanks, pumping stations , and pipe fittings.

CHAPTER TWO

LITERATURE REVIEW

2.1 Definition of Non-Revenue Water (NRW)

NRW in a water supply system is a concept that has been recently introduced by the International Water Association (IWA, 2000) instead of Unaccounted for Water (UfW) (Farley et al, 2003). In 1987, Jeffcoate et al (1987) defined the term UfW as the difference between net production (the volume of water delivered into a network) and consumption (the volume of water that can be accounted for by legitimate consumption, whether metered or not). The definition is simply identified, but determining the true figure can be difficult. Part of the difficulty in determining the true UfW Figure was the lack of a meaningful standard water balance. Being aware of the problem of different water balance formats, methods, and leakage performance indicators, the International Water Association (IWA) has developed a standard international water balance structure and terminology (Alegre et al, 2000). According to this international water balance structure, the definition for Non-Revenue Water (NRW) can be defined as the difference between the amount of water put into the distribution system and the amount of water billed to consumers in authorized metered and un-metered water consumption. NRW is comprised of apparent losses and real losses.

$$NRW = Total\ System\ Input - Billed\ Authorized\ Consumption$$

In percentage form:

$$NRW = \frac{(Total\ System\ Input - Billed\ Authorized\ Consumption)}{Total\ System\ Input} \times 100\%$$

The first stage of assessing NRW is to make a water balance within the system in order to know how much water is actually used and paid for but also how much water is lost and how it is lost. Water balances are widely used by water utilities but the diversity of formats and evaluations of the losses prevented international comparisons between water utilities (Lambert, 2003). The International Water Association (IWA) published “best practices" for water balance calculation and gave clear and proper definitions of the different components of water losses (Alegre et al., 2006; Lambert, 2002). In "Performance Indicators for water supply services", Alegre et al. 2006 present the frame developed by the IWA for the calculation of water balances with precise definitions and methodology. Table 1 below gives an overview of the components of a water balance. A clear understanding of NRW is shown in table 1 below which is based on IWA Standard Water Balance

Table 2.1: The IWA Standard Water Balance

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	Commercial losses	Unauthorized Consumption	
			Customer Metering Inaccuracies and Estimations	
		Physical losses	Leakage on transmission and/or distribution mains	
			Leakage and overflows at utility storage tanks	
			Leakage on Service connections up to point of customer use	

Source: Kingdom et al (2006)

The component of this water balance reveals two kinds of water losses: the **physical losses**, or real losses (which are the volume of water actually lost through leaks and bursts) and the **commercial losses**, or apparent losses, (which are commercial losses in the sense that the Water is not lost but no one pays for it). The apparent losses are mainly due to fraud (illegal connection, meter by-pass, metered tampering), meter errors and inaccurate data about the consumption. The components of NRW are determined by a field study with investigation of all properties in the study area and all the components of water distribution network such as reservoir, pumps, valves, pipes, etc. (Tabesh & Asadiani, 2005).

2.2 Non-Revenue Water Management worldwide

Significant steps forward have been made in developing both technical strategies (pressure management, flow monitoring) and operational management although developing countries are still facing harder difficulties to cope with their water losses. A recent report by the Asian Development Bank (ADB, 2006) mentions a study performed by the South East Asian Water Utilities Network (SEAWUN) analyzing NRW levels of 47 water utilities across Indonesia, Malaysia, Thailand, the Philippines, and Vietnam, which concluded that the levels of NRW average 30 percent of the water produced, with wide variations among individual utilities ranging from 4 percent to 65 percent.

The World Bank database on water utility performance (IBNET, the International Benchmarking Network for Water and Sanitation Utilities, at www.ib-net.org) includes data from more than 900 utilities in 44 developing countries (Farley et al, 2003). The average Figure for NRW levels in developing countries' utilities covered by IBNET is around 35 percent. The actual Figure for overall NRW levels in the developing world is probably more in the range of 40–50 percent of the water produced. Every year, more than 32 billion cubic meters of treated water physically leak from urban water supply systems around the world, while 16 billion cubic meters are delivered to customers for zero revenue (Kingdom et al., 2006). Half of these losses are in developing countries, where public utilities are starving for additional revenues to finance expansion of services and where most connected customers suffer from intermittent supply and poor water quality. Kingdom et al. (2006) quote poor infrastructures and equipment that have not been unmaintained for long periods, high unbilled water through fraud and illegal connection or public establishments that enjoy privileges as the causes of the high NRW in those countries.

Mahmoudi (2007) revealed the positive role of the Iranian government by devoting a part of the budget to the combat of NRW and pressing the water and wastewater companies to allocate a part of their budget to this task. Consequently, they are improving their water losses management through better operational practices (leakage detection and quicker respond to detection, replacements and implementation of new monitoring equipment, following national standards whilst installing new branches, conducting pilots' projects...). The pressure processes are also developed by Ndokosho et al. (2007) who clarify the relation between a public utility and the government owning it. In Namibia, it is the government who is setting overall objectives, such as full recovery cost, but the "Board of Directors" remains in charge of defining the specific targets and elaborating the policies that will lead to the achievement of the overall aims. However, water utilities are generally not totally free to implement new policies as they generally do not have complete authority to set tariffs, as it is the example in Namibia but this scheme of governance is implemented as it is supposed to reduce the political influences that may occur.

2.3 Network Flow Measurement and Water Balance

According to Nwe (2008) the calculation of NRW is carried out using the IWA water balance principle. The result of the water balance analysis depends on sufficient data being available for flow in the distribution network. This enables not only NRW to be determined but also to prioritize which components are contributing the most to the losses. Nwe(2008) explained the steps followed in applying the IWA water balance principle as outlined below.

(a) Determination of the System Input or Production Measure

The volume of water delivered into the distribution network should be accurately metered, but frequently meters are non-existent, out of operation, or seriously inaccurate. When the entire system input is metered, the calculation of the annual system input should be a straightforward task. 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.
But, if there be some un-metered 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.

(b) **Determine the Authorized Consumption**

There is billed authorized consumption and unbilled authorized consumption. Billed authorized consumption includes billed metered consumption and billed un-metered consumption. Unbilled authorized consumption includes unbilled metered consumption and unbilled un-metered consumption.

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) has to be extracted from utility's billing system and analyzed. Special attention should be paid to the group of very large consumers.

Billed Un-metered Consumption- The billed un-metered consumption can be obtained from the utility's billing system. In order to analyze the accuracy of the estimates, un-metered domestic customers should be identified and monitored for a certain period. For example- measure a small area with a number of un-metered consumers.

Unbilled Metered Consumption- The volume of unbilled metered consumption has to be established similar to that of billed metered consumption.

Unbilled Un-metered Consumption- Traditionally, this includes water used by the utility for operational purposes, which 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.

The Design Manual Manual for Water Supply in Kenya (2005) recommends that only 5% of the water produced be used for cleaning/ backwashing water treatment plants Components of unbilled un-metered consumption should be identified and individually estimated. For example:

- Mains flushing: How many times per month? How long? How much water is used?
- Firefighting: Has there been a big fire? How much water was used?

(c) **Determine the Water Loss**

Water losses include commercial or apparent losses and physical or real losses. Apparent losses comprise unauthorized consumptions, metering inaccuracies and data handling errors. Real losses can be leakage on transmission and/or distribution mains, leakage and overflows at utility's storage tanks, and leakage on service connection up to point of customer metering.

Unauthorized Consumption- It is difficult to provide general guidelines of how to estimate unauthorized consumption. The estimation of unauthorized consumption is always a difficult task and should be done in a transparent, component based way so that the assumptions can later easily be reviewed. Unauthorized consumption includes illegal use, and this could be 1) sole illegal connections, 2) illegal connections to properties that also have legal connections, or 3) illegal connections for the purpose of selling water (Mclntosh, 2003).

Customer Metering Inaccuracies and Data Handling Errors-

Metering inaccuracies can include malfunctioning water meters, estimated water consumption (when meters are not working), and misreading water meters (Mclntosh, 2003). The extent of customer meters 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) will be established for different user groups. Data handling errors are sometimes a very substantial component of apparent losses.

Calculating Real Losses- The calculation of real losses in its simplest form is now easy. Volume of NRW minus volume of apparent losses – this Figure is useful for the start of the analysis in order to get a feeling which magnitude of real losses can be expected. However, it always has to be kept in mind that the water balance might have errors and therefore it is important to verify the real loss Figure by one of the following two methodologies: (i) Component Analysis and (ii) Bottom-up real loss assessment. To accurately separate, real losses into its components will only be possible with a detailed component analysis. However, a first estimate can be made using a few basic estimates.

Leakage on Transmission and/or Distribution Mains- 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”.

Leakage and Overflow at Utility’s Storage Tanks- Leakage and overflow at storage tanks are usually known and can be quantified.

Leakage on Service Connections up to Point of Customer Metering- By deducting mains leakage and storage tank leakage from the total volume of real losses, the approximate quantity of service connection leakage can be calculated. This volume of leakage includes reported and repaired service connection leaks as well as hidden (so far unknown) leaks and background losses from service connections. As above determination of the water in a system that is metered or not fully metered, where billed to consumers must be derived for revenue of that system and unbilled consumption will be NRW for that system. Logically, NRW consist of unbilled authorized consumption and water losses as these are the component for which the utility does not receive revenue.

2.4 Factors that Contribute to Water Losses

Generally, physical or real losses and commercial or apparent losses are the main losses in the water supply system. Other factors contributing to water losses are also briefly discussed in this section.

2.4.1 Factors affecting physical losses

There are several factors, which affect the physical losses from a distribution system. According to the Queensland Environmental Protection Agency and Wide Bay Water Corporation, Manual 6 (2002), these factors can be put under seven broad headings as follows:

i) Pressures

Nwe (2008) explained that pressure can affect losses from a system in the following five ways.

Rate of leakage: for a system with a number of leaking or broken pipes and leaking or faulty fittings, a change in the pressure will affect the loss of water.

Frequency of bursts: increasing system pressure, in some cases by only a few meters, can result in a number of bursts occurring within a relatively short period of time.

Location of leaks: higher pressures will increase the rate of water from an individual leak and may cause the leak to appear sooner. The higher rate of loss usually makes the leak easier to locate using sounding methods.

Pressure surges: sometimes pressure greater than the design strength of the pipeline, can be caused when a pump set or booster is switched on or off or when a valve is opened or closed too quickly. Surges can cause the main or service pipeline to fracture, move thrust blocks or blow the joint sealant from the joint cavity. There is also some evidence that surges cause pipes to flex and move against rocks or other obstacles, resulting in local stress concentrations and sometimes failure of the pipe.

Pressure cycling: pipe material fatigue is caused by cycling the pressure between high and low values within the design pressure. Fatigue occurs when a pump set or booster switches on and off because of faulty pressure reducing valves. Although the contribution of pressure cycling to leakage is probably quite small, special care may be required during the design of plastic pipelines because they can be more susceptible to fatigue than other pipes.

ii) Soil movement

Soil movement is sometime caused by changes in moisture content, particularly due to clay soils, changes in temperature, frost heave and subsidence, and drought. Countries that suffer from minor earth tremor will continually have problems with under-ground infrastructure. This may not be apparent above ground. In iron pipes, there is some evidence to suggest that small amounts of soil movement can cause stress concentrations, leading to the onset of fissure corrosion. (Alegre et al., 2006)

iii) Deterioration of water mains and pipes

The most serious problems are the corrosion of metallic pipes. Internal corrosion is generally more severe in soft waters from upland sources. In the case of iron water mains, it takes the form of tubercles, on the pipe bore. The tubercles are associated with pitting. As corrosion of iron and steel pipe proceeds, the residual thickness of metal is reduced and hence the ability of the pipe to withstand internal pressure diminishes. Ultimately, this process leads to complete penetration of the pipe wall and failure of the pipe with leakage. The common forms of failure are hole formation and transverse or longitudinal fracture of the pipe. External corrosion can arise from a variety of causes including differential aeration, bimetallic collection, variations in concentrations of dissolved salts and microbiological action. The effects of external corrosion are similar to those of internal corrosion. Corrosion of concrete or asbestos cement pipes can be caused by soils or water containing high levels of sulfate. (Nwe, 2008)

iv) Poor quality of fittings, materials and construction

Leakage caused from poor quality fittings, materials and construction can occur on the water mains up to the meter and the private pipe work after the meter. The careful design and specification of installations, coupled with a high standard of supervision during construction, will keep faults to a minimum. Asbestos cement pipes can also corrode due to presence of high levels of sulfates in the water or soil. External corrosion on the other hand is caused by aggressive properties within the soil, particularly on those pipes and fittings with no external protective coating. (Alegre et al., 2006).

v) Age of pipe

Age also comes into play, as older pipelines tend to deteriorate more than pipelines which have just been laid. Age of pipe-work is an important factor, but pipes and fittings that are well protected have been known to last well over fifty years.

Many of the factors listed above are time dependent that is their effect will be greater as time goes on. Consequently, age of a pipeline can appear to be the most significant factor affecting the livelihood of leakage but on its own, age is not necessarily a factor. (Vermersh and Rizzo, 2007)

vi) Soil Characteristics

An important factor, which affects the running time of individual leaks, is the permeability of the soil in which the pipes are laid. In some soils, water from underground leaks may show quickly on the surface, whereas similar leaks in chalky or sandy soils, for example, can run indefinitely without becoming visible on the surface. (Nwe, 2008)

vii) Traffic loading

The effects of vibration caused by heavy vehicles and other traffic are thought to be a major factor affecting the failure of buried pipelines. With the exception of pressure, none of these factors can easily be altered by a water utility once a pipeline has been laid. Therefore, it is extremely important that these factors are actively considered during the design and construction stages. Adequate supervision should be given to ensure that the desired standards are achieved. (Nwe, 2008)

2.4.2 Factors Affecting Commercial Losses

According to the IWA standard water balance definition, apparent losses consist of inaccuracies associated with production metering and customer metering, unauthorized consumption (theft or illegal use), data transfer errors, and data management errors (Queensland Environmental Protection Agency and Wide Bay Water Corporation, Managing and Reducing Losses from Water Distribution Systems, Manual 7, 2002).

i) Illegal or unauthorized consumption

It is water used that is not registered or paid for. This type of water loss can occur in various forms such as illegal access to water hydrant, illegal use of unmetered fire hose reels, illegal water connections. (Lambert, 2002)

Illegal access to water hydrant - this type of water theft occurs when water vendors or property developers access water hydrants without authorization. If access to designated fill points is not metered then the potential for water theft is increased.

Illegal water connections-These include unauthorized connections to the reticulation network, as well as attempts to tamper with or by-pass customer meters.

Illegal use of un-metered source from fire hose reels - this type of water loss occurs in commercial consumers. They are supplied with fire hose-reels and might use them for personal or commercial use like washing down driveways and footpaths as the most common example.

ii) Inaccuracy of metering or errors in customer meter

It is usually inaccuracies caused by wear or failure in the recording mechanism of the water meter. Meters are not only the cash registers of water utility. These are essential tools for managing water loss. Metering also provides a means to determine usage charges as well as assessing NRW levels. Water bills (based on meter readings) are the principal method of communication between a water utility and its customers.

Thus, meter accuracy may substantially affect the revenue and the potential for water loss and demand reduction to a water utility. In case of bulk meters, under-registration can lead the water utility to underestimate its real losses, and its true level of NRW. It is important to remember that:

a) Under-registration of production meters and over-registration of customer meters leads to under-estimation of real losses
b) Over-registration of production meters and under-registration of customer meters, results in over-estimation of real losses.

In water loss management, accurate measurement of supply and consumption is an integral part of the process. Some of the key factors influencing meter accuracy are: consumption volume and meter age, incorrect meter installation, class or type of meter, inappropriate meter size, water quality, pressure and air surges and meter failure rate. (Alegre et al., 2006).

iii) Data transfer and data management errors

It would be impossible to remove all potential for systemic and human error in water metering and data collection systems. Data handling errors are usually simple human errors- a wrong keystroke, miss reading a meter, or even reading the wrong meter are examples of data handling and transfer errors. According to Nwe (2008) data management errors can occur when:

i) a new service connection and meter is supplied, and is not added to the billing system,
ii) unbilled users are metered, and are not added to the billing system,
iii) a property changes ownership and new owners are not added to the billing system.

2.4.3 Other factors affecting water losses

According to Nwe (2008) other water loss components are sources, head-works, and treatment losses. These are physical losses of water excluded in NRW. These losses occur before that water is put into the distribution system. They include leakages and overflows of untreated water from storage reservoirs and tanks, watershed leakage and bypasses inadequately controlled leakage from untreated water transmission lines and excessive use of water due to inefficient operation of the treatment process. These losses are normally regarded in a separate light, their control being a matter for the maintenance staff working on problems of source of supply, raw water transmission, and water treatment plants. They may add up to a significant loss, which merits close investigation, and it is appropriate that attention be directed at this problem concurrently with the instigation of improved control of NRW. These losses are excluded from NRW but can be of equal importance and require investigation by management at the same time (Jeffcoate et al, 1987)

2.5 Methods of Leakage Control

There are a number of methods for leakage control currently practiced. Each method involves field leakage detection except pressure control, which can be considered supplementary to each of the other methods. Each method requires a different level of staff input and equipment and consequently each has different capital and operating costs. Each method will also maintain leakage at different levels. Commonly, leakage control includes regular survey and leakage monitoring. According to Farley et al (2005) regular survey is a method of starting at one end of the distribution system and proceeding to the other using techniques. Six methods of leakage control are currently in practice (Mclntosh, 2003) such as:

i) Passive leakage control
ii) Regular sounding for leaks on pipe-work and fittings,
iii) District metering (detection by metering and analysis of flows into various pre-determined districts over a period of time, followed by systematic soundings),

iv) Waste metering (detection by metering of low flows at night from predetermined waste districts served by a single pipeline, followed by systematic soundings), and
v) Combined district and waste metering
vi) Pressure control

These measures can be used in combination. For example, if passive leakage control is undertaken, regular soundings, district metering and waste metering methods can further reduce leakage. Leakage monitoring includes flow monitoring into zones or district metered areas (DMAs) to quantify leakage and to prioritize leak detection activities. Leakage detection is driven by both product availability and by economic considerations. An economic analysis is generally required to determine the most cost-effective method, but ultimately, a balance between doing nothing and attempting to stop every leak must be achieved. Potential target levels of leakage can be determined by selecting the most appropriate method. It would depend on the level of leakage, cost of leakage, and cost effectiveness of each method, because each method requires a different level of resources such as staff, equipment, capital and operating costs. Brief descriptions of each method for leakage control are discussed as follows.

a. Passive Leakage Control

This method requires the least effort on the part of the water undertaking and in most cases results in the highest levels of leakage. No attempt is made to measure or detect leaks. Generally, only the leaks that are reported the ones that are repaired because of either water showing on the ground surface or of consumer complaints such as poor pressure or noise in the plumbing system. The police, public or water undertaking personnel going about some other duty normally make reports of this nature. Leak location may still be required for some of these self-evident leaks. This type of leakage control will not normally be cost effective except in areas where water is very cheap, and/or soil conditions are such that underground leaks quickly come to the surface. When the water authority is satisfied as to the total volume of water being put into their distribution network, the next step should be to learn more about how this water is being distributed. The overall objective is to supply the water as economically as possible. To fulfill this goal, the manager and his staff must have detailed knowledge of how the system performs. The quickest way to obtain this knowledge is to divide the network in separate districts of a convenient size (Jeffcoate et al, 1987). Flow meters are installed at strategic points within the system. Ideally, the district should include 2,000 to 5,000 properties, but if the authority has no previous experience with districts, it can begin with larger districts via meters and the integrated flow into each area measured for more convenience. Meters are normally read at regular periods, weekly or monthly, and the results analyzed to determine any areas in which significant increases in supply have occurred. If no legitimate measure can be found for the increases in an area, the inspection teams sound all stopcocks, hydrants, valves and other fittings searching for the characteristic noise of leaking water. District meters can benefit from the use of loggers. This method of leakage control has the advantage that the inspectors are always working in those districts where leakage is anticipated to be highest and therefore are likely to return the greatest benefits for their efforts. It also has the additional advantage that information regarding flows and use of water within the network is obtained which can be useful for the day-to-day running of the network and for the planning and design of future extensions or rehabilitation and reinforcement. District metering is not as sensitive as to change in leakage as is not waste metering nor does it so clearly determine the position of leaks. This may be the most effective active waste control method.

b. Regular Sounding

Leaks are located by deploying teams of inspectors who systematically work their way around the system listening on consumers' stop taps, hydrants, valves and other convenient fittings. The arguments normally put forward in favor of these methods are based on the premises that area leaks are located by sounding and each part of the distribution system will always contain a certain number of unknown leaks. Consequently, time spent on metering can be more effectively used for locating leaks. These conclusions would be true provided leaks were evenly distributed throughout the system and occurred at evenly spaced intervals of time. This, however, is not normally the case. Therefore, although this method of leakage control normally costs less to implement than those incorporate metering, it results in higher average leakage levels. Regular sounding will probably be most effective in areas where the value of saving water is fairly low and where the soil conditions are such that large leaks show themselves fairly quickly and only small underground leaks need to be detected by inspection staff.

c. District metering

When the water authority is satisfied as to the total volume of water being put into their distribution network, the next step should be to learn more about how this water is being distributed. The overall objective is to supply the water as economically as possible. To fulfill this goal, the manager and his staff must have detailed knowledge of how the system performs. The quickest way to obtain this knowledge is to divide the network in separate districts of a convenient size (Jeffcoate et al, 1987). Flow meters are installed at strategic points within the system. Ideally, the district should include 2,000 to 5,000 properties, but if the authority has no previous experience with districts, it can begin with larger districts via meters and the integrated flow into each area measured for more convenience. Meters are normally read at regular periods, weekly or monthly, and the results analyzed to determine any areas in which significant increases in supply have occurred. If no legitimate measure can be found for the increases in an area, the inspection teams sound all stopcocks, hydrants, valves and other fittings searching for the characteristic noise of leaking water. District meters can benefit from the use of loggers. This method of leakage control has the advantage that the inspectors are always working in those districts where leakage is anticipated to be highest and therefore are likely to return the greatest benefits for their efforts. It also has the additional advantage that information regarding flows and use of water within the network is obtained which can be useful for the day-to-day running of the network and for the planning and design of future extensions or rehabilitation and reinforcement.

d. Waste Metering

Waste metering involves setting up areas of ideally between 1,000 and 3,000 properties such that when appropriate valves are closed these areas can be supplied via a single pipe in which it is possible to place a flow meter. The flow meter used is one, which is capable of measuring low rates of flow and normally referred to as a waste meter. The waste meter may be permanently installed on a by-pass or carried as a mobile unit and connected temporarily into the system via hydrants or specially provided connections on a by-pass, is normally used only to measure night-flow rates. If the minimum night flow rate has increased above some predetermined level or if it is above the previously recorded minimum night flow in that waste district, then it is indicative of leakage and the area is inspected. The inspection may consist of sounding the entire area supplied by the meter or more commonly by repeating the measurement and successively closing valves within the district, thus isolating sections of the district and enabling the corresponding reduction inflow rate to be determined. A large reduction inflow rate indicates the existence of a leak within the section last isolated. This procedure obviously has to be performed at night and is generally known as either a step test or a valve inspection. At the end of the step test, those sections showing evidence of leakage are investigated by the inspectors. Night-flow rate measurements are normally made on a regular basis, typically two to six times per year. This type of leakage control has the advantages that it is sensitive to small leaks and establishes the position of that leak between valves. The disadvantages are that time must be spent in monitoring districts where no leakage has occurred and hence no benefits obtained. This type of leakage control is likely to be appropriate in areas where the value of saving water is high.

e. Combined District and Waste Metering

This method of leakage control consists of a combination of the two methods discussed above. District meters are used to monitor large areas (ideally 2,000-5,000 properties) of the system. When these indicate an increase in consumption, waste meters are used downstream to determine more precisely the position of the leak. When the water authority is satisfied as to the total volume of water being put into their distribution network, the next step should be to learn more about how this water is being distributed. By suitable selection of district sizes and of meters, both waste and district meter areas can effectively coincide.

f. Pressure Control

Leakage reduction by pressure control is probably the simplest and the most immediate way of reducing leakage within the distribution system as detection of leaks is not involved. Pressure reductions may be achieved in a number of ways such as reducing pumping heads, installing break pressure tanks and most commonly, using pressure reducing valves. Although this method of leakage control has limited application, it has been found to be more beneficial than theoretical considerations suggest. It is likely to be most worthwhile not only in areas with generally high pressures but where the pressure rises to high levels at night. Measures to prevent or reduce surges are also part of pressure control for reducing bursts.

2.6 Strategies to Reduce Non Revenue Water

Traditionally, water loss management and leak detection have been treated as an afterthought in network operations. However, in recent years a water loss strategy has become one of the major operational tasks of the distribution network. This has consequences by a combination of global water shortages, privatization, regulation, and making companies increasingly accountable to customers, shareholders and regulators. (Nwe, 2008).Any strategy for managing NRW control must obviously be addressed to gain a better understanding of the reasons for NRW and the factors, which influence its components. It is then that techniques and procedures can be developed and tailored to the specific characteristics of the network and local influencing factors, to tackle each of the components in order of priority. Currently, Farley et al (2005) adopted an analytical approach for practical implementation of achievable NRW reduction strategy that can be applied to any water company, anywhere in the world, for NRW management.

The recommended strategy includes some questions about network characteristics and the operating practices, the typical questions and each task required to address each question are summarized in Table 2.2 below.

Table 2.2 : Tasks and Tools for Developing a NRW Reduction Strategy

Questions	Task
1. How much water is being lost? -measure components	**Water Balance** - Improved estimation/measurement techniques - Meter calibration policy and meter checks - Identify improvements to recording procedures
2. Where is it being lost from? - Quantify leakage - Quantify apparent losses	**Network Audit** - leakage studies (reservoirs, transmission mains, distribution network) - Operational/customer investigations
3. Why is it being lost? Conduct network and operational audit	**Review of network operating practices** - Investigate: - Historical reasons - Poor practices /materials/ infrastructure - Quality management procedures - Local/Political influences/cultural/social/financial factors
4.How to improve perfor Design a strategy and action plans	**Upgrading and strategy development** - Update records systems, Introduce zoning and 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/O & M procedures - Water conservation and demand - Management programs - Action plan recommendations

Source: Farley & Liemberger, (2005)

During the first workshop of the Project of Non-Revenue Water Management in Kenya (2011) measures cited in tables 2.3 and 2.4 below were given as appropriate for reducing NRW.

Table 2.3 : Examples of NRW Reduction Measures

Stage	NRW Level	Purpose of NRW Reduction Activity	Measures
First	More than 30%	To reduce commercial loss To decrease surface leakage	-Conduct public awareness -Install water meters -Improve billing and revenue collection system by computerized system
Second	30%-25%	To decrease underground leakage	Implement zoning, map of pipeline, train staff, Detect underground leakage and undertake underground leakage survey
Third	25%-20% (Overlapping second stage)	To stop recurrence of leakage	Increase leakage control activities Begin replacement of aged pipes
Fourth	20%-12%	To carry out thorough leakage control activity	Revise working method Accelerate pipe replacement work
Fifth	12%-5%	To conclude thorough leakage control activity	Replace old pipes and streamline organizations Prepare sustainable overall maintainance strategy
Sixth	Less than 5%	To maintain minimum NRW ratio	Conduct regular leakage control activities Maintain this ratio with minimal measures Assess cost benefit analysis

Source: Manual of NRW Reduction for WSP, Version 1 (2011)

Table 2.4 : Details of NRW Reduction Measures

Measure	Item	Activities
Fundamental Measures	Preparatory Works	• Establish operational measures • Prepare maps (distribution pipeline map), maintenance of measuring equipments • Analysis of volume of distributed water • Identify causes of NRW
Commercial loss Reduction Measures	Public Awareness	• Restore customer trust (transfer customers to use public water , handling customer complaints, increase in number of new customers, change from flat rate system to commodity charge system)
	Billing and Revenue Collection	• 100% installation of customer water meter • Improve meter reading accuracy • Set up a billing and revenue collection system • Introduce computer system • Training of staff • Test customer water meter accuracy by using meter testing equipment • Improve water quality by reducing suspended materials and air in water • Improve customer care • Reduce unpaid bills of big users • Detect illegal connections • Improve work efficiency
Physical Loss Reduction Measures	Detection and Repair of Leakages	• Repair of Visible Leakages (improve quality of material used and management of facilities) • Detect and repair Non-Visible Leakages • Establish Water Demand Characteristics (establish level of physical loss)

Source: Manual of NRW Reduction for WSP, Version 1 (2011)

2.7 Challenges in Reducing NRW

Of particular significance is the use of the term "non-revenue water" (NRW) in place of the widely used "unaccounted-for water", due to the scope for misinterpretation and manipulation (McKenzie and Seago, 2005). The definition of NRW is simply explained as the difference between system inputs of water and billed for water. However, NRW reduction is difficult to control and not a simple matter to implement (Kingdom, Liemberger, Marin, 2006). Upper management often does not address water loss issues and this mindset can permeate an entire organization (Queensland Environmental Protection Agency and Wide Bay Water Corporation, Managing and Reducing Losses from Water Distribution Systems, Manual 1, 2002). Root of this issue is not only do new technical approaches have to be adopted, but effective arrangements must also be established in the managerial and institutional environment. Understanding of the problem, lack of capacity, missing management focus, importance of enabling environment and incentives are the main causes for delay implementation of NRW reduction management.

Understanding of the problem: not understanding the magnitude, sources and cost of NRW is one of the main reasons for insufficient NRW reduction efforts around the world (Kingdom et al, 2006). Only by quantifying NRW and its components, calculation appropriate performance indicators, and turning volumes of lost water into monetary values can the NRW situation be properly understood and the required action be taken. Despite the fact that many utilities in the developing countries have implemented NRW reduction programs with donor funding, it is rare that a comprehensive water balance was actually developed and calculated. Therefore, there is no doubt that the end results often fail to match expectations. NRW management is not technically difficult, but it is complex. Properly understanding the baseline situation is a critical first step in moving toward an effective reduction program.

Lack of Capacity: Many governments and water utilities can find it difficult to identify accurately the amount of water they lose each year through problems such as theft, system leakage, un-metered water use, and inaccurate meters. All these actions are the reason of lack of capacity for reducing NRW activities. NRW reduction activities require a range of skilled staff, including managers and professional engineers at one end of the spectrum right through to street crews, technicians, and plumbers at the other. "NRW reduction," in its broadest sense, staff with necessary skills is not widely available. Addressing this issue will require both an acceptance of the widespread challenges and consequences associated with NRW and then the development of appropriate training materials, methods, and institutions. A major initiative is required to build such capacity.

Missing management focus: establishing and maintaining an effective NRW program is, besides all other difficulties, a managerial problem, because managing NRW calls for effective institutional management systems that are comprehensive and operational. Day to day operations and future planning should have this important factor in their perspective. This implies that human beings and machinery should be planned and managed in such away. They would timely and effectively react and prevent any water losses (Tumuheirwe et al, 2005). Physical loss reduction is an ongoing, particular activity with few supporters among the following:

i) Politicians: there is no "ribbon cutting" involved.
ii) Engineers: it is more "fun" to design treatment plants than to fix pipes buried under the road.
iii) Technicians and field staff: detection is done primarily at night, and pipe repairs often require working in hazardous traffic conditions.
iv) Managers: it needs time, constant dedication, staff, and up-front funding

Moreover, the reduction of commercial losses is very unpopular among the following:

i) Politicians: unpopular decisions might have to be made (disconnection of illegal consumers or customers who don't pay).
ii) Meter readers: fraudulent practices might generate a substantial additional income.

iii) Field staff: working on detecting illegal connections or on suspending service for those, who do not pay their bills is unpopular and can even be dangerous.

iv) Managers: it is easier to close any revenue gap by spending less on asset rehabilitation (letting the system slowly deteriorate) or asking the government for more money.

v) Except for those customers who do pay their bills, it might appear that there is no support from any party (Kingdom et al, 2006).

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

Enabling Environment and Incentives: Most of the above challenges do apply to both private and public utilities, but in general, private operators have incentives to reduce NRW because this can generate more revenues and reduce operating costs, in addition to specific contractual targets in several cases (Brocklehurst et al, 2006). It is, however, more difficult for publicly managed utilities because they often lack an adequate enabling environment and a proper incentive framework for performance. For instance, a lack of flexibility in human resources management could make it difficult to reorganize working shifts and pay bonuses for staff who works at night on leakage detection. Recent findings suggested, however, that the right incentives can be put in place in a public utility within a broader framework of encouraging autonomy, accountability, and market and customer orientation (Baietti et al, 2006). It is improving NRW performance in clearly a major outcome that would be desired from such an initiative. It is instructive to consider the incentives related to NRW programs in a little more detail and wonder why, despite the obvious benefits of NRW reduction, the NRW performance of utilities in the developing world is so poor. A commonly voiced answer is that politicians are mostly interested in the utility management to obtain a new water treatment plant or project than for a leakage reduction program. In reality, implementing a NRW reduction program is inherently complex. It requires addressing, in a comprehensive manner, the various problems that lie at the root of the poor performance of a water utility. This represents a challenge that goes beyond just NRW performance. NRW reduction is risky that utilities manager feel uncertain and civil servants tend to be risk averse. Therefore, when confronted with a choice between reducing NRW and increasing production capacity, they choose the second one. This might not make much sense in economic terms, but at least they feel confident that they will have something tangible to show to their constituency that the expected benefit can be realized. Therefore, the key obviously overlooked message is that NRW must not be considered in a vacuum, but it should be within the broader context of utility reform. The designer of any NRW program needs to look carefully at the incentives for the managers and staff of the program, as well as all the parties involved. Any program should ensure, as far as possible, that the incentives are properly aligned with the objective of developing an efficient and effective utility that meets the needs of its consumers (Kingdom, Liemberger et al, 2006).

2.8 Conceptual Framework

This study used IWA water balance model to explain the factors that contribute to NRW. The components of this water balance reveals two kinds of water losses: the **real losses**, or physical losses(which are the volume of water actually lost through leaks and bursts) and the **apparent losses**, or commercial losses,(which are commercial losses in the sense that the water is not lost but no one is pays for it). The apparent losses are mainly due to fraud (illegal connection, meter by-pass and metered tampered), meter errors and inaccurate data about the consumption. The model also lists unbilled authorized consumption as contributing to non-revenue water. Other studies have also used this model to assess the factors that contribute to NRW (Charalambous, 2008; Fanner et al., 2007; Lambert, 2002). These studies pointed out that apparent losses and real losses contributed to NRW. Also, Noor (2005) noted that the human factor is really significant for the apparent losses, with the customer behavior as well as the accounting errors and data handling. The above-mentioned authors have successfully used IWA model to analyze factors influencing NRW. This study also adopts the IWA model. By understanding the model, this study further seeks to explore the factors that inflence NRW in Garissa Township. Figure 1 presents the conceptual framework for this research.

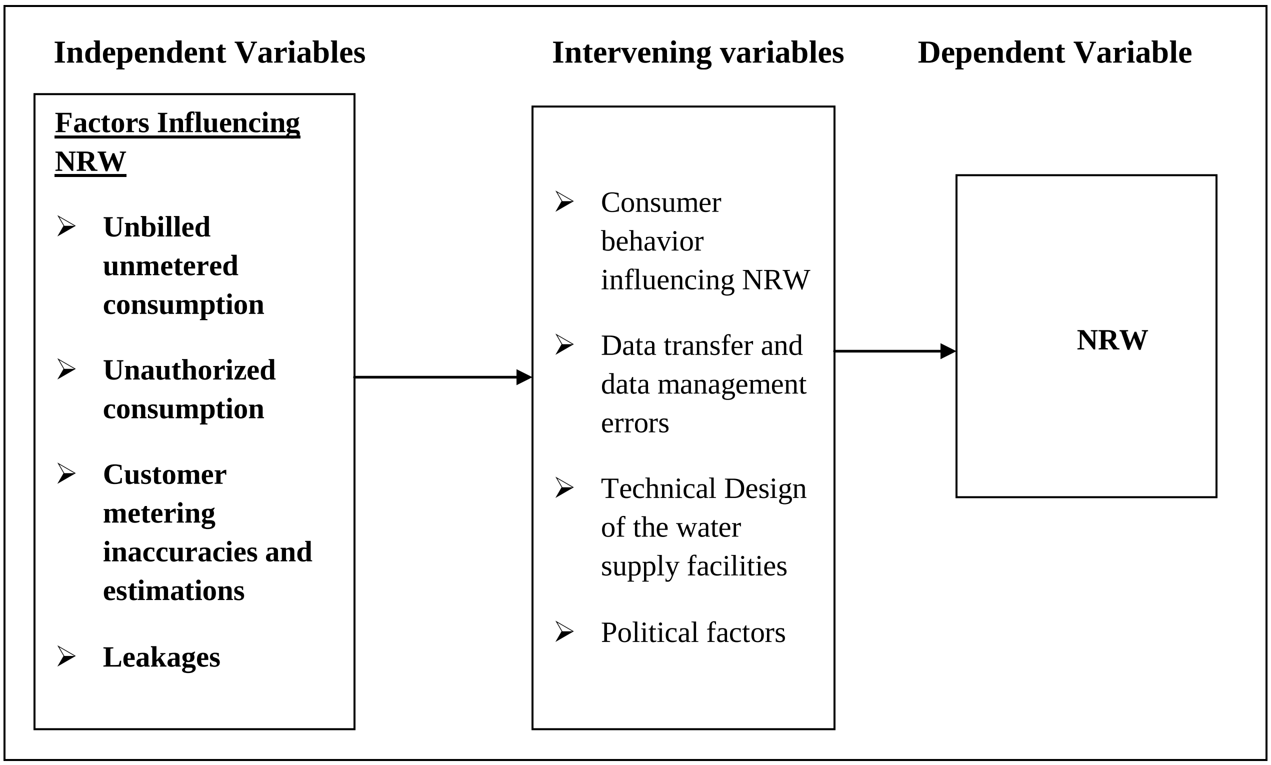

Figure 1: Conceptual Framework

The figure shows the four indicators of NRW as unbilled unmetered consumption, unauthorized consumption, customer meter reading inaccuracies and estimations, and leakages .Unauthorized consumption and customer metering inaccuracies and estimates result in commercial losses. Leakage on transmission and/or distribution mains and leakages and overflows at utility storage tanks result in physical losses. Therefore, this research provides a holistic conceptual framework for linking non-revenue water to its indicators. This framework involves the identification of issues on the research.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

This chapter provides details on the method used to gather the data whose findings inform this report and the methodology applied to process and analyse the data.

3.2 Research design

The design and implementation of this research was geared towards a realistic understanding of factors contributing to Non-Revenue Water in Garissa Township. The initial step in the research was the project preparation. A research proposal setting the methodology and outlining research tasks was developed. The main tasks comprised preparing sample frame and sampling, design of interview instrument, interviewing, data analysis and report writing. Research Assistants services were not required due to the small sample size. Thus, data was collected by the researcher. To pre-test the research instrument, actual interviews were conducted among the field technical staff of GAWASCO. The choice of pre-test site was therefore deliberate to come as close as possible to reality especially by being able to interview at least some field technical staff in GAWASCO. Interviews were carried out with 2 technical staffs of GAWASCO. There was useful feedback on questionnaire design that helped in revision of the research instrument. Field logistics and fieldwork then commenced.

3.3 Sampling

The study utilized purposive sampling technique to select the respondents due to the technical nature of the research topic. In this case, the respondents were field technical members of staff of GAWASCO and thus sharing the same broad occupation. A homogeneous sample (consisting of only field technical staffs) was chosen since the research questions that were being addressed were of a specialized field falling within the occupation of this particular group of respondents. This enabled the researcher answer his research questions by subsequently examining the subject matter of NRW in detail.

A formal request was made to the Managing Director, GAWASCO, by use of the letter of transmittal, to assist in obtaining a list of the names and designations of the company's field technical staff. The list formed the sampling frame from which the list of respondents of the study was drawn. Table 3.1 below gives a summary of the list of all the field technical staff in GAWASCO, their designation and the number of personnel in each cadre. Since the sample size was small, the researcher opted to interview all the 29 field technical staff in GAWASCO. Simple random sampling method was used in selecting twenty seven members of staff to form the final sample with the remaining two being used for pretesting the questionnaire. Mugenda et al (2003) holds that that the number of cases in the pretest should normally be between 1% and 10% depending on the sample size, the bigger the sample, the smaller the percentage. Consequently, only the 27 were interviewed for the final study.

Table 3.1 Sampling Frame of the Study

Designation	Number of Personnel	Number Interviewed
Plumbers	9	9
Assistant plumbers	1	1
Supervisor of meter readers	1	1
Meter readers	3	3
Assistant meter readers	1	1
Sewerage supervisor	1	1
Sewerage attendants	3	3
Water Supply Operators	2	1
Inspector of Water / TSM	1	1
Inspectors of Water	2	1
Publicity Assistant	1	1
Pump attendants	2	2
Line Patrollers	2	2
TOTAL	**29**	**27**

3.4 Research Instrument, Data and Collection of Data

The researcher formulated the research instrument for collection of data. After obtaining the pre-test results, the instrument was refined and finalized for use in the field. The instrument was in form of a structured questionnaire to be administered to individual field technical staff of GAWASCO. This was particularly significant for providing an "insider view" and to help attain a balanced understanding of the NRW status in Garissa Township. The information to be solicited comprised personal background, respondent's knowledge on NRW and suggestions to reduce NRW in Garissa Township. The research was therefore structured to obtain primary data through interviews with respondents individually.The responsibility for conducting interviews was solely for the researcher. The GAWASCO field technical staffs, who were the respondents in this Survey, were all interviewed during their free time, especially on weekends, after making prior arrangements with their boss, the Technical Services Manager (TSM).The field work implementation plan was successfully undertaken. However, due to unforeseeable developments the time schedule was constantly reviewed and revised. The researcher developed a letter of introduction and made interview appointments to actually reach the technical staff.The research relied on secondary data as well as involving a review of both published and unpublished materials to gather relevant information.

3.5 Validity and Reliability

To test for validity of the instruments, a pre-test was conducted. There was useful feedback on questionnaire design that helped in revision of the research instrument thus validating the instrument.

Cronbach's alpha (α) using SPSS was utilized for reliability analysis of the variables in the questionnaire. Cronbach's alpha was run on a sample size of 27 respondents. The results of the test are as presented in table 3.2 below

Table 3.2 Reliability Statistics

Aspect	Value
Cronbach's Alpha	0.812
Cronbach's Alpha based on standardized items	0.781
Number of items	27

Cronbach's alpha (also referred to as overall reliability coefficient) was found to be 0.812 therefore implying a high level of internal consistency thus ascertaining the reliability of the instrument. (Note that a reliability coefficient of .70 or higher is considered "acceptable" in most social science research situations.)

3.6 Methods of Data Analysis

Quantitative analytical technique was used for data analysis. Questionnaires were checked, coded and entered for computerized data analysis using the Statistical Package for Social Sciences (SPSS). This comprised of descriptive statistics to show the distribution of the demographic variables and proximate variables contributing to NRW in Garissa Township. Cross tabulations was used to determine the associations between the level of knowledge on NRW and years of working experience in the water sector. The method also served as a quality check on the data and gave a clear picture of how various variables are distributed.

3.7 Ethical considerations

A letter of transmittal was used to administer the questionnaires. Other ethical issues observed while conducting the study are outlined below.

3.7.1 Confidentiality and Privacy

Due to the possibility that information given may reveal some shortcomings of the WSP confidentiality was promised to all the respondents on the letter of transmittal with further assurance being given when administering the questionnaires.

3.7.2 Anonymity

Respondents were not required to give their names on the questionnaires in order to protect their identity.

3.7.3 Voluntary and Informed Consent

An informed consent was obtained from the respondents after the study objectives, purpose, and significance of the study had been read to them. The same information was also disclosed to the Managing Director of WSP before the interviews were conducted.

3.7.4 Dissemination of Findings

The researcher promised to avail a copy of the final report to the respondents upon request.

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION AND INTERPRETATION

4.1 Introduction

This chapter presents findings of the study. It presents results arising from the analysis of data collected using descriptive statistics. The findings are presented in tabular summaries and their implications discussed. In particular, it documents the questionnaire response rate, demographic information of the respondents, level of knowledge of the respondents on NRW, factors that contribute to NRW, strategies employed to reduce NRW, challenges faced in reducing NRW and suggestions to help reduce NRW in Garissa Township.

4.2 Response Rate

The study was able to get response from 27 respondents from 27 questionnaires administered to individual field technical staff amounting to a 100% response rate.

4.3 Background Information of the Respondents

The background characteristics of the respondents were sought in the Study to establish the characteristics of the participants of the Study. In this study the demographic characteristics that were analyzed were; the gender of the respondents, education level, professional qualification and years of experience of the respondents in the water sector. The results are summarized in this section.

4.3.1 Gender of the Respondents

All the respondents interviewed in the Study were male.

4.3.2 Highest Education Level of the Respondents

All the respondents interviewed in the Study had College level of education as their highest level of education.

4.3.3 Professional Qualification of the Respondents

All the respondents interviewed in the Study had been trained in a water related discipline.

4.3.4 Years of Experience of Respondents in the Water Sector

Years of experience of respondents in the water sector are as presented in Table 4.4 below.

Table 4.1: Years of Experience of Respondents in the Water Sector

Years of working experience	Frequency	Percent
<= 2 years	3	11.1
3-6	21	77.8
15 or more	3	11.1
Total	**27**	**100**

From Table 4.1 above, a majority, 77.8 per cent, had 3 to 6 years of experience in the water sector while 11.1 % had less than two year of experience and 15 or more years of experience respectively.

4.4 Level of Knowledge in Non-Revenue Water

This section analyses the relationship between years of experience in the water sector and the level of knowledge in NRW and unbilled unmetered consumption of water which is a proxy indicator of NRW.

4.4.1 Relationship between Years of Experience in the Water Sector and the Level of knowledge in NRW

Relationship between years of experience in the water sector and the Level of knowledge in NRW is as presented in Table 4.2 below.

Table 4.2: Relationship between Years of Working Experience in the Water Sector and the Level of knowledge in NRW

Years of working experience	Level of knowledge in NRW					
	Frequency			Percent		
	Average	Good	Excellent	Average	Good	Excellent
<= 2 years	0	0	3	0	100	0
3-6	6	15	0	28.6	71.4	0
15 or more	3	0	0	100	0	0
Total	**9**	**15**	**3**	**33.3**	**55.6**	**11.1**

Table 4.2 shows the relationship between years of working experience in the water sector and the level of knowledge in NRW. From the findings it is apparent that all respondents with 2 and below years of experience had excellent knowledge on NRW. While a majority (71%) of those with 3-6 years' experience had good knowledge on NRW while all respondents with 15 or more years of experience had average knowledge on NRW. Thus it can be deduced that years of experience of the respondents in the water sector has a significant effect on the level of knowledge in NRW. The association is statistically significant since the Pearson chi square value is 33.429 and p- value is $0.000<0.05$, thus the years of experience of the respondents in the water sector is an important factor determining level of knowledge in NRW. Thus the fewer years of experience one has the more knowledgeable one is in NRW.

4.4.2 Relationship between Years of Experience in the Water Sector and the Level of Knowledge in Unbilled Unmetered Consumption (A Proxy Indicator of NRW)

Relationship between years of experience in the water sector and the Level of knowledge in unbilled unmetered consumption of water, a proxy indicator of NRW, is as presented in Table 4.3 below:

Table 4.3: Relationship between Years of Experience in the water sector and Knowledge of Unbilled Unmetered Consumption

Years of working experience	**Level of knowledge of UUC**					
	f			**%**		
	Average	Good	Excellent	Average	Good	Excellent
<= 2 years	0	0	3	0	0	100
3-6	9	12	0	42.9	57.1	0
15 or more	0	3	0	0	100	0
Total	**9**	**15**	**3**	**33.3**	**55.6**	**11.1**

Table 4.3 reveals that, years of experience in the water sector has a significant effect on the level of knowledge in unbilled unmetered consumption of water. From the findings it is apparent that all respondents with 15 and more years of experience had good knowledge on unbilled unmetered consumption water while those with 2 and less years had excellent knowledge. A majority (57%) of those with 3-6 years' experience had good knowledge while 43% reported to have average knowledge. Thus it can be deduced that years of experience of the respondents in the water sector has a significant effect on the level of knowledge in unbilled unmetered consumption. The association is statistically significant since the Pearson chi square value is 29.314 and p- value is 0.000<0.05, thus the years of experience of the respondents in the water sector is an important factor determining level of knowledge in unbilled unmetered consumption of water. Thus the fewer years of experience one has the more knowledgeable one is in unbilled unmetered consumption of water.

4.5 Perception on Non-Revenue Water in Garissa Township

This section analyses the perception of the respondents on the level of NRW and determines the relationship between perception on the level of NRW versus amount of unbilled unmetered consumption and the quantity of water that is unbilled unmetered consumption, a proxy indicator of NRW.

4.5.1 Respondents Opinion on Level of Non-Revenue Water

According to the Study most respondents (67%) had the opinion that the level of NRW was high while the rest thought it was moderate (See Table 4.4).

Table 4.4: Opinion on Level of NRW

Level of NRW	Frequency	Percent
High	18	66.7
Moderate	9	33.3
Total	**27**	**100**

4.5.2 Relationship between the level of NRW and the Amount of Unbilled Unmetered Consumption

Relationship between perception on the level of NRW and amount of unbilled unmetered consumption, is as presented in Table 4.5.

Table 4.5: Relationship between the level of NRW and the Amount of Unbilled Unmetered Consumption

Opinion on level of NRW	f			%		
	At most 5%	5-10%	More than 10%	At most 5%	5-10%	More than 10%
High	3	3	12	16.7	16.7	66.7
Moderate	0	6	3	0	66.7	33.3
Total	**9**	**15**	**3**	**11.1**	**33.3**	**55.6**

From the result of the cross tabulation, level of NRW was found to have a significant association with the amount of water that is unbilled unmetered consumption. According to the findings, it is apparent that those who perceived the level of NRW to be high, a majority (67%) reported the amount of unbilled unmetered consumption to be more than

10% while those who perceived the level of NRW to be moderate, majority (67%) reported the amount of unbilled unmetered consumption to be between 5-10%. Thus it can be deduced that the level of NRW is associated with the amount of unbilled unmetered consumption. The association is statistically significant since the chi square value is 7.200 and p- value is 0.027<0.05. Thus, the higher the level of NRW the more the amount of unbilled unmetered consumption. The results from this research provide strong evidence supporting the hypothesis that the level of NRW has a positive effect on the amount water that is unbilled unmetered consumption.

4.6 Factors Influencing Non Revenue Water in Garissa Township

This section summarizes the Study findings on the key factors found to influence NRW in Garissa Township, one of the objectives of the study. From the conceptual framework, it is worth noting that there are three main factors that influence NRW. These are: unbilled authorized consumption (e.g. unbilled unmetered consumption), commercial losses (e.g. Unauthorized Consumption and Customer Metering Inaccuracies and Estimations) and physical losses (e.g. Leakage on transmission or distribution mains and Leakage and overflows at utility storage tanks). The respondents were asked to state whether or not the factors, which are the indicators of NRW, manifest themselves in Garissa Township. The results are discussed below

4.6.1 Unbilled Unmetered Consumption

All respondents agreed that unbilled unmetered consumption is one of the factors influencing NRW in Garissa Township. The results are shown on table 4.6 below.

Table 4.6: Respondents Opinion on Quantity of Unbilled Unmetered Consumption

Level of UUC	**Frequency**	**Percent**
<= 5% of water produced	3	11.1
5-10%	9	33.3
More than 10%	15	55.6
Total	**27**	**100**

According to the Study most respondents (56%) stated the amount of unbilled unmetered consumption water to be more than 10 per cent. Thirty three percent perceive the amount to be between 5-10% while a few (11%) perceive the amount to be less than 5 %.

4.6.2 Illegal Connection

All respondents agreed that there are cases of illegal connections which results into unauthorized consumption, a factor influencing NRW. The results are presented on table 4.7 below.

Table 4.7: Frequency of Encountering Cases of Illegal Connections

Frequency of encountering illegal connections	**Frequency**	**Percent**
Once a week	6	33.3
Monthly	18	66.7
Total	**27**	**100**

According to the results of the study most cases of illegal connections are encountered on a monthly basis.

4.6.3 Meter Reading Inaccuracies and Estimations

All respondents agreed that there are cases of illegal connections which results into unauthorized consumption, a factor influencing NRW. The results are presented on table 4.8 below.

Table 4.8: Reported Cases Relating to Meter Reading Inaccuracies and Estimations

Reported cases relating to Meter reading inaccuracies	Frequency	Percent
Malfunctioning meters	27	100
Misreading meters	15	55.6
Water meters nor working	15	55.6
Total	**57**	**211.1**

Malfunctioning water meters are the most type of cases experienced by all respondents relating to meter reading inaccuracies and estimations. This is followed by water meters not working and misreading water meters as reported by 56% of the respondents. The three constitute commercial losses, a factor influencing NRW.

4.6.4 Leakages from Transmission and Distribution Mains

All respondents reported to have encountered cases of leaks from transmission and distribution mains. Leakages from transmission and distribution mains constitute physical losses, a factor influencing NRW.

4.6.5 Leakages and overflows from Utility Storage Tanks

All respondents reported to have encountered cases of leakages and overflows from utility storage tanks. This results into physical losses, a factor influencing NRW.

4.7 Strategies Employed to Reduce Non Revenue Water in Garissa Township

One of the objectives of the study was to find out the find out the existing strategies employed to combat NRW in Garissa Township. This section summarizes the Study findings on the objective.

4.7.1 Strategies Employed to Reduce Meter Reading Inaccuracies and Estimations

The respondents were asked the existing strategies used to reduce meter reading inaccuracies and estimations. The results are shown on table 4.9 below. The two key strategies employed to reduce meter reading inaccuracies and estimation are prompt replacement of malfunctioning water meters and training meter readers as reported by 89% and 78% of the respondents respectively and presented in Table 4.9 below.

Table 4.9 Strategies Employed to Reduce Meter Reading Inaccuracies and Estimations

Strategies employed to reduce Meter reading inaccuracies and estimations	Frequency	Percent
Conducting public awareness	9	33.3
Prompt replacement of Malfunctioning water meters	24	88.9
Training meter readers	21	77.8
Total	**54**	**200**

From the results, the two key strategies employed to reduce meter reading inaccuracies and estimation are prompt replacement of malfunctioning water meters and training meter readers as reported by 89% and 78% of the respondents respectively .

4.7.2 Strategies Employed to Reduce All other Forms of NRW

Implementation of zoning, installing consumer water meters and training staff on NRW are the three main strategies employed to reduce NRW. This is as reported by 67% 56%

and 56% of the respondents respectively. Other strategies are as presented in Table 4.10 below

Table 4.10 Strategies Employed to Reduce All other Forms of NRW

Strategies employed to reduce other forms of NRW	Frequency	Percent
Conducting public awareness	9	33.3
Installing water meters	15	55.6
Improving billing and revenue collection by computerized system	6	22.2
Training staff on NRW	15	66.7
Implementing zoning	18	55.6
Total	**63**	**233.3**

4.8 Challenges Faced in Reduction of NRW

One of the objectives of the study was to find out the challenges faced in reducing the level of NRW in Garissa Township. This question was posed to the respondents and the results are shown on table 4.11 below.

Table 4.11: Challenges Faced in Reducing NRW

Challenge	Frequency	Percent
Public ignorance on NRW	21	77.8
WSP staff ignorance on NRW	9	33.3
Inadequate technical capacity in NRW	9	33.3
Reluctant management	15	55.6
Reluctant technical staff	12	44.4
Lack of a proper staff incentive Framework for performance	9	33.3
Old and defective pipelines	3	11.1
Hostility of the community towards some NRW reduction measures	3	11.1
Prohibited access to some consumers residences	3	11.1
Corruption among some WSP staff	3	11.1
Total	**87**	**233.3**

Public ignorance on NRW, reluctant management and reluctant technical staff are the three key challenges facing reduction of NRW in Garissa. This was as reported by 77.8%, 55.6% and 44.4% of the respondents respectively

4. 9 Suggestions to Reduce NRW

One of the objectives of the study was to come up with recommendations on possible recommendations strategies which may be employed to reduce NRW in Garissa township. The respondents were asked to come up with suggestions touching on this objective by use of a likert scale. The results are as presented on Table 4.12 below

Table 4.12: Recommendations on how to reduce NRW

Suggestion	f				%			
	Strongly Agree	Agree	Undecided	Disagree	Strongly Agree	Agree	Undecided	Disagree
WSP should Hold public awareness on NRW	12	15	0	0	44.4	55.6	0.0	0.0
Implement zoning	15	6	6	0	55.6	22.2	22.2	0.0
Train WSP staff On NRW	15	12	0	0	55.6	44.4	0.0	0.0
Improve billing To computerized system	18	0	6	3	66.7	0.0	22.2	11.1
Introduce proper staff Incentive framework	21	3	3	0	77.8	11.1	11.1	0.0
100% installation of Water meters	24	3	0	0	88.9	11.1	0.0	0.0

Most respondents (88.9%) strongly agreed that 100% installation of water meters for all connected consumers would reduce NRW. A few (11%) disagreed with the suggestion of billing and revenue collection to be computerized as a way to reduce NRW.

CHAPTER FIVE

SUMMARY OF THE FINDINGS, DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter summarizes the Study findings, gives the conclusions derived from the Study, and finally comes up with some recommendations based on these findings.

5.2 Summary of the Study

The main objective of this Study was to find out factors influencing Non-Revenue Water (NRW) in Garissa Township. The Study had three other objectives which focused on establishing factors that influence NRW in Garissa Township and coming up with solutions to help reduce NRW in the township. To achieve these objectives, the researcher utilized cross sectional descriptive design. The main tasks comprised sampling, design of interview instrument, interviewing, data analysis and report writing.

To test for validity of the instruments, a pre-test was conducted. There was useful feedback on questionnaire design that helped in revision of the research instrument thus validating the instrument. Cronbach's alpha (α) using SPSS was utilized for reliability analysis of the variables in the questionnaire. Cronbach's alpha value was, 0.812 (also referred to as overall reliability coefficient) implying a high level of internal consistency thus ascertaining the reliability of the instrument.

Research Assistants services were not required due to the small sample size. Thus the interviews were conducted by the researcher. The Study population consisted of the field technical member of staff of GAWASCO. The researcher was able to get response from 27 respondents from 27 questionnaires administered to individual field technical staff accounting to 100% response rate.

Quantitative analytical technique was used for data analysis. Questionnaires were checked, coded and entered for computerized data analysis using the Statistical Package for Social Sciences (SPSS). Summary statistics such as percentages and counts were prepared and appropriate statistics calculated to show the distribution of the demographic variables and proximate variables contributing to NRW in Garissa Township. Further analysis comprised preparation of cross tabulation and chi-square tests.

Based on field technical staffs' in GAWASCO responses, the researcher came up with findings which were then used to make conclusions and give recommendations. These findings were as a result of data analysis in chapter four. The researcher used descriptive survey in this study which aimed at collecting data from GAWASCO field technical staff in relation to their level of knowledge on non revenue water and their opinion on the factors that contribute to non revenue water in Garissa Township. The results arising from the analysis of data collected using descriptive statistics were then presented in tabular summaries and their implications discussed.

5.3 Discussion of the Findings

Most respondents (67%) were of the opinion that the level of NRW in Garissa Township was high. In order to establish the relationship between perceived level of NRW and amount and quantity of unbilled unmetered consumption, cross tabulation and chi-square tests were done. The results of the study revealed that the level of NRW is associated with the amount of unbilled unmetered consumption. The association was statistically significant with a p- value of 0.027. Thus, the higher the level of unbilled unmetered consumption the more the amount of NRW. Moreover, it can be deduced that the level of NRW is associated with the quantity of unbilled unmetered consumption. Of the respondents who had the opinion that the level of NRW was high, a majority (83%) reported the quantity of unbilled unmetered consumption to be unreasonable. Those who perceived the level of NRW to be moderate all reported the quantity of unbilled unmetered consumption to be unreasonable. The association, though not statistically significant, is very important since according to the Design Manual for Water Supplies in Kenya (2005) any amount of unbilled unmetered consumption above 5% is considered unreasonable and results to high NRW. Most respondents (56%) had the opinion that the amount of unbilled unmetered consumed water was more than 10 per cent which is unreasonably high.

All respondents agreed to have encountered cases of illegal connections which results into unauthorized consumption, a factor influencing NRW. Malfunctioning water meters are the most type of cases experienced by all respondents relating to meter reading inaccuracies and estimations. The second most cases experienced was water meters not working and misreading water meters as reported by 56% of the respondents. These result into commercial losses, a factor influencing NRW. Additionally, all respondents reported to have encountered cases of leaks from transmission and distribution mains which results into physical losses, a factor influencing NRW. In addition, all respondents reported to have encountered cases of leakages and overflow from utility storage tanks which results into physical losses, a factor influencing NRW.

Implementation of zoning, installation of consumer water meters and training staff on NRW are the three main strategies employed to reduce NRW. This was reported by 67%, 56% and 56% of the respondents respectively. The strategies deviate significantly from those contained on table 2.3 which recommends conducting public awareness, installation of water meters, and improvement of billing and revenue collection system to computerized system as the most suitable strategies for reducing NRW to below 30%.It is also worth noting that despite majority of the respondents citing public ignorance on NRW as the main challenge facing reduction of NRW in Garissa Township , conducting-public-awareness was found to be the second least used strategy for reducing NRW .

Upper management often does not address water loss issues and this mindset can permeate an entire organization (Queensland Environmental Protection Agency and Wide Bay Water Corporation, Managing and Reducing Losses from Water Distribution Systems, Manual 1, 2002). This assertion was also reflected in the findings of the study which showed reluctant management and reluctant technical staff to be among the three key challenges facing reduction of NRW in Garissa Township. The said reluctance was reported by 56% and 44% of the respondents respectively. A high NRW level is normally a surrogate for a poorly run water utility that lacks the governance, the autonomy, the accountability, and the technical and managerial skills necessary to provide reliable service to their population (Kingdom et al, 2006). This assertion agrees with the findings of the study whereby 33.3% of the respondents' cited inadequate technical capacity in the WSP among the challenges facing reduction of NRW in Garissa Township. However, according to Kingdom et al (2006) "NRW reduction," in its broadest sense, is not taught at universities or technical colleges or in many of the water industry training institutions around the world. As a consequence, staff with necessary skills is not widely available. Addressing this issue will require both an acceptance of the widespread challenges and consequences associated with NRW and then the development of appropriate training materials, methods, and institutions. A major initiative is required to build such capacity. This was manifested in the findings of the study in which a majority of the respondents did not have an excellent knowledge of NRW despite all of them having been trained in water related disciplines.

Most respondents (88.9%) strongly agreed that 100% installation of water meters for all connected consumers would reduce NRW. The second most strongly agreed suggestion to reduce NRW was the introduction of a proper staff incentive framework for performance by Water utility management as reported by 78 percent of the respondents. This significant deviation of the suggestion from the priorities listed on table 2.3 may be attributable to a majority of the technical staff not having an excellent knowledge of NRW.

5.4 Conclusion

The Study aimed at establishing the factors contributing to Non-Revenue Water (NRW) in Garissa township. The results of the Study reveal that the level of NRW in Garissa Township is unreasonably high with the quantity of unbilled unmetered consumption being more than 10%. The three factors responsible for the high NRW in Garissa township were: unbilled unmetered consumption, physical losses and commercial losses**.**

The three key strategies being employed to reduce NRW in Garissa township are: Implementing zoning, training staff on NRW management and installing consumer water meters. Public ignorance, reluctant management and reluctant technical staff are the three key factors militating against the successful implementation of the NRW reduction strategies facing Garissa Township.

5.5 Recommendations

Nwe (2008) stated that any strategy for managing NRW control must obviously be addressed towards gain a better understanding of the reasons for NRW and the factors, which influence its components and it is then that techniques and procedures can be developed and tailored to the specific characteristics of the network and local influencing factors, to tackle each of the components in order of priority .This study sought to find out the reasons for NRW and its components in Garissa township upon which recommendations for its reduction would be objectively based.

First, the study recommends one hundred percent (100%) installation of water meters for all connected consumers in order to reduce the level of NRW which most respondents cited to be high and introduction of a proper staff incentive framework for performance. Corruption among WSP staff may be abated by improving billing and revenue collection to a computerized system with the consequent effect of reducing NRW. The results of the study also showed that a majority of the respondents did not have excellent knowledge of NRW. Consequently, the study recommends that WSP staff be trained on NRW management.

According to the Manual on NRW reduction for WSP (2011) GAWASCO should prioritize holding conducting public awareness and improving billing and revenue collection to computerized system in order better its chances of reducing NRW levels to less than 30%. The study findings showed that the two were the least employed strategies and yet they are the ones most advocated for by the Manual for WSPs reporting NRW levels of more than 30%. An understanding of NRW would minimize the hostility by the community towards some of the NRW reduction measures. Incidences of malfunctioning water meters probably caused by fraudulent practices by consumers may also be reduced.

Mahmoudi (2007) revealed the positive role of the Iranian government by devoting a part of the budget to the combat of NRW, pressing the water and wastewater companies to allocate a part of their budget to this task. Because the foregoing reason they improved their water losses management through better operational practices (leakage detection and quicker response to detection, replacements and implementation of new monitoring equipments, following national standards whilst installing new branches, conducting pilots' projects...). In this study 56% of the respondents cited reluctant management as one of challenges facing the reduction of NRW in Garissa township. This study recommends active involvement of management by channeling of some of the WSP resources towards combating the high NRW levels.

5.6 Recommendations for further study

Nwe (2008) holds that in order to efficiently reduce NRW each of the factors influencing it should be tackled in the order of priority. This study dug deep into the factors influencing NRW in Garissa municipality but fell short of prioritizing them. Consequently, future studies should fill the gap by investigating and analyzing the influence of each of the factors on NRW. There is also need to replicate this study in other WSPs in order to enable comparison of the results

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APPENDICES

Appendix I: Letter of Introduction

Collins Komora Owiti
University of Nairobi,
P.O. Box 30197, 00100,
Nairobi.

31st January, 2013

Dear Sir/Madam,

RE: REQUEST FOR RESEARCH DATA

I am a post-graduate student in the School of Distance and Continuing Education, University of Nairobi. I am conducting a research titled "Factors Influencing the High Non-revenue Water in Garissa Township."

You have been selected to form part of this study. Kindly assist by filling in the attached questionnaire. The information you will give will be treated in strict confidence and is needed purely for academic purposes. In no way will your name appear in the final report.

A copy of the final report will be availed to you upon your request.

Your assistance and cooperation will be highly appreciated.

Yours Sincerely,

……………………….

Komora, Collins Owiti

(Student)

Tel. No. 0725670912

Email: komora,collins09@yahoo.com

Appendix II: Questionnaire

The following questionnaire is designed to gather information on factors that contribute to non-revenue water in Garrissa Township.

Questionnaire no…………..

Date……………………….

SECTION ONE: GENERAL INFORMATION

1. Gender

   1. Female ( ) **2.** Male ( )

2. What is the highest level of education you have attained?

   1= Primary level ( )

   2=Secondary level ( )

   3= College ( )

   4= University ( )

   5= Any other (please specify) ……………………………………………..

3. Indicate your professional qualification under the following categories

   1= Untrained in water related discipline ( )

   2= Trained in water related discipline ( )

4. How would you rate your knowledge of **Non-Revenue Water**?

   4=excellent ( ) **3=**good ( ) **2=**average ( ) **1=** poor ( )

5. Indicate your years of working experience in the water sector?

   1= ≤ 2 years ( )

   2= 3-6 ( )

   3= 7-10 ( )

   4= 11-14 ( )

   5= 15 or more ( )

   6= Any other (please specify)……………………………………….

SECTION TWO: NON -REVENUE WATER

6. In your own opinion, how would you rate the level of Non-Revenue Water in Garissa Township?

1= Very high ( ) 2= High ( ) 3= Moderate ( ) 4= low ( ) **5=** very low ( )

7. Which of the following events contribute to unbilled unmetered consumption (You may tick more than one alternative).

1= Mains flushing ( )

2= Firefighting ( )

3= Back washing water treatment plant ( )

8. In your opinion how much water is unbilled unmetered consumption?

1= $\leq$ 5% of water produced ( )

2= 5-10% ( )

3=More than 10% ( )

9. What is your perception about the quantity of water that is unbilled unmetered consumption?

1= Reasonable

2= Unreasonable

10. How would you rate your knowledge about unbilled unmetered consumption?

4=excellent ( ) **3=**good ( ) **2=**average ( ) **1=** poor ( )

11. Do you have cases of illegal connections? **1=** Yes ( ) **2=** No ( ).

12. If Yes, How frequently do you encounter cases of illegal connections?

1= Daily ( )

2= Once a week ( )

3= monthly ( )

4= Annually ( )

5= Rarely ( )

6= Any other (Please specify)………………………………………

13. Which of the following cases do you get that are related to meter reading inaccuracies and estimations? (You may tick more than one alternative).

1= Malfunctioning water meters ( )

2= Water meters not working ( )

3= Misreading water meters ( )

14. Which of the following strategies have you employed to reduce meter reading inaccuracies and estimations in Garissa Township? (You may tick more than one alternative)

1= Conducting public awareness ( )

2= Prompt replacement of malfunctioning water meters ( )

3= Training meter readers ( )

4=Any other (please specify)

………………………………………………………….

15. Do you encounter cases of leaks from transmission and distribution mains?

1= Yes ( ) **2=** No ( )

16. If Yes, Which of the following methods do you use to detect leaks from transmission and distribution mains (You may tick more than one alternative)

1=Reports of water showing on the ground surface **(**)

2= Reports by consumers on poor water pressures ( )

3= Regular soundings by inspectors ( )

4= District metering only ( )

5= Waste metering only ( )

6=Combined district and waste metering( )

7= Any other (please specify)……………………………………….

17. How frequently do the cases of leaks occur?.

1= very frequently( )

2= Frequently( )

3= Less frequently( )

4= Not at all( )

18. How long do you take to repair reported leaks from transmission and distribution mains?

1= less than 1 hour( )

2= 1-2 hours

3= 2-3 hours ( )

4= 3-8 hours ( )

5= More than 8 hours ( )

19. Do you encounter cases of leakages and overflows from utility storage tanks? **1=** Yes ( ) **2=** No ( )

20. If Yes, Which of the following methods do you use to detect leakages and overflows at utility storage tanks (You may tick more than one alternative)

1= Observation of outer surface wetness ( )

2= Reports by inspectors ( )

3= Any other (please specify)……………………………………….

21. How frequently do the cases of leakage and overflows at utility storage tanks occur?

1= very frequently( )

2= Frequently( )

3= Less frequently( )

4= Not at all( )

22. How long do you take to attend to reported leakage and overflows at utility storage tanks

1= less than 1 hour( )

2= 2-3 hours( )

3= 4-8 hours ( )

4= More than 8 hours ( )

23. Which of the following strategies have been employed to reduce Non Revenue Water in Garissa township? (You may tick more than one alternative)

1= Conducting public awarene**ss** ( )

2= Installing consumer water meters ( )

3= Improving billing and revenue collection by computerized system ( )

4= Implementing zoning ( )

5= Training staff on NRW management ( )

6= Any other (please specify)……………………………………….

24. Which of the following are challenges faced in the reduction of NRW in Garissa? (You may tick more than one alternative)

1=Public ignorance on NRW **(**)

2= WSP staff ignorance on NRW ( )

3= Inadequate technical capacity in the WSP ( )

4=Reluctant management ( )

5= Reluctant technical staff ( )

6=Lack of a proper staff incentive framework for performance ( )

7= Any other……………………………………

In question 25-30 below, circle the number that best describes your suggestions about what should be done to reduce NRW in Garissa.

KEY: 5= strongly agree 4= Agree 3= Undecided 2= Disagree 1=strongly disagree

25. The WSP should hold public awareness on NRW	**5**	**4**	**3**	**2**	**1**
26. 100% installation of water meters for all connected Consumers should be done	**5**	**4**	**3**	**2**	**1**
27. Water utility staff should be trained on NRW management	**5**	**4**	**3**	**2**	**1**
28. Water utility management should introduce a proper staff Incentive framework for performance	**5**	**4**	**3**	**2**	**1**
29. Billing and revenue collection should be improved To computerized system	**5**	**4**	**3**	**2**	**1**
30. Zoning should be implemented	**5**	**4**	**3**	**2**	**1**