AN ASSESSMENT OF FACTOR INFLUENCING NON REVENUE OF WATER IN TANZANIA WATER INDUSTRIES: THE CASE OF ARUSHA URBAN WATER SUPPLY AND SEWERAGE AUTHORITY (AUWSA)

By

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Dissertation Submitted to Mzumbe University Dar es Salaam Campus College in Partial fulfillment of the requirements for Award of Masters of Business Administration – Corporate Management of Mzumbe University

2013
CERTIFICATION

We, the undersigned, certify that we have read and hereby recommend for acceptance by the Mzumbe University, a dissertation/thesis entitled An assessment of factor influencing non Revenue of Water in Tanzania Water Industries: The Case of Arusha Urban Water Supply and Sewerage Authority (AUWSA) in partial/fulfillment of the requirements for award of the degree of Master of Business Administration of Mzumbe University.

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DECLARATION
This research is my original work, produced with normal supervisory assistance from my supervisor. All the relevant sources of knowledge that I have used during the course of writing this dissertation have been fully credited and acknowledged. Also, this dissertation has not been submitted for any academic or examination purpose in any other university.

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DEDICATION
To my parents for the education and parental care during my young age, this constituted a strong foundation for my overall academic success.
To my beloved wife Jestina G. Mdachi and my daughters for their support, love and patience which have brought me all this far.
To Baasha’s family for their great support and care on ensuring my success as far as educational aspect is concerned.
LIST OF ABBREVIATIONS

ADB : African Development Bank
AUWSA : Arusha Urban Water Supply and Sewerage Authority
DAWASCO : Dar es salaam water and sewerage Company
DAWASA : Dar es salaam Water Supply and Sewerage Authority.
MU : Mzumbe University
FY : Financial Year
GIS : Geographical Information System
EWURA : Energy and Water Utilities Regulatory Authority.
IWA : International Water Association
KFW : Kreditansalt Für Wiederaufbau (Germany development bank)
KPI : Key Performance Indicators
l/c/d : Liters per capital per day
MoU : Memorandum of Understanding
MoW : Ministry of Water
UFW : Un Account for Water
O & M : Operation and Maintenance
PVC : Polyvinyl Chloride
SPSS : Statistical Package for the Social Sciences
TIF : Tagged Image File
TZS : Tanzania Standard
UFW : Unaccountable For Water
uPVC : unplasticsized polyvinyl chloride
USA : United State of America
UWSA : Urban Water Supply and Sewerage Authorities
WSSA : Water Supply and Sanitation Authority
MBA-CM : Masters of Business Administration in Corporate Management
Pg : Page
HOD : Head of Department
ABSTRACT

A lot of challenges have been faced up within Authorities which include the unavailability of enough water supply against demand of people, old infrastructures which cause the loses of water, poor services from the source of water to the distribution channel. In additions was mindset of the entire management and its staff towards service provided, high Non-Revenue water and availability of funds. The researcher will only focus on Non-Revenue of Water.

Generally, the study investigated the factors which influence the non revenue of water towards the water industries. Specific objectives of the research were to explore the factor which provided the non revenue of water in water sector industries.

The key issues analyzed the Non revenue of water in water industries. These key issues were considered to be a result of organizational commitment, availability of enough water supplies against demand of people, old infrastructure, poor service from source of water to distribution channel, old water meter, leakages of water in all infrastructures.

The Authority provides the way on how to avoid non revenue of water by making better on both availability of enough water supplies against demand of people, old infrastructure, and poor service from source of water to distribution channel, old water meter, and leakages of water in all infrastructures. The extent of non revenue of water recognized within the Authority is very high as per the findings on rewards offered; reduce of non revenue of water influence and sense of achievement satisfaction level to authorities responding to the study.

The Non-Revenue Water (NRW) is a great challenge to the water industry in general and it affects the level of revenue realized from water billings and services level and customer satisfaction to meet the water demand from customers which in turn affects service sustainability in the sector. There are several reasons which cause the NRW here in Tanzania and among them are poor infrastructure, poor water meter, un proper of collection of water from source of water, theft caused by customers, aged pipe in all infrastructure, lack of technology in billing software.
The study generally concludes that the loss of water is the great contributing factor towards water industries performance as findings from questionnaires, observations and interviews indicates.
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CHAPTER ONE

OVERVIEW OF THE STUDY

1.1 Introduction
Water Authorities are the organization which has formed by the water cap, 1997. They have been introduced in such a way that will help Government to collect and supply water to his people around the countries. Previously the government under the Ministry of water and irrigation were the one who are responsible for the water service all over the country, but later it seems difficult to operate in all region and hence it introduce the Authorities in every region.

1.2 Background of the Problem.
Almost 20 years back the water sector in Tanzania has been undergoing changes from semi autonomous institution in 1993 to full autonomous Authorities in January 1998, Arusha urban Water Supply and Sewerage Authority (AUWSA), being among of them (Water CAP 272, 1997). This law has been amended to accommodate sanitation aspect in 2009 and named as new Act, Water Supply and Sanitation Authority (WSSA) Act, 2009. The Regional UWSA’s in Tanzania comprise Arusha, Babati, Bukoba, Dodoma, Dar es Salaam, Iringa, Kigoma, Lindi, Mbeya, Morogoro, Moshi, Mtwara, Musoma, Mwanza, Shinyanga, Singida, Songea, Sumbawanga, Tabora and Tanga UWSAs.

A lot of challenges have been faced up within Authorities which include the unavailability of enough water supply against demand of people, old infrastructures which cause the loses of water, poor services from the source of water to the distribution channel. In additions was mindset of the entire management and its staff towards service provided, high Non-Revenue water and availability of funds. The researcher will only focus on Non-Revenue of Water.

The Arusha Urban Water Supply and Sewerage Authority (AUWSA), is a newly established entity charged with the overall operation and management of water supply and sewerage services in Arusha Municipality replacing the former Urban
Water Supply Department, which operated under the Regional Administration. AUWSA was established under the auspices of the Water Works Ordinance Cap. 281 as amended in February 1997. It was declared a fully autonomous entity by order of the Minister responsible for Water Affairs in January 1998.

AUWSA is governed by the Board of Directors and headed by the Managing Director. Under the Managing Director there are three Departments namely Technical Services, Commercial Services and Finance & Administration. There are ten Sections under these three Departments. Also there are three units namely Internal Audit, Information and Communication Technology and Public Relations. AUWSA has 207 employees of different qualifications and professions.

AUWSA have two different sources of water namely springs and boreholes. The spring sources include Olesha – Masama, springs source along Themi River located 4 km north of the Municipality and Ngarendolu springs located within the Municipality. There are 13 deep wells (boreholes) located in the northern part of the Town (Arumeru District) and two boreholes located within the Municipal area. The boreholes contribute half of the daily water production and the springs the other half.

The production capacity fluctuates seasonally from an average of 32,000m³/day in dry season to 44,000m³/day during the rainy season. The water distribution system comprises of 213km of pipeline with diameters ranging from 32mm (1½") to 700mm (28"'), the pipe materials are of very old Cast Iron, Ductile Iron, PVC and Polythene. The system also includes storage reservoirs with a total capacity of 13,500m³, 24 Break Pressure Tanks.

The sewer network consists of sewer pipes of various sizes and materials; and inspection manholes. The sewer line is 33.4km long, the pipes are ranging from 100mm to 600mm diameter; made up of PVC, Cast Iron and Concrete. There are 533 manholes for inspection and access for cleaning. The service coverage is about 9.1%, which is very low compared to clean water service level, which is 94%. Sewer
cleaning and blockage removal are done on routine basis. There are monthly average of 320 sewer cleaning and 230 sewer blockage removal occasions.

The Non-Revenue Water (NRW) is a great challenge to the water industry in general and it affects the level of revenue realized from water billings and services level and customer satisfaction to meet the water demand from customers which in turn affects service sustainability in the sector. There are several reasons which cause the NRW here in Tanzania and among them are poor infrastructure, poor water meter, un proper of collection of water from source of water, theft caused by customers, aged pipe in all infrastructure, lack of technology in billing software.

According to German water industry association BGW, German Non Revenue water level are on average of 7% Farley (2005) while it has been reported by European environmental agency that Denmark Non revenue water is less than 10%, Liemberger (2006) unlike the developing countries including Tanzania with most of regional UWSAs have NRW above 20%, (EWURA Annual report, 2011/2012. According to Energy Water Utility regulatory Authority (EWURA) key performance indicator (KPI) the recommended level of Non-Revenue water is 20% or below but few water Authorities in Tanzania met that level. This study will focus on the factors which cause Non-Revenue Water (NRW); taking the case of Arusha Urban Water Supply and Sewerage Authority (AUWSA).

1.3 Statement of the Problem

The Non-Revenue Water (NRW) referred as the difference between the amount of water produced and the amount of water billed to customers. One of the major factor affecting water utilities in the developing world is the considerable difference between the amount of water put into the distribution system and the amount of water billed to consumers (also called Non-Revenue Water). For all 20 regional UWSAs in Tanzania we lost more than 70 million m³ per year of treated water which is equivalent to more than 40 Billion Tanzania Shillings. Saving just half of that amount UWSAs would supply water to an additional of 958,904 people without any further investment (EWURA Annual Report, 2006/2007, 2007/2008, 2008/2009, 2009/2010,
Many of Water industries in Tanzania face the similar problem in reducing Non-Revenue water.

The problem of NRW had been experienced since the Water Authorities undergone a full autonomous in 1998. For the financial year 2008/2009 all 20 Water Authorities it shows that, water produced was 110,489,595 m$^3$, water billed was 69,381,201 m$^3$, and water lost was 41,108,394 m$^3$. For the financial year 2009/2010 water produced was 192,150,274 m$^3$, water billed 112,754,387 m$^3$ and water lost was 79,395,887 m$^3$ as well as for the financial year 2010/2011 water produced was 201,430,179 m$^3$, water billed 112,460,956 m$^3$ and water lost was 88,969,223 m$^3$ and for the financial year 2011/2012; water produced was 205,338,909 m$^3$, water billed 117,535,761 m$^3$ and water lost was 87,803,148 m$^3$ (Annual Water Authorities Reports, 2008/2009, 2009/2010, 2010/2011, and 2011/2012).

Despite of individual Water Authorities efforts made to reduce NRW by implementing UFW reduction programs with donor funding like KFW, World Bank and other Donor projects by encouraging autonomy, accountability and market and customer orientation; but many Water Utilities in Tanzania have failed to address this issue effectively and often failed to match expectations$^3$. One of the major challenges facing these water utilities is the high level of water losses. This has a serious effect on the financial viability of water utilities through lost revenue, lost water resources, and increased operational costs, reducing their capacity to fund expansion of service, especially for the poor (ULG Northumbrian and LA Consulting Ltd, National urban Water Supply and Sewerage Strategy, 2005).

1.4 Objectives of the Study
Generally, the study seeks to investigate the factors which contributing NRW in Tanzania water industry;

1.4.1 General Objectives
General objective was to investigate the factor which contribute non revenue of water in Tanzania water industry
1.4.2 Specific Objectives

Specific objectives of the research were:

i. To assess the infrastructure network of all water pipe system in helping the Non-Revenue Water in Arusha City

ii. To identify water meters that’s contribute to Non-revenue Water.

iii. To assess the effects of motivation factor to UWSAs employees and customers on management of Non-Revenue Water

iv. To identify the leakage of water and see if they contribute NRW

v. To identify the capacity of billing software if suite the requirement.

1.5 Research Questions

Generally research question was to answer the question, “What are the factors influencing Non-Revenue Water in Tanzania water industry?”

Specific Questions

i. Have the infrastructure network of all water pipe system helping the Non-Revenue Water?

ii. How does a water meter contribute to Non-Revenue Water?

iii. Does motivation of employee increase Non-Revenue Water or reduce Non-Revenue water?

iv. Does the leakage of water through system contribute NRW?

v. Does the capacity of billing software suite the requirement?

1.6 Significance of the Study

This study is a timely conducted because though various reforms have been done in water sector in order to improve service delivery by reducing NRW in Tanzania Urban Water Supply and Sewerage Authorities are facing the problem of Non-Revenue Water. Therefore this study intends to analyze factors influencing Non-Revenue water and offer practical solutions to the UFW challenges by doing so findings will give water industry Managers and Technical staff the opportunity to understand the factors that influence Un Account for Water and the solutions for managing it.
Moreover, this study will provide information to the Tanzania Urban Water Supply and Sewerage Authorities so as will improve the service deliver by reducing Non-Revenue Water. Of the upper most importance, upon successful completion of the study, the researcher will qualify for award of a Masters Degree in Business Administration in Corporate Management of Mzumbe University.

1.7 Limitations of the Study
Like any other social research, this study had some constraints, these were: the case study design, despite of its flexibility in terms of data collection and analysis, has its limitations by having a particular focus (Cress well, 2004). In that case, it cannot be generalized, because its findings are fundamentally limited within the scope of the study. Further, the nature of the study demanded a keen and thorough investigation. To achieve this, more time was required to examine in breadth and depth on the subject matter in question.

1.8 Delimitations and scope of the Study
However, the study became tiresome in the sense that some of the respondents had to be contacted after working hours especially those dealt with technical activities (operational employees) avoiding distorting their working schedules for attending customers in the field hence it needed extra efforts to capture them up. Once captured most of them were found already tired therefore, the researcher had to be more brief and specific.

More interesting, some respondents were the very one who involved in non-revenue water activities therefore during data collection some interviewees were not cooperative enough to the researcher. Despite such constraints, the researcher believes that nothing was carried out so hurriedly as to impair the expected results so much.
CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction
In this chapter, reviewed literature is provided. The reviewed literature includes theoretical and empirical literature. The theoretical literature includes similar information from published and unpublished documents. The empirical literature provides similar research work (to this) which was done by other researchers. The chapter is concluding by explanations on the research gap and conceptual framework.

2.2 Theoretical Literature

2.2.1 The Definition and Role of NRW
The Non-Revenue Water (NRW) referred as the difference between the amount of water produced and the amount of water billed to customers. One of the major factor affecting water utilities in the developing world is the considerable difference between the amount of water put into the distribution system and the amount of water billed to consumers. Non Revenue Water (NRW) is water that has been produce and is lost before it reaches the customers. Loss can be real losses (through leaks, sometimes also referred to as physical losses) or apparent losses (for example through theft or metering inaccuracies). High levels of NWR are detrimental to the financial viability of water utilities as well to the quality of water itself. NRW is typical measured as the volume of water “loss” as share of net water produced. However, it is sometimes also expressed as the volume of water lost per km of water distribution network per day.

Accordingly NRW it has the following components:
Physical losses comprise leakage from all parts of the system and overflows at the utility's storage tanks. They are caused by poor operations and maintenance, the lack of active leakage control, and poor quality of underground assets.
Commercial losses are caused by customer meter under registration, data-handling errors, and theft of water in various forms.
Unbilled authorized consumption includes water used by the utility for operational purposes, water used for firefighting, and water provided for free to certain consumer
In many utilities the exact breakdown of NRW components is simply not known, making it difficult to decide about the best course of action to reduce NRW. Metering of water use at the level of production (wells, bulk water supply), at key points in the distribution network and for consumers is essential to estimate levels of NRW.

2.2.2 How Much Water is Lost
Although it is widely acknowledged that NRW levels are very high, in fact, very few data are available in the literature regarding the actual figures, largely because most water utilities in the developing world do not have adequate monitoring systems for assessing water losses and many countries lack national reporting systems that collect and consolidate information on water utility performance. The result is that NRW data are usually not readily available, and when they are, they are not always reliable because it is common for the management of poorly performing utilities to practice “window dressing” in an attempt to conceal the extent of their own inefficiency.

2.2.3 What are the Benefits From Reduced NRW
It is not realistic to expect water utilities to eliminate all commercial and physical losses. However, in developing countries, it is certainly not unrealistic to expect that the high levels of physical losses could be reduced by half. Based on the above example, this would provide more cubic meters per year of already treated water enough water to service an additional million of people who currently lack access to piped water and to save an a lot of billions per year in production and pumping costs for public utilities. Similarly, if commercial water losses in developing countries could be cut by 50 percent, then more billions in additional revenues could be generated each year.

Thus, reducing NRW to just half the current level in AUWSA a reasonable objective would deliver the following benefits:
More billion cubic meters of already treated water would be available to service customers.
Many more people could gain access to water supply, without increasing demand on endangered water resources.

Water utilities would gain access to an additional billion of money in self-generated cash flow, equivalent to more than a quarter of the amount currently being invested in water infrastructure in AUWSA, and this without affecting in any manner the debt capacity of AUWSA.

Fairness would be promoted among users by acting against illegal connections and those who engage in corrupt meter-reading practices.
Consumers would have improved service delivered by more-efficient and more-sustainable utilities.
More economic growth with new business opportunities would be created for NRW reduction activities, with thousands of jobs created to support labor-intensive leakage reduction activity.

2.2.4 Non-Revenue Water: The Technical Issues
Although the above-mentioned global costs and scale of NRW may not have been so starkly presented before, the technical issues surrounding NRW have been written about extensively (albeit much of the writing coming from the United Kingdom and the International Water Association [IWA] in the 1980s and 1990s).

2.2.5 Why do Utilities Struggle with NRW Reduction
In spite of the potential benefits, NRW reduction is not a simple matter to implement, and this explains why so many water utilities fail to address this issue effectively. Not only do new technical approaches have to be adopted, but effective arrangements must be established in the managerial and institutional environment often requiring attention to some fundamental challenges in the utility.

2.2.6 Understanding 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. Only by quantifying NRW and its components, calculating appropriate performance
indicators, and turning volumes of lost water into monetary values can the NRW situation be properly understood and the required action taken. It is noteworthy that despite the fact that many utilities in the developing world have implemented NRW reduction programs with donor funding, it is rare that a comprehensive water balance, was actually developed and calculated. It is no wonder, therefore, 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.

2.2.7 Lack of Capacity
NRW requires 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, is not taught at universities or technical colleges or in many of the water industry training institutions around the world. As a consequence, staffs with necessary skills are 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.

2.2.8 Challenges in NRW Missing Management Focus
Establishing and maintaining an effective NRW program is, besides all other difficulties, a managerial problem. Physical loss reduction is an ongoing, meticulous activity with few supporters among the following:

- Politicians: there is no “ribbon cutting” involved.
- Engineers: it is more “fun” to design treatment plants than to fix pipes buried under the road.
• Technicians and field staff: detection is done primarily at night and pipe repairs often require working in hazardous traffic conditions.

• Managers: it needs time, constant dedication, staff, and up-front funding. Nor is the reduction of commercial losses very popular among the following:

  • **Politicians:** unpopular decisions might have to be made (disconnection of illegal consumers or customers who don’t pay).
  • **Meter readers:** fraudulent practices might generate a substantial additional income.
  • **Field staff:** working on detecting illegal connections or on suspending service for those who don’t pay their bills is unpopular and can even be dangerous.
  • **Managers:** it is easier to close any revenue gap by just spending less on asset rehabilitation (letting the system slowly deteriorate) or asking the government for more money.

Except for those customers who do pay their bills, it might appear that there is no support from any party. Given this situation, a utility manager trying to establish an NRW program to reduce high levels of losses may face frustrating responses from his or her own staff and from the utility owners. Engineers and operational staff will assure him or her that the levels relate solely to commercial losses (that is, there is no leakage problem), while the commercial staff will say that it is all leakage.

### 2.2.9 Importance of Enabling Environment and Incentives

It is instructive to consider the incentives related to NRW programs in a little more detail and wonder why, the NRW performance of utilities in AUWSA is so poor. A commonly voiced answer is that politicians are mostly interested in “ribbon cutting,” and so it is easier for the utility management to obtain support for a new water treatment plant than for a leakage reduction program. The reality, as usual, is more complex. Such explanation fails to account for the fact that implementing an 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. It should come as a surprise to no one that both politicians and utility management see investments in NRW reduction as risky because they feel uncertain that the expected benefits can be realized. Because civil servants tend to be risk-averse, it is therefore logical that when confronted with a choice between reducing NRW and increasing production capacity, they choose the second solution. This might not make much sense in economic terms, but at least they feel confident that they will have something tangible (in this example, a new treatment plant) to show to their constituency. In summary, therefore, the key, obvious, and generally overlooked message is that NRW must not be considered in a vacuum, but 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. It is for these reasons that performance-based service contracting, where performance improvement is made against defined contractual objectives, might offer an enabling environment and incentives conducive to reducing NRW, with immediate operational and financial benefits. It can therefore create a positive dynamic for reform, but should not be considered as a substitute for carrying out the broader institutional reforms necessary to promote the sustainability of the sector.

2.2.10 Potential for Private Sector Involvement in NRW Reduction Activities

It can be seen that most utilities in the developing world lack the capacity to efficiently implement on their own an NRW reduction program. They operate under an inadequate incentive framework; they typically lack expertise, technology, and the practical experience of putting in place such programs; and they therefore need external assistance. An obvious source of assistance is the private sector, where
involvement can take many forms, ranging from long-term arrangements to service contracts or subcontracting of certain tasks. According to Brooks. D.B et al (1997), Depending on the option chosen, the private sector can bring the following:

- New technology and the know-how to utilize it efficiently
- Better incentives for project performance
- Creative solutions for the design and implementation of the program
- Qualified human resources
- Flexibility for field work (for example, night crews)
- Investment, under certain conditions

2.2.11 Optional for Involvement of the Private Sector in NRW Reduction

Delegated Management Under a Public-Private Partnership (PPP) Contract

There are a number of established and well-studied PPP models for the delegated management of utilities, such as concessions, lease, and management contracts. Long-term PPP contracts such as concessions are not designed solely for NRW reduction; however, the private operator typically has strong financial incentives to reduce the NRW level because this translates into higher revenues and lower operating costs, as well as the postponement of costly investments to increase production capacity. There are even cases of afterimage contracts (like those in Senegal) where specific objectives for NRW reduction were included in the contracts, with bonuses or penalties for the private operator in case of compliance or noncompliance.

2.2.12 Outsourcing of NRW Reduction Activities

Under this approach, a water utility subcontracts specific elements of an NRW reduction program to a private firm. This can range from a specific activity through to overall management of the NRW program. In all but the latter case, the utility remains in charge of the overall implementation of the program. This approach is particularly appropriate for all field work such as leak detection, pipe repairs, minor civil works, meter replacement and reading, updating the cadastre, and identification of illegal connections. There are several advantages for the utility in adopting such an outsourcing approach, including reduced unit costs through competitive bidding,
more flexibility for night work, and mobilizing additional resources for dealing with backlogs.

It also brings access to a specialized workforce and equipment. Outsourcing of leak detection is nothing new. Many water utilities in Europe, the United States, and even in some developing countries use private leak detection contractors to survey the distribution network periodically. According to Wyatt .A.S (2010) this approach is limited in many developing countries by three major constraints:

- The lack of capacity of the water utility to implement a comprehensive program and to coordinate the work of various contractors.
- The often undeveloped nature of the local private sector. Depending on the country, simple labor-intensive tasks such as meter reading and pipe repairs can be subcontracted, but local firms with the capacity to conduct more technical tasks such as leak detection and network zoning are often not available.
- Lack of knowledge about the existence of the various options and lack of guidance materials (for example, sample contracts, target setting, and payment mechanisms).

### 2.2.13 Technical Assistance Contracts

In connection to this phrase Torence. I. McGhee (2009) state that, The traditional option for delivering NRW technical assistance in developing countries is one in which a public utility will contract a private company to design and/or provide implementation capacity building for an NRW reduction program. Such companies are typically consulting engineering firms or subsidiaries of private operators and construction companies engaged through the technical assistance/capacity building contracts.

Often the water utility believes that it has delegated the entire NRW reduction program to the private partner, even though the contractor has to implement the project through existing utility staff that have no real incentives to deliver results and
are unsure whether they should report to the contractor or to the utility management. In some cases also, the budget allocated for field works such as leak repair and equipment installation (such as meters and valves) was not sufficient, given the overall deterioration of the networks and the magnitude of the problems.

The fundamental weakness of this approach is that the private sector has limited control over the implementation program and thus cannot be accountable for the end result, but only for providing advice. The private contractor cannot, and does not, guarantee that at the end of the project the levels of NRW will have been reduced according to any specific target. Not surprisingly, therefore, there are countless examples in developing countries of NRW technical assistance/capacity-building contracts that have failed to reach their objectives. Another frequent problem is that the NRW program is a small part of a larger development project; there is limited focus, and the NRW work often takes a lower priority compared with that of the physical investment program.

The result is that everyone (the utility the contractor and the donor) enters into the assignment on a “best endeavors” basis, and the poor results are the inevitable consequence. In addition, the improvements made by the main project component (for example, construction of a new water treatment plant) can result in increased supply hours and improved pressure, leading to greater losses which too often offset the achievements of the (insufficient) leakage reduction program.

**2.2.14 Benefits of NRW Reduction in Particular of Leakage Reduction**

Financial gains from increased water sales or reduced water production, including possibly the delay of costly capacity expansion;

i. Increased knowledge about the distribution system;

ii. Increased firefighting capability due to increased pressure;

iii. Reduced property damage;

iv. Reduced risk of contamination.

v. More stabilized water pressure throughout the system
Leakage reduction may also be an opportunity to improve relations with the public and employees. A leak detection program may be highly visible, encouraging people to think about water conservation. The reduction of commercial losses, while politically and socially challenging, can also improve relations with the public, since some consumers may be reluctant to pay their water bills knowing that many others use services without being billed or being under billed.

2.2.15 Programs to Reduce NRW and Their Pitfalls
According to Torence. I. McGhee (2009) state that Reducing and controlling NRW is complex. Many programs to reduce NRW have failed in the long run. Often they focus on real losses, without sufficient attention being paid to apparent losses. If programs achieve an initial reduction in NRW levels, they often increase again over the years to the same or even higher levels than before the program. Both apparent and real losses have a natural tendency to increase if nothing is done: more leakage will occur, there will be more defective meters, and information on customers and networks will become more outdated.

In order to sustain NRW at low levels, investments in fixing leaks and replacing meters are insufficient in the best case and ineffective in the worst case. To achieve permanent results, management procedures related to a utility's organization, procedures and human resources have to be changed. Additionally the implementation of an Intelligent Pressure management system is an efficient approach to reduce the total real losses in the long term. It is one of the most basic and lucrative forms of optimizing a system and generally provides fast investment paybacks.

2.2.16 Reasons Why NRW Levels IN Developing Countries Have not Been Reduced Significantly
Politicians: there is no “ribbon cutting” involved.
Engineers: it is more “fun” to design treatment plants than to fix pipes buried under the road.
Technicians and field staff: detection is done primarily at night, and pipe repairs often require working in hazardous traffic conditions.
Managers: it needs time, constant dedication, staff, and up-front funding.

2.2.17 The Reduction of Commercial Losses
Politicians: unpopular decisions might have to be made (disconnection of illegal consumers or customers who don’t pay).
Meter readers: fraudulent practices might generate a substantial additional income.
Field staff: working on detecting illegal connections or on suspending service for those who don’t pay their bills is unpopular and can even be dangerous.
Managers: it is easier to close any revenue gap by just spending less on asset rehabilitation (letting the system slowly deteriorate) or asking the government for more money.

2.2.18 Additional Most Frequent Reason for Failure of NRW Reduction Programs as Follows
In connection to this phrase Torence. I. McGhee (2009) state the reason for failure of NRW reduction programs as follows
  i. Poor design of the real program
  ii. Diagnoses based on preconceptions rather than experimentation
  iii. Partial implementation of the program
  iv. Failure to mobilize the necessary human and financial resources
  v. Lack of coordination between the components of the program
  vi. Underestimation of the difficulties
  vii. Underestimation of the time factor

2.2.19 Leakage Control
Not all the water that leaves a water treatment works reaches the consumer. A significant amount as much as 50 %, or even more is lost through leakages. All pipe materials deteriorate with age, and all connections are potential sources of leaks. A common feature of water distribution networks in developing countries is the high number of unauthorized connections to the network.
These cause many problems, including loss of pressure and contamination of the supply, and contribute significantly to leakage. It is impossible to get zero leakage from a system. There comes a point where the cost of leakage direction and control outweighs the benefits of locating and repairing the leaks. This is sometimes referred to as the economic level of leakage. Recent experience in the UK where great efforts have gone into leakage control show that it is difficult to get under a figure of about 12% of water lost through leakage. Typical figures for leakage in an average developing country are around 30% to 40%.

In connection to this phrase Wyatt .A.S (2010) state that there are many electronic methods of leakage control used in developed countries. Most of these are expensive and inappropriate for developing countries.

A common feature of water supply networks in low and middle income areas is that they do not supply water 24 hours a day. Sometimes, the rationale is that by limiting the hours of supply, then the consumption can be limited, but the reverse is often true. When supply is limited, many people store water as a safeguard, and when supply is resumed they waste the stored water. Also, as the supply is limited and there are many illegal connections, the pressure of the water is often very low. In such circumstances, people tend to connect their own small booster pump to their connection to the main, and draw out what water they can. This reduces the pressure in the main further and sucks out all the available water and adds to the possibility of further leakage.

According to Stephen, P (2011) Water in a pipeline is under pressure, so when there is a hole it will escape. As it does so, there is a noise—a hissing sound. Most leakage detection methods are based on listening for this sound. There are many types of sophisticated instruments used to listen for the sound electronically, but the most traditional way is through the use of a listening stick used by a trained operator as labor is usually cheap and listening sticks can be made by local craftsmen, this is often the most appropriate way of detecting leaks.
When there is an intermittent supply at low pressure, however, leakage detection is very difficult because if there is no flow in the pipe, there will be no sound to detect. Under such conditions, leakage detection has to be carried out by isolating sections of the network and testing pressure when it is there (and it will often have to be artificially induced).

Leakage detection and control in many developing countries is usually done as a response when a leak is reported it is repaired. However, leakage detection should be a routine preventive function of a water utility as the water lost is a waste of a valuable commodity which is limited in its availability, and of money (in the effort spent in treating and distributing the water which is wasted, and in the loss of the potential revenue associated with the lost water). To sum up, for real effectiveness leakage monitoring and control must be a regular activity, and not based on incident response as is often the case in developing countries. Leaks waste a scarce resource: the money invested in treatment and distribution and the revenues from lost sales.

2.2.20 Commercial losses

According to Pearson, D and Trow, S (2005) Sometimes called as apparent losses include water that is consumed but not paid for the use (Malcolm, 2008). In most cases, water has passed through the meters but is not recorded accurately. In many countries commercial losses is higher than physical losses and commercial losses has high value because reducing commercial losses increase revenue while reducing physical losses reduce the production costs. Commercial losses comprise unauthorized consumption and metering inaccuracies. It is estimated that in Developing countries 50 - 65% of NRW is due to commercial losses (World Bank, 2011; Global Water Partnership, 2011).

Unauthorized consumption means illegal use, and this could be: Sole illegal connections, illegal connections to properties that also have legal connections i.e. residents in street divert water for a short time from their illegal to their legal connections, illegal connections for the purpose of selling water. Metering
inaccuracies can include malfunctioning water meters, estimated water consumption (when meters are not working) and misreading water meters. Further meter reading errors can be caused due to negligence, aging meters or due to corruption during the exercise of reading the meters and billing customers. Meter readers may read the meters incorrectly or make the simple errors, such as placing the decimal in wrong place also dirty dial, faulty meter and jammed meters can cause the reading errors.

Meter by-passing - in some cases customers are trying to reduce consumption by installing water by pass which is an additional pipe connected around the meter, this additional pipe is buried in the ground and it is difficult to detect, in this type of connection the small amount of water allowed to pass through water meter and the rest pass through the bypass pipe as the result the amount of water to be paid will be less. Unbilled Legal Connections, if Connections are not in the Billing System, Connections are not updated in Billing System and Block Maps.

Under Billing and Meters not installed, due to faulty Meters, Meters not read, tempered Meters, wrong applied Billing Rate, wrong Billing Category, Dripping Losses (meter does not record small quantities of water leaking due to damaged stop-cocks, etc). Redundant and not updated Data Base, due to reluctant Information Flow and reporting in between relevant departments, delayed update of Customer Status, lack of appropriate Control and Management Routines and Procedures as well as lack of activated Software Routine Checks. It is a responsibility of the meter reader to report any observed problems and the responsible section should take immediately action to remedy the problem. If the remedy action is too slow, the meter readers may become demoralized and they may stop reporting the problem.

2.2.21 Physical Losses

Sometimes is called real losses or leakages. There are three components of physical losses which include: leakages occurred in transmission or
distribution mains (lines); leakage and overflow from utility storage, water reservoirs; and leakages occurred on service connections up to the customer’s meter (Malcolm, 2008; Lolland, 2010). The leakages occurred in transmission, water reservoirs, distribution mains and overflow are easily visible to internal and external customers and which are quickly repaired compared to the leakage occurred on service connections to the customer’s meter.

2.2.22 Unbilled Authorized Consumption
It can be categorized in two groups which are unbilled metered consumption and unbilled unmetered consumption. Unbilled consumption can includes water used for fire fighting, water used by the water utility for operational purposes (e.g. flashing of the water system) and water provided for free to certain consumer groups (e.g. refugees camps, Orphans, Urban poor people and employees of the water utility). That is to say that the unbilled authorized consumption reflects the public policy decision to allocate without monetary compensation.

2.2.23 Strategies to Reduce and Manage NRW
Many tools have been developed on how to reduce and manage Non Revenue water. Table 1 below depicts those tools required to be used for reducing and manage Non Revenue water (NRW)
Table 1: Tasks and tools for developing NRW reduction strategy

<table>
<thead>
<tr>
<th>Questions</th>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>How much is being lost?</td>
<td>Water Balance</td>
</tr>
<tr>
<td>- Measure components</td>
<td>- Improved estimation/measured techniques</td>
</tr>
<tr>
<td></td>
<td>- Meter calibration policy</td>
</tr>
<tr>
<td></td>
<td>- Meter checks</td>
</tr>
<tr>
<td></td>
<td>- Identify improvements to recording procedures</td>
</tr>
<tr>
<td>Where is being lost from?</td>
<td>Network Audit</td>
</tr>
<tr>
<td>- Quantify leakage</td>
<td>- Leakage studies (Reservoirs, transmission mains, distribution networks)</td>
</tr>
<tr>
<td></td>
<td>- Operational/customer investigation</td>
</tr>
<tr>
<td>Why is it being lost?</td>
<td>Review of network operating practices</td>
</tr>
<tr>
<td>- Conducting network and operational audit</td>
<td>- Investigate: historical reasons:-poor practices, Quality management procedures, poor materials/infrastructure, local/political influences and cultural/social/financial factors</td>
</tr>
<tr>
<td>How to improve performance</td>
<td>Upgrading and strategy development</td>
</tr>
<tr>
<td>- Design a strategy and action plans</td>
<td>- Update records systems</td>
</tr>
<tr>
<td></td>
<td>- Introduce zoning</td>
</tr>
<tr>
<td></td>
<td>- Introduce leakage monitoring</td>
</tr>
<tr>
<td></td>
<td>- Address causes of apparent losses</td>
</tr>
<tr>
<td></td>
<td>- Initiate leak detection/repair policy</td>
</tr>
<tr>
<td></td>
<td>- Design short-medium-long-term action plans</td>
</tr>
<tr>
<td>How to maintain the strategy?</td>
<td>Policy change, training and O&amp;M</td>
</tr>
<tr>
<td></td>
<td>- Training: improve awareness, increase motivation, transfer skills and introduce best practice/technology</td>
</tr>
<tr>
<td></td>
<td>- O&amp;M: community involvement, water conservation and demand management programmes, action plan recommendations and O&amp;M procedures</td>
</tr>
</tbody>
</table>

Source: Farley and Liembergerger, 2005
2.2.24 Leakage Control

According to Pearson, D and Trow, S (2005) Not all the water that leaves a water treatment works reaches the consumer. A significant amount as much as 50 %, or even more is lost through leakages. All pipe materials deteriorate with age, and all connections are potential sources of leaks. A common feature of water distribution networks in developing countries is the high number of unauthorized connections to the Network. These cause many problems, including loss of pressure and contamination of the supply, and contribute significantly to leakage

It is impossible to get zero leakage from a system. There comes a point where the cost of leakage direction and control outweighs the benefits of locating and repairing the leaks. This is sometimes referred to as the economic level of leakage. Recent experience in the UK where great efforts have gone into leakage control show that it is difficult to get under a figure of about 12% of water lost through leakage. Typical figures for leakage in an average developing country are around 30% to 40%.

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When supply is limited, many people store water as a safeguard, and when supply is resumed they waste the stored water. Also, as the supply is limited and there are many illegal connections, the pressure of the water is often very low. In such circumstances, people tend to connect their own small booster pump to their connection to the main, and draw out what water they can. This reduces the pressure in the main further and sucks out all the available water and adds to the possibility of further leakage.
In connection to this phrase Roy, A (2009) state that, Water in a pipeline is under pressure, so when there is a hole it will escape. As it does so, there is a noise - a hissing sound. Most leakage detection methods are based on listening for this sound. There are many types of sophisticated instruments used to listen for the sound electronically, but the most traditional way is through the use of a listening stick used by a trained operator as labor is usually cheap and listening sticks can be made by local craftsmen, this is often the most appropriate way of detecting leaks. When there is an intermittent supply at low pressure, however, leakage detection is very difficult because if there is no flow in the pipe, there will be no sound to detect. Under such conditions, leakage detection has to be carried out by isolating sections of the network and testing pressure when it is there (and it will often have to be artificially induced).

Leakage detection and control in many developing countries is usually done as a response when a leak is reported it is repaired. However, leakage detection should be a routine preventive function of a water utility as the water lost is a waste of a valuable commodity which is limited in its availability, and of money (in the effort spent in treating and distributing the water which is wasted, and in the loss of the potential revenue associated with the lost water). To sum up, for real effectiveness leakage monitoring and control must be a regular activity, and not based on incident response as is often the case in developing countries. Leaks waste a scarce resource: the money invested in treatment and distribution and the revenues from lost sales.

2.2.25 The Application of Geographical Information System in Water Industry

According to Roy, A (2009), Mapping, monitoring, modeling and maintenance are the four most important activities in effectively managing water industry. A Geographical Information System (GIS) can be used to implement or improve NRW. GIS can be applied in various activities in water industry (Rolf, 2000). Mapping work involves data collection, mapping and data management. The commonly accepted definition of GIS is “a computer -based system used to capture, store, edit, display and plot
geographically referenced data”. Water Industry is a commercial activity that provided water services.

The design operation and maintenance of water distribution and sanitary sewer collection systems necessitate the daily use of a variety of map products and associated geographically referenced information resources. Geographically referenced or geo referenced is information describing or relating to a specific location, such as manhole, pipe line segment or valve location.

The design and management of Water utility facilities is more and more based on digital information acquired from various sources such as scanned maps, digitized maps, satellite images, and aerial photography or similar. Those background information are based on spatial data and provide the Geographic Information. Both digital and spatial information are incorporated into a Geographic Information System (GIS). Most common software packages used for working with these digitized information are MapInfo and Arc view.

The GIS based data alone are not sufficient for utility management and design purpose, additional information systems are required, those are mainly pipeline and other asset data, information about grid systems, combined being called none partial data. Only the combination between these two systems or data sets provide major advantages for design and management purposes of utility facilities such as water supply, power supply, sewage networks.

2.2.26 Software Packages for GIS Based Modeling and Water System Management Arc View 3.2

Arc View, version 3.2 was established by Environmental Systems Research Institute in the USA and provided extensive geographical information within the package, also allows incorporating detailed geographical information of a certain region, which are not provide by the software package itself. Those information are:
Detailed topographical maps Aerial photographs in TIF format and other certified Databases can be linked and jointed and hereby provide essential information about the future development, and also details about a current situation. For example bulk meter reading in a form of a simple spreadsheet database can be compared to calculated demand figures and thus giving information about possible leaks in a particular area

Customer databases in spatial form, if regularly updates can provide information about implementation requirements for extension of systems, for example a certain area may develop faster than others and would require a network extension to maintain the main supply, via a query the latest time for the implementation of those extensions can be calculated

2.2.27 Epanet 2.0
Epanet is a hydraulic analysis tool, which provides in a very simple manner intensive information about a hydraulic situation in a water supply or sewerage network. Epanet it can be used without the GIS database for hydraulic designs simulations of network situation during extended time periods, provided a time pattern is established, which can be user defined or the standard version which form part of the software package can be applied (Rolf, 2000).

All essential parts of a network system can be entered such as pipes, nodes, junctions, pumps, tanks, reservoirs etc. Once all data are entered a hydraulic system check can be initialized resulting in a report showing possible errors made during the digitization process. Most common errors are:

Pipes are not properly connected due to the zoom factor applied during digitization and the two ends of the pipes are not properly linked.
The response message is either missing node or missing junction and Epanet will ask the user whether he wants to add those.
With tanks a control pattern has to be established, which has to be conformity with the internal control pattern and requires user given data about closing, opening and levels in tank. Those data are generally required for the design of a tank and therefore can be entered through an OBDC link with a spreadsheet.

Valves, particularly pressure control valves, pressure sustaining valves require information about user intended outlet pressure. Once all data are entered in a correction form, Epanet returns a report about the hydraulic conditions of the system over a time period such as nodal pressures, flows and velocities in pipes, flow direction in pipes, levels in reservoirs and similar. By adding a time pattern about demand and various consumers’ classifications (industrial, commercial, domestic with different housing classes) Epanet returns on an hourly basis all information required about the condition of the network.

2.2.28 Major Advantages of the Digital Information in Water Industry Reduction of Non-Revenue Water
Hydraulic model gives a very realistic picture of the real situation in a water distribution system, real operational data in form of a spreadsheet database can be compared with the theoretical situation. For example a pressure zone has been designed for a certain flow under most realistic assumptions and time pattern.

When a bulk meter measures the flow into a particular pressure zone, these meter readings can be compared with the theoretical condition. In this case there is a considerable gap between the theoretically calculated and the real measured valve further investigation should be initiated by employees since this could be an indicator for either a leak or other options for the NRW such as illegal connections. In addition customer meter reading can also be compared with theoretical flows and the time pattern or other general databases can be upgraded according to real occurring conditions (Dorch Consult, 2009).

The comparison between theoretical and real values reduces for the employees the area for NRW search quite considerably and is hereby far more efficient in comparison to
flow data for the entire system. The link with customer database and the meter reading data results in very detailed information in regard to so-called commercial losses and or physical leaks\(^7\). The flow data calculated are a reasonable indicator and if the gap between the real flows and the quantity of water sold is increasing, detailed consumption comparison can be carried out for each node leaving the operating Authority a powerful tool for minimizing their onsite research work and allows them to act on very particular areas only.

**2.2.29 Improve Billing and Accounting Procedures**

With the customer database in digital form detailed information become available about the overall consumption structure in the system, where the highest flows occur, where highest income is generated and similar information. This allows the employees to act on very particular parts of their system with highest efficiency for example in upgrading in case of low pressure, accommodating the flow situations already in the design particularly for areas with high income structure, where higher revenues can be expected. Employees can visualize payments of bills and hereby allows employees to concentrate their efforts in revenue collection.

**2.2.30 Improve Maintenance**

Computerized Maintenance management permit more comprehensive planning and scheduling of preventive and corrective tasks also potential maintenance backlog can be identified quickly and be scheduled. Maintenance work can be managed efficiently if the problem areas and maintenance work can be displayed on maps. This can be accomplished by linking the utility’s existing maintenance module to GIS (Dorch Consult, 2008).

To sum up, the following are the advantages of GIS based modeling includes: reduction of field work during pre-designed stage, design is reliable and incorporate existing system, identification and reduction of NRW through comparison of simulated flow data and bulk meter reading, customer data base digitized in Arc View and its possible to run queries on payment done, outstanding and amount invoiced for
different customers and prepare maintenance schedule, since appurtenance installed are digitized and time schedule with staff assignment generated and followed up. Therefore, application of Geographical Information System is a milestone in the development water Industry. It serves time and resources in planning and management of water activities.

2.2.31 Water Distribution Network Automation as a Means of Managing NRW for Aged Pipes

Many components such as pipe, isolation or block valves, hydrants, reservoirs, tanks or pump stations can be readily utilized in the new automated system. The word automatic is defined as “having an inherent power or action” and as being “self-acting”. The word control is defined as “to keep within limits, to exercise directing, guiding or restraining power”. An automatic control valve certainly does conform to these definitions and it actually goes one step further, it replaces the human element. It does, without human assistance or supervision, those functions that otherwise would require regular or continuing physical attention.

Many distribution systems when automated rely on a constant pressure design concept. Typically, the water resources and the distribution network are engineered to provide maximum flow demand requirements at a constant pressure to a zone. Depending on the topography of the site, one or more zones are also created throughout the entire system network.

Automatic control valves are used at various points in the system to help maintain constant pressure to the various zones and to help ensure adequate supply of water sources to the zones. By designating control parameters for the valves which control reservoir levels, operating pressures and flows the network can be automated. As system requirements change, these control valve settings can be easily changed to accommodate to the new requirements. The automatic control valve performs a variety of functions within the water system in order to reduce Non-Revenue Water (NRW).
2.2.32 Level Control
There are a number of ways in which automatic valves can be utilized to control reservoir level. When the reservoir level is down and it is calling for water, the constant head or fixed force positions the control to open the valve because this force is greater than the force created by the head in the reservoir. As the reservoir fills, the differential is neutralized; the pilot control shifts and directs the valve to the closed position. The advantages to this type of valve are that there is no float. Because there is no, installations are easier and less expensive. In freezing climates surface ice is not a problem and climbs to the top of high tanks for inspections are not required. The pilot-controlled altitude type and float type and float type level control valves have the flexibility for adding other functions such as backpressure control, rate of flow control, pressure sensitive closing or surge relief.

2.2.33 Control Pressure
When we think of controlling pressure we most frequently think of holding pressure at a near constant value in some type of a distribution system. Most commonly this is accomplished by reducing a high supply pressure down to a lower pressure where it is more practical to handle. If the upstream or supply pressure is constant and if the demand downstream is uniform then some type of a fixed restriction such as an orifice or perhaps a manual valve that is throttled in a partially open position, will effectively reduce the pressure.

Frequently, there are supply pressures that are relatively constant but only rarely are distribution system encountered where the demand is consistent and uniform. The back pressure or pressure sustaining valve can also be called a pressure relief valve. It can be used to control pressure in a system where it is installed on a tee so that it can relieve from the system any pressure in excess of a present value.

The same automatic valve utilized in a relief capacity can be used to maintain a constant pressure in a booster pump system. This is timely and appropriate to relate
these theories of NRW management and actuality considered for NRW management in AUWSAs.

2.2.34 The Conceptual Framework

According to Sekaran (2006), the conceptual framework was defined as “a conceptual model of how one theorizes or makes logical sense of the relationships among the several factors that have been identified as important to the problem”. The conceptual framework shows the relationships among the identified variables that are deemed to be integral to the dynamics of the situation being investigated. The non-Revenue Water depends on aged water pipe systems, water meters, motivation of employees and other factors related to social, cultural, Economical and political factors. Therefore dependent variable is Nonrevenue Water and Independent variables are aged water pipe systems, water meters, motivation of employees and other factors such as socio-cultural factors, economic and political influences.

Figure 2.2 Conceptual Framework

Source: Field Survey Data, 2011
NRW indicators

The most commonly used indicator to measure NRW is the percentage of NRW as a share of water produced. While this indicator is easy to understand and indeed has been widely used, it has increasingly been recognized that it is not an appropriate indicator to benchmark NRW levels between utilities or even to monitor changes over time. When losses in terms of absolute volume are constant the percentage of NRW varies greatly with total water use, i.e. if water use increases and the volume of losses remains constant the percentage of NRW declines. This problem can be eliminated by measuring NRW not as a share, but in terms of absolute losses per connection per day, as recommended by the International Water Association (IWA). Nevertheless, the use of percentage figures to compare levels of NRW remains common despite its shortcomings. The International Benchmarking Network for Water and Sanitation recommends using different indicators (percentage, losses per connection or losses per km of network) together. Losses per kilometer of network are more appropriate to benchmark real losses, while losses per connection are more appropriate to benchmark apparent losses.

The concept of NRW as an indicator to compare real losses of water utilities has been criticized as flawed, particularly because real losses depend to some extent on factors largely outside the control of the utility, such as topography, age of network, length of network per connection and water use per capita. As an alternative indicator for the measurement of real losses an Infrastructure Leakage Index (ILI) has been developed. The ILI is defined as the ratio of Current Annual Real Losses (CARL) to Unavoidable Annual Real Losses (UARL).

Benefits of NRW reduction

The World Bank has estimated the total cost of NRW to utilities worldwide at US$14 billion per year. Reducing by half the current levels of losses in developing countries, where relative losses are highest, could generate an estimated US$ 2.9 billion in cash and serve an additional 90 million people.
Benefits of NRW reduction, in particular of leakage reduction, include

- financial gains from increased water sales or reduced water production, including possibly the delay of costly capacity expansion;
- increased knowledge about the distribution system;
- increased firefighting capability due to increased pressure;
- reduced property damage;
- reduced risk of contamination.
- More stabilized water pressure throughout the system

Leakage reduction may also be an opportunity to improve relations with the public and employees. A leak detection program may be highly visible, encouraging people to think about water conservation. The reduction of commercial losses, while politically and socially challenging, can also improve relations with the public, since some consumers may be reluctant to pay their water bills knowing that many others use services without being billed or being under billed. In the specific context of the United States NRW reduction can also mean reduced legal liability and reduced insurance payments.

Optimal level of NRW?

There is some debate as to what is an economically optimal level of leakage or, speaking more broadly, of NRW. From a financial or economic point of view it is not appropriate to try to reduce NRW to the lowest possible level, because the marginal cost of reducing NRW increases once the cheaper options have been exploited. Once the marginal cost of reducing NRW exceeds the marginal benefits or water savings, an economic optimum has been achieved. Benefits should be measured through reduced production costs if reduction of NRW results in lower water production, through the avoided costs of additional supply capacity if the system is close to the limit of its capacity and demand is growing, or through the value of water sold if reduction of NRW results in additional water sales. The latter can be done by valuing water through water tariffs (financial value) or through the willingness to pay by customers (economic value). There are fewer financial incentives for a utility to
reduce NRW if water production is cheap, if there is no or little metering (so that revenues thus are independent of actual consumption), or if volumetric tariffs are low.

In the United Kingdom the assessment of economic levels of leakage has a long history. The first national study on the topic was published in 1980 setting down a methodology for the assessment of economic leakage levels. This led to the implementation of sectors (District Metered Areas) in most water companies in the UK. The findings were reported in a major national research program in 1994. As a result of a drought in 1995/96 a number of companies initiated major leakage management programmes based on economic assessments. The situation in other parts of the world is quite different from the UK. Particularly in developing countries sectorisation is very rare and proactive leakage control limited. The benefits of pressure management are not widely appreciated and there is generally no assessment of the economic level of leakage.

From a public health and drinking water quality point of view it is being argued that the level of real water losses should be as low as possible, independently of economic or financial considerations, in order to minimize the risk of drinking water contamination in the distribution network. The World Bank recommends that NRW should be "less than 25%", while the Chilean water regulator SISS has determined a NRW level of 15% as optimal in its model of an efficient water company that it uses to benchmark service providers. In England and Wales NRW stands at 19% or 149 liter/property/day.

In the United States the American Water Works Association's (AWWA) Water Loss Control Committee recommended in 2009 that water utilities conduct annual water audits as a standard business practice. AWWA recommends that water utilities should track volumes of apparent and real losses and the annual cost impacts of these losses. Utilities should then seek to control excessive losses to levels that are economic for the water utility. In 1999 the California Urban Water Conservation Council identified a 10 percent benchmark for non-revenue water.
Increasing revenue and availability of water sources

Non revenue water (NRW) is water that has been produced and is “lost” before it reaches the customer. Such losses may be caused through leaking and burst pipes, illegal connections and metering inaccuracies, for example. The imperative to effectively manage NRW is further heightened due to a rapidly growing and urbanised global population and the impacts of climate change which together put greater demand on scarce water resources. Furthermore, reducing levels of NRW can contribute to attaining MDG target to reduce the proportion of people without access to safe drinking water.

Whilst the problem is global in scale, solutions need to be tailored to local circumstances due to variation in the cause of water loss and the mechanisms available to manage them. Such differences in the causality include, for instance, a greater proportion of water loss being of a commercial nature (customer meter under registration, data-handling errors, theft of water etc) in developing countries in comparison to developed countries where physical losses are by far the highest loss factor. On the solution side, the right mix of technological, institutional and financial mechanisms need to be adapted to meet local circumstances.

Non-Revenue Water Impact on Customers
The main objective of a water utility is to satisfy customer demand. A high level of NRW has a severe and direct impact on the ability of utilities to meet this objective and therefore has a negative impact on customers. High physical losses often lead to intermittent supply, either because of limited raw water availability or because of water rationing, which may be needed to reduce supply hours (and therefore hours of water leakage) per day. In addition to substandard service, intermittent supply poses a significant health risk, as contaminated groundwater, or even sewerage, can enter the leaking pipes during supply interruptions and very low pressure periods. The avoidance of this significant public health risk should be reason enough to reduce leakage to enable continuous supply. High leakages also increase flow rates in the pipe network, which can cause unnecessarily high pressure losses that affect customers and often lead to supply interruptions during peak demand hours. Yet
another problem is that intermittent supply will leave customers unsatisfied, resulting in low willingness to pay for improved service. This will discourage local governments to approve tariff increases that could help improve the situation, and the vicious NRW management cycle will be reinforced. In the long run, high levels of NRW may lead to unnecessarily high tariffs (if tariffs are properly set). In these cases, high water tariffs can, in effect, represent a subsidy borne by paying customers to cover NRW. If tariffs are not high enough, the water utility will remain financially weak and will not be able to provide appropriate service to its customers. In water systems characterized by unsatisfied demand and limited coverage, a high level of NRW is often the main reason why the system cannot be improved. In many cases, the population is then forced to use alternative water sources, which are often of poor quality and high in cost. There are two reasons for this situation. First, where raw water is limited, the volume of water that is physically lost is often required to supply unserved areas. Second, poor financial performance that results from high NRW makes it difficult to finance distribution network expansion.

**Non-Revenue Water and the Urban Poor**

The urban poor are often blamed for high levels of NRW, especially due to illegal connections. On the other hand, the poor are significantly affected by high water losses. While theft of water in low-income communities is certainly a reality in many Asian cities, its impact must be put in the proper perspective. The volume of water that is illegally consumed by a poor household is normally quite small, because of the lack of washing machines, flush toilets, garden irrigation, etc. Furthermore, this low level of consumption would nearly always be in the lowest tariff category (if such category exists). Therefore, the financial impact is even less than the volumetric impact. Experience in many countries shows that water theft by higher income households, and commercial and industrial users can be much more of a problem. Case studies from various Asian cities also indicate that there is very often a high willingness to pay for piped water supply among the poor, as this is nearly always cheaper than water purchased from water vendors. Unfortunately, in many cities, it is illegal to supply water to informal settlements, which automatically leads to the
construction of illegal connections. These are nearly always built of inferior quality and at the tapping points the main pipes are damaged, so the physical losses in such areas often exceed the commercial losses caused by the theft of water. In the case of intermittent supply, which is frequently caused by excessive leakage, the urban poor often suffer most, as they cannot afford proper storage facilities and pumps and often have to buy water from vendors during non-supply hours. Reducing physical losses will also make more water available and enable water utilities to increase coverage, including to poor communities.

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**The Importance of Establishing a Water Balance**

Twenty years ago, NRW management was based more on guesswork than on precise science. This has changed dramatically in many industrialized countries, kick-started by the regulatory pressure on UK water companies to cut leakage. Yet, despite some encouraging success stories, most water supply systems worldwide continue to have high levels of water losses. Part of the problem is the lack of a standard approach to defining and quantifying the components of NRW. Surprisingly, few water utilities in developing countries establish a water balance. Even if they do, no standard approach or terminology is used, so they all differ from each other. To address this situation, a number of national associations have adopted the International Water Association’s (IWA) standard international water balance structure and terminology. The components of the water balance can be measured, estimated, or calculated using a number of techniques. Ideally, all of these important components will be measured, but this is often not the case. Sometimes even key data, such as the total system input, are not really known, so determining water balances is usually inexact to start. However, it is always worth trying to establish a water balance, even if main elements are based on estimates. By doing this, it will be possible to produce a
catalogue of required actions that are needed to improve the accuracy of the water balance. After all the groundbreaking work done by the IWA, there is no reason for a utility to develop different water balance forms and definitions. Thus, national associations should consider making the International Water Balance a national reporting requirement and make audited water balance a precondition for any water supply improvement or expansion project. In addition, water utilities should publish the water balance in their annual reports and on their webpage.

**What You Should Know about Physical Losses**

Physical losses can occur along the entire distribution system, from storage reservoirs and the primary network to the smallest service connections. When people think about leakage, they normally think of big and spectacular pipe bursts. These often cause a lot of damage but are insignificant in volume compared to all the other leaks that do not come to the surface. Normally around 90% of water that is physically lost from leaks cannot be seen on the surface. These leaks might eventually become visible after many years, but until then, large volumes of water are lost every year. Sometimes, undetected leaks can be quite large, such as those that run directly into a sewer or a drain. Therefore, a water utility that does not practice a policy of efficient and intensive active leakage control will always have a high level of leakage, except if the infrastructure is new and/or in excellent condition. A major challenge facing water utilities and municipalities is reducing NRW. Essentially, NRW is the difference between the volume of water supplied to a system and the volume of water that is billed to its consumers. It is made up of three components, un-billed authorized consumption, apparent loss and real loss. Each component has its own particular cause, effect, value and set of solutions.

To develop an effective NRW management strategy, utilities and municipalities and often the regulator must first be able to obtain a thorough understanding of the causes and effects of components of NRW in their water system through a detailed water audit and forensic analysis that quantifies and validates the components of water consumption and water loss in a system. The results of this audit are then used to
formulate a management strategy that will reduce the component volumes of NRW to economic levels within the system.

### 2.3 Empirical Literature

A research done by Johnson Paul (1996) in Florida indicate that more than 15% of the water are lost before they are billed due to lack of good infrastructure network of all water pipe system, adequate monitoring systems for assessing water losses and also lack national reporting systems that collect and consolidate information on water utility performance. According to the findings, there should introduce the system of assessing water loss so as to avoid NRW.

According to research done by Pearson, D and Trow, S on Waterloss they discover that most of water were lost due to fault of water meter, when water meter are not in a good order they tend to lose the accurate of reading, they propose the calibration of water meter once in every five month so as they will have accurate reading.

Public-Private Infrastructure Advisory Facility (PPIAF) from United Kingdom, conduct the research and discovered that consumers paying for inefficiencies of water utilities, a precious and scarce resources being wasted and unnecessary investments in production. Another important consideration is that high Non-Revenue Water rates equate to poor governance, which results in low utility staff morale. From the consumer’s point of view, those who have illegal connections or have estimated actual consumption below real consumption are cheating those who pay for water. The result will be that NRW data are usually not readily available, and when they are, they are not always reliable because it is common for the management of poorly performing utilities to practice “window dressing” in an attempt to conceal the extent of their own inefficiency.

Farley, M (2011) Losses compare the advantage of control the lost of water against the real consumption used in a society and conclude that a lot of water are lost due to bad
infrastructure network of water pipe which cause a lot of leakage in a water system. He conclude by assist on good infrastructure network of water network system.
IRC (2009) Partners for Progress examines the extent to which The non-Revenue Water depends on aged water pipe systems, water meters, motivation of employees and other factors related to social, cultural, economical and political factors. Therefore dependent variable is Non Revenue Water and Independent variables are aged water pipe systems, water meters, motivation of employees and other factors such as socio-cultural factors, economic and political influences.

2.4 Research Gap
The reviewed literature indicates extensive concerned on this subject matter under study. In light of this, there is extensive empirical literature which indicates that there is a wide Non Revenue of Water. However, there is no published document which indicates that the same research have been done specifically where this research is done. Hence, findings from this research will cover the gap.

The issues related to high NRW rates are: consumers paying for inefficiencies of water utilities, a precious and scarce resources being wasted and unnecessary investments in production. Another important consideration is that high Non-Revenue Water rates equate to poor governance, which results in low utility staff morale. From the consumers’ point of view, those who have illegal connections or have estimated actual consumption below real consumption are cheating those who pay for water.
CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction
This chapter presents the overall research design, description of the study area, sample of the study, sample size, sampling techniques used to select respondents, nature of the study, data collection techniques and instruments that was used to collect relevant information during the study, data analysis as well as data source of data, data collection techniques, data analysis and data presentation.

3.2 Research Design
According to Churchill (2002), a research design is a master plan specifying methods and procedure for collecting and analyzing the requirement data. It is a means that is to be followed in completing a research study. The research design will help the researcher to obtain relevant data to fulfill the objective and casual research designs. In conducting this research study, the researcher used a case study design. The reason for choosing this design was on the fact that the researcher has a very limited time to conduct the study. Moreover, the case study design has also be of benefit as it allow flexibility and in-depth investigation of the study problem, while cross-checking responses from triangle data collection sources as it allow the application of more than one method of data collection thus integrating the findings of various methods.

3.3 Area of Study
The study was conducted in Arusha Region. Non Revenue of Water (NRW) and was studied. The study was done in this region because of the bases of convenience and financial constraints on the side of the researcher.

3.4 Source and type of Data
The data for this study was found from both primary and secondary sources. Again the study involved collection of both primary and secondary data.
Primary of Data
Primary data were found from respondents through the use of interviews and questionnaires that were sent to respondents. Primary data that was collected during the study were the data related to water sector which contribute to Non revenue of water, the causes of water loss and unbalance of water produce against water billed.

Secondary Data
A wide variety of secondary data source was collected. These include data obtained from books, journals, reports, files, publications, brochures and unpublished material from internet. Secondary data to be collected during the study include the extent of water loss which causes Non revenue of Water.

3.5 Data Collection Methods and Instruments.
The following are explanations of data collection methods and instruments were used in this research.

Questionnaires
This instrument was used to collect data from respondents. A questionnaire is a set of questions which are usually sent to the selected respondents to answer at their own convenient time and return back the filled questionnaire to the researcher (Churchill, 2002). In this research study, questionnaires with both open and closed-ended questions were administered to respondents in order to collect data and information on the research study.
Primary data were collected through questionnaires that were given out to the respondents. The data collected provide answers to the research questions. The questionnaires developed from extensive review of literature/research problem and designs on the basis of the research questions. Data collected through questionnaires include: - demographic of respondents on the Non revenue of Water.

Observation and Observation Schedule
The observation method were non-participatory whereby the researcher worked in tandem with the sample, but rather observe events, behaviors and activities of the
organization and record them as they occur in the schedule. This enable the researcher to collect current information with regard to the study problem, and the information were not modified.

**Interview and Interviewed questions**

The researcher use unstructured interviews, asking direct questions to the employees in an oral exchange. **Unstructured Interviews** are a method of interviews where questions can be changed or adapted to meet the respondent's intelligence, understanding or belief. Unlike a structured interview they do not offer a limited, pre-set range of answers for a respondent to choose, but instead advocate listening to how each individual person responds to the question.

The method to gather information using this technique is fairly limited, for example most surveys that are carried out via telephone or even in person tend to follow a structured method. Outside of sociology the use of such interviews is very limited. Aaron Cicourel and John Kitsuse used the method in 1963 for their interviews. It enabled them to ask further questions beyond what they already had planned, in addition, it enabled them to clarify meaning of the responses they received. There are both advantages and disadvantages of unstructured interviews. The advantages are that the data collected is said to be valid as it is an exact account of what the interviewee has said. The researcher can also find out important information which did not seem relevant before the interview and ask the interviewee to go further into the new topic.

Unstructured interviews are also more suitable for sensitive subjects such as "domestic violence" as many people would lie in a more formal interview and also their response may not be on the preset question list.

The unstructured interview gave the researcher a room to modify the question to fit the environment and temperament of the respondent, since attitude aspects are considered to be sensitive.
Documentary Review and Documentary Review
Documentation is an instrument used to collect secondary data that were used to collect data and information because it enables the researcher to get ready-made data and information by passing through various documents such as EWURA reports, books, and journals on the topic in question. As far as this study is concerned, several reports will be used in the collection of different information.

3.6 Population, Sample and Sampling Techniques Population Study
The population of this research comprised of all departments at AUWSA and some customers in Arusha Region. The population of the study includes 188 employees, 70 low-income customers, 60 middle-income customers, and 50 high-income customers.

3.6.1 Sample and Sample Size
Kothari (2006) defines sample as collection of some parts of the population on the basis of which judgment is made. A sample is small enough to make data collection convenient and large enough to be a true representative of the population from which it had been selected. Sample size refers to a number of items to be selected from the population of the study to constitute a sample.

3.6.2 Sampling Procedure
According to Kothari (2006), sampling is defined as the selection of some parts of the aggregate of the totality based on which a judgment or inference about the aggregate or totality is made. It is a process of selecting a group of people, events, behavior, or other elements with which to conduct a study. An important issue influencing the choice of sampling technique is whether a sampling frame is available.

3.6.3 Purposive Sampling
The researcher purposively select respondent among middle-level managers in the selected department. Respondent were comprised of 48 Customer Service Department, 112 Technical Department, 10 Finance Department, 7 Procurement Unit, 3 ICT Unit, 4 Internal Audit Unit, and 4 from Public Relations Unit. Also from
customer was 70 Low income Customers, 60 Middle income customers and 50 high income customers.

### 3.6.4 Sampling Frame

#### Table 2: Sampling frame.

<table>
<thead>
<tr>
<th>Unity of enquiry</th>
<th>Sample size (Actual number of respondents)</th>
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<tr>
<td>Managing Director</td>
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<tr>
<td>Technical Manager</td>
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<tr>
<td>Internal Auditor</td>
<td></td>
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<tr>
<td>Public Relations Officer</td>
<td></td>
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<tr>
<td>Financial &amp; Adm. Manager</td>
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<tr>
<td>System Administrators</td>
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<tr>
<td>Supervisors</td>
<td></td>
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<tr>
<td>Planning &amp; Const. Engineer</td>
<td></td>
</tr>
<tr>
<td>Human Resource Sect.</td>
<td></td>
</tr>
<tr>
<td>Technical Department</td>
<td></td>
</tr>
<tr>
<td>Customer Services Manager</td>
<td></td>
</tr>
<tr>
<td>Low income customers</td>
<td></td>
</tr>
<tr>
<td>Middle income customers</td>
<td></td>
</tr>
<tr>
<td>High income customers</td>
<td></td>
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<tr>
<td>Total</td>
<td></td>
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</table>

Source: Field Survey Data, 2012

In carrying out this research, sample of 188 people were responded from: the Technical department, Customer department, Finance and Administration department, Internal Audit Unit, Public relations Unit, Procurement and Information and Communication Unit and other external customers (Low income group, Middle income group and High income group). The choice of these units of inquiry is made basing on their involvement, knowledge, experience and number of years stayed in AUWSA. Out of 188 people 33 (18%) were interviewed and 155 (82%) responded through questionnaire as shown in table 2 below.
3.7 Data Validity and Reliability

Data Validity
Various measures were taken to ensure validity of the study. The researcher ensures data were collected from respondents who have experienced/ well informed on the problem understudy. The questionnaires will be test by at least thirty customers who used the Authority water.

Data Reliability
To ensure the reliability of data the theories that will be select for the study is clear described and research questions were formulated based on the previous theory. Data will be collected on the frame of reference that were drawn from the discussed theories

3.8 Data Analysis Procedure
Data was analyzed by using SPSS software package. Microsoft Excel for prepare charts for data presentation, while total score were used to rank the responses

3.9 Data Analysis Techniques
Data analysis refers to the computation of certain measures along with searching for patterns of relationship that exist among data groups (Kothari, 2994). This employed qualitative method of data collection and therefore the data collects were analyze by using qualitative method. Qualitative data such as finding out the views of respondents are not always computable by arithmetic relations. Qualitative methods of analysis will be use due to their advantage in that they will involve only simple statistics like tables and figures to illustrate the findings. Data analysis in this method is simple and understandable to the majority of people.
CHAPTER FOUR
DATA PRESENTATION, ANALYSIS AND DISCUSSIONS

4.1 Introduction
This chapter presents, discusses and analyses the findings of the study. The main concern of this study was to investigate the factor which influences NRW. The main objective of the study was to assess the factor which influences non revenue of water. In order to achieve the objective, the study had to answer the main research question. “To what extent does the loss of water contribute to revenue of organization performance?” Based on the objective and research questions; the research instruments (questionnaires and interview guides) were devised so as to gauge information that addressed the issue under study.

In this section, the findings of the study are presented on a qualitative analysis; the reason for this was to have a broader understanding of the factor that’s influence NRW on organizational performance. The key issues to be analyzed are the loss of water. The impacts of these components were revealed through interview and observation. In analyzing the factors influencing Non revenue of water in Tanzania Water Industry; taking the case of Arusha Water Supply and Sewerage Authority, the following aspects were analyzed

- The effects of old aged water pipes systems on NRW
- The contribution of water meters to NRW
- The effects of lack of motivation to Arusha Water Supply and Sewerage Authorities employees and customers to NRW
- Other factors contributed to NRW

4.2 The Assessment

4.2.1 AUWSA’s Infrastructure Network for Helping NRW
According to documentary review revealed that, lack of better Infrastructure Network of Arusha Urban Water Supply and Sewerage Authority contribute much on loss of water in Authority, during the financial year of 2012/2013 indicated as follows: for the
Financial year 2006/2007 NRW was about 33%; 2007/2008 NRW was about 22%; 2008/2009 was about 26%; 2009/2010 NRW was about 30%; and for financial year 2011/2012 NRW increased up to 34%. Figure 2 below depicts the NRW trend for Five years in Arusha Urban Water Supply and Sewerage Authority. For the five years the NRW were between 22% to 34% of which is above the maximum recommended NRW of 20% as per Energy and Water utilities regulatory Authority key performance indicator. The percentage of NRW fall when the amount of water produced is low due to minimal rain during the year and rise when the amount of water increased at production points, this has a relation with pressure in the system at high pressure the number of leakages is high due to old aged pipes as shown in figure 2 below.

Figure 4.1: AUWSA’s Non Revenue Water for five years 2007/2008-2011/2012
4.2.2. The Effects of old Aged Water Pipes Systems on non-Revenue Water

Table 3 and Figure 3 shows the trend of AUWSA’s monthly water produced (m3), NRW (m3) and also the figure shows the maximum recommended NRW provided by Energy water Utility regulatory Authority (EWURA) as one of the key performance indicator (NRW is great than 20%) for all water Authorities in Tanzania. The figure also shows that as the amount of water produced increased during the rain seasons the amount of NRW is also decreased and when the amount of water produced decreases the amount of NRW is also decreases which indicate that when the amount of water in the pipes increase the pressure in the water pipes are also increased which causes the old pipes to bust especially the old cast iron pipes which results the water lost to increases

Table 3: AUWSA’s Water produced (m3), Non Revenue water (m3) and maximum recommended NRW (m3) for FY 2011/2012

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<tbody>
<tr>
<td>Water produced (M3)</td>
<td>1,373,197</td>
<td>1,324,411</td>
<td>1,378,770</td>
<td>1,225,333</td>
<td>1,154,729</td>
<td>1,147,112</td>
</tr>
<tr>
<td>Non revenue water (M3)</td>
<td>550,836</td>
<td>512,453</td>
<td>492,552</td>
<td>395,541</td>
<td>305,672</td>
<td>276,705</td>
</tr>
<tr>
<td>Max. recommend NRW (M3)</td>
<td>274,639</td>
<td>264,882</td>
<td>275,754</td>
<td>245,067</td>
<td>230,946</td>
<td>229,422</td>
</tr>
</tbody>
</table>

Source: AUWSAs Monthly reports, 2011/2012
Figure 4.2: AUWSA’s monthly water produced (m3), Non Revenue water (m3), and Maximum recommended Non revenue water (m3) for FY 2011/2012.

Source: AUWSAs Monthly reports, 2011/2012

Questionnaire (A) item number seven (7) and questionnaire (B) item no fourteen (14) required respondents to identify the main causes of NRW in Arusha Urban Water Supply and Sewerage Authority. The total number of the sample was 188 and the results for respondents are as shown in table 4 and figure 4 below.
Source: Field Survey Data, 2012

According to table 4 and figure 4 above and interviews revealed that, 24% of respondents pointed out that the main causes of Un Account for Water in Arusha Water Supply and Sewerage Authority was caused by unauthorized connections (illegal and by pass); 21% of respondents pointed out that UFW in AUWASAs was caused by leakages from water system (transmission mains, Distribution mains, Utility’s reservoirs, service connections);

20% of respondents mentioned that the causes of water losses caused by stopped/injunction water meters (Bulk and customer water meters), whilst 19% respondents enumerated that Un Account for Water was caused by other reasons like Corruption and bribery among meter readers, wrong data capturing, improper customers records, water meter reversal, wrong of water meter installations and unread water meters) and 16% of respondents mentioned that NRW was caused by Overflow from storage tanks and break pressure tanks.
Figure 4.4: Respondents perception on old aged water system have any effect on NRW in AUWSAs Water system.

Source: Field Survey Data, 2012

Questionnaire (A) item 8 and questionnaire (B) item 13 required the respondents to respond if aged water pipes system have any effect to NRW, 180 (96%) out of 8 (4%) of respondents explained that, all water leakages from every water systems were because of old water supply systems „we have very aged water pipes, storage tanks, transmission mains, distribution mains and services connections As shown above in figure 5.

Furthermore, according to documentary review revealed that, leakage from transmission or distribution mains, leakage from services connections up to the point of metering were the main causes of NRW in AUWASA (AUWASAs” Quarterly Progress Report, 2012).
4.2.3. The Contribution of Water Meters to Non Revenue Water

Un Account for Water in Arusha Water Supply and Sewerage Authority occur mostly through tempered with meters, aging; and improperly maintained meters, Wrong installed meters, slow running meters, broken meters, and Make and size of the meters and. Furthermore, there were administrative errors and sometimes caused by corrupt practices during the meter reading and billing process. Questionnaire (A) item number 9, 10 and 11 required respondents from AUWASAs” employees to pinpoint whether water meters contributed to NRW. According to questionnaire, interviews and observation revealed that, water meters contributed for NRW.

Figure 4.5: AUWSAs’ employees reasons as to why water meters contributes to NRW

Source: Field Survey Data, 2012

According to table 5 and figure 6 above and interviews, observation and documentary review revealed that, water meters contributed to NRW in AUWASA. Figure 7 above depicts that, (26%) of AUWASA employees mentioned that residents on street tempered with meters; (20%) of respondents pointed out that
NRW was caused by Aged meters; (19%) of respondents emphasized that slow running meters was the causes of NRW and also (16%) respondents were pointed broken meters was the causes of NRW two other causes of why water meters contributed for NRW these were make and size (5%), and Wrong installation (14%). Questionnaire (B) item number 7 & 8, required customers to respond whether water meters contributed to NRW and why? Table 6 and Figure 7 below depict the responses of customers as regards to the research questions.

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Figure 4.6: Customers responses as to why water meters contributed NRW in AUWSA

According to interviews revealed that, 45% of respondents pointed out that water meters contributed to NRW because of reading errors. As other respondents said that „One month was estimated and bill was over actual meter readings”. While others dared to say that

“Wrong recording of water charges, unusual water bills, inconsistent bill compared with meter reading were the reasons of water meter contribution to NRW; 25% of respondents pointed out that improper maintenance of water meters contributed to NRW with the reasons that when meters are not working lead water meter inaccuracies, malfunctioning and misreading.20% of respondents pointed out that NRW was caused by corruptions 10% of respondents mentioned that administrative errors, data entry errors, delays and loss of records also are the causes of NRW in AUWSA.
4.2.4 The Effects of Lack of Motivation to Auwsa Employees and Customers on NRW Management

Motivation is the set of processes that determine the choices people make about their behaviors. Motivating is the ability of indoctrinating the personnel with a unity of purpose and maintaining a continuing, harmonious relationship among all people (Armstrong, 2009). Motivation efforts must be directed towards improving AUWSA operations. To be effective, however, they must also be designed to show benefits to the employees. Lack of motivation in return affects AUWSA performance.

A number of symptoms may point to low morale: employees being involved in illegal connections, by pass connections, tempering meters, improper maintenance of meters and corrupt practices during the meter readings and billing process and hence leading to high NRW.

Questionnaire (A & B) item number 19 required respondents to point out whether motivation to AUWSAs” employees and customers may enhance them to reduce NRW as well as lack of motivation may cause high NRW. Data gathered from interviews revealed that, many respondents pointed out that reducing NRW is not only looked on technicality such as illegal connections but should be looked on human needs. Therefore they pointed out that, AUWASAs” employees need genuine incentives to their jobs and replace the incentives they have made for themselves through illegal connections and other corruptions.

When respondents asked why there was no motivation in AUWSAs” employees and customers they pointed several reasons, these were: lack of recognition of their performance, low remuneration, no long term trainings, no other rewards, motivation was not given at the right time, leakages reports were not responded quickly.
Table 4: Respondents opinion whether lack of motivation may increase NRW

<table>
<thead>
<tr>
<th>Opinion on lack of motivation</th>
<th>Respondent s</th>
<th>Percentages (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>No responses</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>Agreed</td>
<td>28</td>
<td>15</td>
</tr>
<tr>
<td>Strongly agreed</td>
<td>134</td>
<td>71</td>
</tr>
</tbody>
</table>
| Total                        | 188          | 100             

Source: Field Survey Data, 2012

According to figure 8 above revealed that, lack of motivation may lead to high NRW; 71% of respondents confirmed this statement and 15% of respondents also confirmed whilst 3% of respondents disconfirmed the Statement. As above stated that, AUWSAs’ employees were not motivated.
Figure 4.8: Number of AUWSA’s unauthorized connection reported within 4 years

![Bar chart showing number of unauthorized connection reported](chart.png)

Source: AUWSAs Annual reports, 2012

According to table 8 and figure 9 above the data shows that the number of unauthorized connections increased from 129 during financial year 2007/2008 to 304 during financial year 2008/2009 which was the increase of 136%, but also it was observed that after one year it drops to 223 no of unauthorized connections reported. This increase was caused due to increasing of amount given to good Samaritans whom were reporting the unauthorized connections, the amount given to good Samaritans was increased from Tshs10,000/= (FY 2007/2008) to Tshs 40,000/= (FY 2008/2009) per each reported information. Therefore this confirms that well motivated Customers (external and internal) contribute in reduction of NRW.

### 4.2.5. Other Factors Contributing to NRW

As pointed out in section 4.2 of this study, NRW caused by several factors. Further, findings came up with other factors or reasons among which are the following:- The
following were what respondents using questionnaire and interviews which required the respondents to enumerate other factors which cause NRW in AUWSA.

Figure 4.9: Peoples’ perception on other factors causing NRW in AUWSA

From interview and questionnaire it was revealed that there were several factors causing NRW in AUWSA, it was about 25% of Arusha City water Stakeholders pointed out that Undigitized water network system caused NRW; 18% of respondents pointed out there Political influences caused NRW; it was about 17% of respondents pointed out that Inadequate Technical skill caused NRW it was about 9% of respondents pointed out that poor operations and maintenance such as poor workmanship and poor material during construction of water networks causes NRW. Further 5% of respondents pointed out other factor was greater financial constraints as well as cultural influences was about 12% of respondents pointed this factor; and about 14% of respondents mentioned social influences also was the cause of NRW.
To summarize, as per table 9 and figure 10 it shows that, the other factors leading to Un Account for Water in Arusha Water Supply and Sewerage Authority were: Un digitized water network system, Political influences, inadequate technical skills and poor operations and maintenance such as poor workmanship and poor material during construction of water networks and it follows with social-cultural influences and Greater financial influences.
CHAPTER FIVE
SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction
In this part the researcher summarize, made conclusion and policy implications concerning the factor which influence Non revenue of Water at Arusha Urban Water Supply and Sewerage Authority.

5.2 Summary of the Study
The researcher aimed at looking the effectiveness of None revenue of water in organization performance with the following objectives that assess the infrastructure network of all water pipe system in helping the non revenue of water, to identify the water meter that’s contribute to non revenue of water, to assess the effects of motivation factor to AUWSA employees and customers on management of non revenue of water, to identify he leakage of water and see if they contribute NRW and to identify the capacity of billing software if it suite the requirement.

5.3 Conclusion
This study was set out to analyze factors influencing to NRW for the water industry in Tanzania, taking the case of Arusha Urban Water Supply and Sewerage Authority. In analyzing factors influencing Non Revenue Water for water industry in Tanzania, specifically as regards to Arusha Urban Water Supply and Sewerage Authority (AUWSA), the following four aspects were examined:

The findings from chapter four (4) revealed that NRW in Arusha Urban Water Supply and Sewerage Authority(AUWSA) were caused by the effects of old aged water pipes systems, water meters, lack of motivation to AUWSAs employees and other factors including Un digitized water network system.

5.3.1. The Effects of Old Aged Water Pipes Systems on NRW
The findings revealed that 96% of respondents pointed out that high NRW AUWSA”s water system were caused by leakages due to old aged water
system. Also it was observed that when pressure in the water system increased the old pipe bust and resulted the water loss to increase.

5.3.2. The Contribution of Water Meters to NRW
According to interviews, observation and documentary review revealed that high NRW was caused by tempering with meters, followed by Aged meters and slow running meters, wrong installation of water meters, make and size of water meter and improper maintenance of meters, also it was mentioned that corruptions and Administrative error were contributing to NRW.

5.3.3. The Effects of Lack of Motivation to NRW Management
It was about 71% of respondents confirmed that motivation is a tool for enhancing employees to perform their performance and avoiding involvement of employees in dealing with illegal connections and tempering meters, therefore they confirmed that AUWSAs’ employees were not motivated because of lack of recognition of their performance, low remuneration, no long-term training, motivation was not given in time, leakage reports were not responded promptly, as a result employees were involved in illegal connections, tempering meters, improper maintenance of meters and corrupt practices during the meter readings.

5.4. Recommendations
There are various ways of reducing NRW, base on this study findings the following are the recommendations in order to reduce NRW in AUWSA:

i. The Utilities should carry out the Water balance exercise in order to identify the amount of water loss for technical (real loss) and commercial (apparent loss).and then to concentrate on the item which causes high percentage of NRW.

ii. In the study it has observed that number of staff whom are dealing with NRW are not enough, therefore it is recommended to allocate more staff to deal with leakages repair and unauthorized consumption.
iii. The meter readers should be properly trained so that they can take proper meter readings.

iv. Most of AUWSA water network system has been used for long time, therefore it is recommended for Authority to conduct a survey using efficient modern equipments in detecting aged pipes and replace those which are in poor condition which will help to reduce leakages.

v. It is recommended that Authority should make sure that all water meters (Bulk and Customers) are installed properly and working in good condition and should be replaced or calibrated when their useful life are reached its ends as specified by manufacturers, also the customer water meters should be installed considering the pressure in that area.

vi. One of the secret of success in any organization is motivated employees, the study has observed that AUWSA”s employees are not well motivated, therefore it is recommended that Authority should motivate their employees toward Authority goals.

vii. The study has observed that the number of unauthorized connections reported to AUWSA increased for one year after the amount given to Samaritan increased and then after it started to drop, basing on this findings the study recommend the amount given to Samaritan has to be increased in every financial year until the number of unauthorized connections are reduced to minimum.

viii. The study has also observed that un digitized of water network systems one of the reasons causing Non Revenue water, therefore it is recommended for AUWSA to digitize its water network system by using Geographical Information System (GIS).
This Study Identified the Following Key Elements For Further Research:
Corrupt practices during the meter readings. This study findings revealed that some customers had the tendency to regulate Water tape therefore, the quantity of water passing through the meter cannot be measured. Therefore this study recommends further research can be done on how dripping system contributes NRW. Similar studies to be done country wide to determine similarities on the factors contributing NRW.
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APPENDIX A

QUESTIONNAIRE TO AUWSA STAFF

Dear AUWSA Staff,

This questionnaire is aimed to collected information which will assist to analyze the factors contributing to Non Revenue Water for water industry in Tanzania. The information being collected will be treated confidential and shall be used for academic purpose and not otherwise. Kindly respond correctly and thank you very much for taking your time to answer this questionnaire.

1. What is your gender? (Tick)
   a) Male    b) Female

2. What is your age range?(Tick)
   a) Under 20 years
   c) Between 40 to 50 years
   b) Between 20 to 40 years
   d) Over 50 years

3. What is your highest education level? (Tick)
   a) Secondary /Middle School    b) College
   c) Advanced Secondary School    d) Diploma
   e) Undergraduate degree/Advanced Diploma    f) Masters Degree

4. How long have you worked with AUWSA..............................

5. What is your position in the organization..............................

6. Does your position put you in any direct contact with the customer? If yes what complain do you receive from customers?

........................................................................................................
........................................................................................................
........................................................................................................

71
7. What do you think is the main causes of Non Revenue water to AUWSA’s water system?
   a) Leakages
   b) Overflow
   c) Unauthorized connections
   d) Stopped water meters
   e) Others Specify
   ……………………………………………………………………………………………
   ……………………………………………………………………………………………
   ……………………………………………………………………………………………

8. Does the aged water pipe system have any effect of Non Revenue water? If yes what do you think should be done to reduce the Non Revenue water?
   ……………………………………………………………………………………………
   ……………………………………………………………………………………………
   ……………………………………………………………………………………………

9. Does the measuring devices (Water meter) when used over time have any effect to the level of water losses? If yes what AUWSA should do to reduce water losses?
   ……………………………………………………………………………………………
   ……………………………………………………………………………………………
   ……………………………………………………………………………………………

10. Do you think that the size and make of customer’s water meter contribute to Non Revenue water? If yes How? ……………………………………………………………

11. Do you think that all water meters (Bulk and Customer water meters) are working properly? If not what do you suggest…………………………………………………

12. How often do you see leakages in AUWSA’s water system? (Tick)
   a) Very little
   b) Little
   c) Average
   d) Many.
13. What do you think are the reasons of the Leakages? (Tick)
   a) Poor workmanship during installation.
   b) Low quality of material
   c) High pressure in the system.
   d) Others Specify ………………………………………………………………

14. How long does it take AUWSA”s employees to respond on reported leakage? (Tick)
   a) Less than two hours
   b) 2 hours to 4 hours
   c) One day
   d) More than one day

15. Does the employees who are dealing with leakages repair are enough compare to AUWSA water network system? If not what do you suggest
   ………………………………………………………………………………………
   ………………………………………………………………………………………
   ………………………………………………………………………………………

16. Do you think that in AUWSA water system is any unauthorized water connections (Illegal and By-pass) , if yes what do you think is the reason
   ………………………………………………………………………………………
   ………………………………………………………………………………………

17. What should be done in order to reduce the unauthorized water connections
   ………………………………………………………………………………………
   ………………………………………………………………………………………
18. Do you think that information from internal and external customers on water thefts contribute to reduce non revenue water? If yes what should be done to improve the communication methods?

…………………………………………………………………………………………
…………………………………………………………………………………………

19. Does the motivation to employees contribute in reduction of Non Revenue water?
a) Disagree 
b) Strongly disagree
c) Agreed 
d) Strongly agreed If yes explain how

…………………………………………………………………………………………
…………………………………………………………………………………………
APPENDIX B

QUESTIONNAIRE TO AUWSA WATER CUSTOMERS

Dear AUWSA Customer,

This questionnaire is aimed to collected information which will assist to analyze the factors contributing to Non Revenue water for water industry in Tanzania. The information being collected will be treated confidential and shall be used for academic purpose and not otherwise. Kindly respond correctly and thank you very much for taking your time to answer this questionnaire.

1. Which area do you reside in Arusha?

2. How long have you registered as AUWSA”s Customer
   a) Less than two years
   b) Between 2 years and 4 years
   c) Between 4 years and 6 years
   d) Above 6 years.

3. What is your account Number …………………..or /Meter number …………………

4. Is the water supply 24 hrs accessibility at your area? If not what do you think AUWSA should do to improve the service

   …………………………………………………………………………………………………
   …………………………………………………………………………………………………
   …………………………………………………………………………………………………
   …………………………………………………………………………………………………

5. How is the pressure of water supply at your premise(s)? (Tick)
   a) Very good
   b) Good
   c) Fair
   d) Poor

6. Since you were connected with AUWSA”s water connection have you experiences any problem with your water meter? If yes what was the problem?
7. Do you think that all water meters (Bulk and Customer water meters) are working properly? If not what do you suggest

8. Does the measuring devices (Water meter) when used over time have any effect to the level of water losses? If yes what AUWSA should do to reduce water losses?

9. Have you ever complained to AUWSA on your water bill? If yes what was the problem

10. Does the aged water pipe system have any effect of Non Revenue water? If yes what do you think should be done to reduce the Non revenue water?

11. In terms of water supply what do you think are biggest problems you are experiencing as a customer?

12. What is respond time in case of leakages repair team?
   a) Very fast
   b) Fast
   c) Slow
   d) Very slow

13. Does the aged water pipes system causes of those leakages?
14. What do you think is the main causes of water losses to AUWSA’s water system?
(a) Leakages
(b) Overflow
(c) Unauthorized connections
(d) Stopped water meters
(e) Others Specify

15. How do you rate AUWSA employee’s competency
   a) Very good
   b) Good
   c) Fair
   d) Poor

16. How do you rate the Integrity/Transparency of AUWSA’s employees?
   a) Very good
   b) Good
   c) Fair
   d) Poor

17. Do you know any illegal connection or by pass connection in Arusha City? If yes what do you suggest AUWSA should do to reduce them?

…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………

18. What do you suggest AUWSA should do to get information on unauthorized connections and leakages?

…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………

19. Do you think that motivation to internal and external customers contribute in reduction of Non Revenue Water (water loss)?
a) Disagree
b) Strongly disagree
c) Agreed
d) Strongly agreed
If agreed explain how

…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………