ADDIS ABABA UNIVERSITY

COLLEGE OF GRADUATE STUDIES

WATER SUPPLY LINE LEAKAGE MANAGEMENT IN ADDIS ABABA: THE CASE OF BOLE SUBCITY IN THE DISTRICTE METERED AREA OF THE WATER WORKS ENTERPRISE

BY

RAHEL MAMO

Addis Ababa, Ethiopia

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A THESIS SUBMITTED TO

CENTER FOR ENVIRONMENT AND DEVELOPMENT OF ADDIS ABABA UNIVERSITY IN PARTIAL FULFILLMENT OF MASTERS OF SCIENCE DEGREE IN WATER RESOURCES MANAGEMENT

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APPROVED BY BOARD OF EXAMINERS: Signature

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Acronyms

AAWSA	Addis Ababa Water and Sewerage Authority
ALC	Active Leakage Control
DMA	District Metered Area
IWA	International Water Association
NRW	Non-Revenue Water
SPSS	Statistical Package for Social Science
UK	United Kingdom

APPENDIX

Abstract

The percentage of people served with some form of improved water supply rose from time to time. On the other hand, shortcomings in the management of water by focusing on developing new water sources rather than managing existing ones, and top-down sector approaches to water management have resulted in uncoordinated development and management of the resource. The city of Addis Ababa is suffering from losing 35.73% of its supply in its distribution systems.

A study was conducted to identify the communities water leakage related knowledge, and assessed AAWSA's practice of water leakage management, and explained the gap between the communities knowledge of water leakage and AAWSA practice of water leakage management using District Metered Area application in the study area.

Semi structured questionnaire, interviews, field measurement and document surveys was used to collect the relevant data. The semi structured questionnaire form, which was attended by a covering letter, consisted six parts. The first part sought Demographic and household characteristics information about the respondents profile and the second part assesses the Water sources and service leakage data .In the third part, participants were asked to tell if there are information sources about water leakage. The fourth part the respondents requested to explain their Life experience and psychosocial factors when there is shortage of water. The fifth part the respondents requested to know about the Household water perception data. On the sixth part the respondents requested if they have understanding to take Measures of water-related behaviors and policy support. The interviewee incorporates officials of AAWSA expert members. The data's collected were entered in to SPSS version 21 software. Software analysis was used to evaluate water leakage knowledge of the study population. The results of the field measurement were also presented it was seen that there is low and fragmented connection between the community understanding and the practical application of leakage management. The conclusion part concludes the findings by considering the existing water leakage management knowledge of the community and the AAWSA water leakage management practice and recommendation were given on the subject matter of the study.

Key words: leakage, DMA, water knowledge, leakage management

CHAPTER ONE

1 INTRODUCTION

1.1 Background

Water is an essential but limited natural resource which is indispensable for life and economic development. Water for human, commercial and industrial consumption is abstracted from natural water bodies, purified and distributed through water supply systems to users. There is renewed international awareness that water distribution systems worldwide are aging and deteriorating, while the demands on these systems, and thus on our natural water resources, are ever increasing (Milkessa, 2017) .

The percentage of people served with some form of improved water supply rose from 79% (4.1 billion) in 1990 to 82% (4.9 billion) in 2000. At the beginning of 2000 one-sixth (1.1 billion people) of the world's population was without access to improved water supply. The majority of these people live in Asia and Africa, where two out of five Africans lack improved water supply and the 2000 coverage of water supply for the urban population of Africa and Ethiopia was 85% and 77% respectively (WHO, 2000) .

According to the millennium goal targets, about 663 million people of African urban areas lack improved drinking water sources from 2000 to 2015(WHO, 2010, 2015) . On the other hand, in African largest cities, only 43% inhabitants have house connection water supply services. Due to shortage of resources developing countries are challenged to provide access to safe water for their citizens.

Water withdrawals have increased more than twice as fast as population growth and currently one third of the world's population lives in countries that experience medium to high water stress. On the other hand, shortcomings in the management of water by focusing on developing new water sources rather than managing existing ones, and top-down sector approaches to water management have resulted in uncoordinated development and management of the resource (Simbeye, 2010) .Unaccounted-for-water in water distribution systems is reaching alarming levels throughout the world. Unaccounted-for-water is defined as the difference between the volumes of water entering a water distribution system and that accounted for, typically through customer water meters. Unaccounted-for-water is made up of various components including physical losses (leaks), illegitimate use, and unmetered use and under registration of water meters. Leakage makes up a large part, sometimes more than 70 % of the total unaccounted for water (Milkessa, 2017) .

Addis Ababa Water and Sewerage Authority conducted water loss study during the years 1982 and 1995; the water loss in 1982 was reported to be 22% while this figure rose to 35.6% in 1995. Although the authority's target was to reduce these figures to 10% gradually, the total water loss further rose to 38.01% in 2006. This shows that the situation is worsening and the infrastructure is deteriorating.

One of the major issues 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" [NRW]). Although it is not feasible to eliminate all NRW in a water utility, reducing by half the current level of losses in developing countries appears a realistic target. Non-revenue water management is not a one off activity, but one requiring a long term commitment and involvement of all water utility departments. Like most city in developing counties, Addis Ababa is a city with high growth rate. High growth of the town in turn necessitates the need of adequate and pertinent water supply. Water loss study should therefore be conducted frequently and periodically for safe and healthy usage of the water resource (AAWSA, 2017) . Accordingly, total water supply to the city was 83,170,607m^3 while the corresponding consumption was 51,556,041m^3; resulting in total losss of 31,614,566.00m^3. The city level real loss is calculated to be the total loss minus apparent losses which equals 35.73% of total water distribution or 29,717,692.04 m^3 for the year 2006 (Gamtessa, 2008) .

Although leakage is one of the major causes for loss of water in a network distribution system, the loss of water through illegal connections and non-functioning meters is also contributing a lot that needs a proper management and monitoring system. While developed cities have started using online continuous operation and monitoring service, the developing cities have great difficulties even to collect information on their previously performed operation and maintenance activities that could help them developing a strategy for the future. Many developed countries use water audit procedures to determine the efficiency of the system and to identify the location and magnitude of water losses (Desalegn, 2005) .

Inefficient and ineffective water use of the existing water supplies in Addis Ababa is due to high water loss rate in water distribution system around 40%, older or high flow rate of plumbing fixtures (toilets, shower heads and taps) which are installed at a customer homes and buildings and low water tariff rate that provides an increasing subsidy (Ejigineh, 2010) .

Furthermore, major problem in water leakage management planning practice in the city is that most AAWSA water leakage management practice promotes the development of water leakage management practice within its limited department without adequately reviewing water related knowledge of the community and awareness creation to the population that is being affected unknowingly. Therefore, there is a lack of understanding of principles, scope and the potential of water leakage management as a strategic management tool for developing and implementing by Addis Ababa Water and Sewerage Authority (Sarega, 2010) .

Following the trend, by developing a new water sources and infrastructures for meeting the shortfall supply and projected future demand of the city cannot be sustained indefinitely as the costs; environment and climate change impact of the new water sources development is increasing. The challenges can be solved by developing and adapting water leakage management option (Sarega, 2010) .

Water leakage management option is designed to increase water use efficiency and promote water conservation so that to consumer behavior is changed and/or changes to the stock of water using equipment is achieved. Increasing water use efficiency can be achieved by replacing water using equipment and appliances (toilets, shower heads and faucet) with more efficient types and by finding and repairing leaks in the water distribution system. Behavior change in consumers can be promoted via educational campaigns or through economic instruments such as pricing. Replacing or regulating water using equipment and appliances as a conservation strategy is based on the notion that demand for a resource such as water is not in fact a demand for that resource itself but rather for the services that the resource provides, often called end use. Consumers are therefore seen to generate a demand for services, end uses, such as toilets, clothes washing and showers rather than a demand for kiloliters. Water leakage knowledge and the current practice of AAWSA on leakage management enable to see the gap between them.

Therefore, the purpose of this research is to study the scope and potential of water leakage management knowledge and Leakage management practice in terms of potential benefits from water savings, costs, and downsizing the need of new water sources development and reducing operation and maintenance cost.

1.2 Statement of the problem

Knowledge and understanding of water issues in the community is considered a core ingredient of solving water-related problems. Knowledge is central to models of water-related engagement, environmental citizenship, and environmental literacy. It has been argued that greater knowledge allows community members to contribute to innovation and problem solving. The concept of 'water literacy', and other forms of literacy such as health literacy, integrates topic knowledge and the capacity to apply this knowledge to decisions. The literature has not identified specific areas of knowledge considered necessary for adequate water literacy in water leakage management. The emerging emphasis on sustainable water management suggests that key areas of individual-level water knowledge include the urban water cycle and impacts of the community.

Leakage is often a large source of unaccounted for water and is a result of either lack of maintenance or failure to renew ageing systems. Leakage may also be caused for poor management of pressure zones, which is resulted in pipe or pipe-join failure. Although some leakage may go unnoticed for a long time, detection of visible leakage also requires good reporting which includes some level of public participation (Desalegn, 2005) .

Although the report of AWWSA showed that the total loss of water can easily be estimated by comparing billing on water consumption and the total water produced and distributed to the network system, identifying the causes of the water loss and their spatial distribution is the challenge of many cities including Addis Ababa. For this reason many water companies that Addis Ababa water authority is among them are forced to consider the total loss as being caused by the physical loss like leakage, but in reality the causes for water loss include others such as illegal connection, non-functioning of water meters, etc .

On the one hand as every water point, being it is individual house connection or common water tap, is metered which supports a lot to introduce modern geographic information system, however due to lack of appropriate distribution and recording system of relevant information along the network, identifying and characterizing the loss of water in its spatial distribution is becoming very difficult. As the entire city water network systems are interconnected to each other without separating which system is serving which area and how much water is distributed to which area, this makes the identification and the distribution of the water losses at different spatial locations difficult(UN-HABITAT,2002). For this reason the apparent and real losses cause water scarcity to the community and financial loss in the city. Presently Addis Ababa faces a serious deficit in the water supply due to increased population and expanded economic actually in and around the subsystems. This paper will fill the gap by developing an approach by considering the existing water leakage management knowledge of the community and the AAWSA water leakage management practice.

1.3 Objectives

1.3.1 General objective

The general objective of the study is to assess the water leakage knowledge and its management in Addis Ababa, Bole Sub city.

1.3.2 Specific objectives

- To identify the communities water leakage related knowledge.
- To asses Addis Ababa Water and Sewerage Authorities' practice of water leakage management
- To examine the gap between the community and AAWSA practice of water leakage management.
- To explain the District Metered Area application in the study area.

1.4 Research Questions

The study tried to answer the following:

- What is the level of community's knowledge on water leakage management?
- What type of practice AAWSA does to control leakage?
- What is the gap between the community and the AAWSA practice of leakage management?
- How District Metered area application takes place?

1.5 Scope and limitation of the study

The overall goal of this study is investigating community's knowledge in water leakage and water leakage management practice. Therefore, the scope of the research is delimited to communities who live in Addis Ababa specifically around water works enterprise.

The study may be more important if it was included more areas other than water works enterprise. But, it is too difficult to analyse, organize, and interpret the data within the available material. So, the study should be confined into Bole sub city around water works enterprise.

As the study is cross-sectional in design, the possibility of recall biases resulting in under or over reporting and misreporting of events was likely. In addition, information's that use questionnaire required a good memory were vulnerable to recall bias.

Moreover, in spite of the researcher's efforts to gather the necessary information as objective as possible, the analysis of this study was based on the opinion of respondents, so the respondent may not cooperate well to fill and gave all the necessary data. This may in turn limit the ability to make broader generalization from the study undergone.

1.6 Significance of the study

The study provides communities understanding on water leakage management practice. It would as such help to know the level of understanding of the community in leakage management because it provides information on how the knowledge helps in minimizing water leakage.

The significance of the paper is to see the relationship between the population understanding of water leakage and the Addis Ababa Water and Sewerage leakage management practice. The study will further serve as a point for any investigation on the issue as a useful material for academic purposes.

1.7 The research framework

This study contains five chapters. The introduction gives the overview of background of leakage management, the research problem, objectives, research questions, scope and limitation of the study, and significance of the study. The second chapter reviews important literature on water leakage management. The chapter on material and methods outlines the study design and data collection and analysis methodologies. The fourth chapter consists of the analysis of data and an overall discussion. Finally, conclusions recommendations and suggestions are presented in fifth chapter of the study.

CHAPTER TWO

2 LITERATURE REVIEW

2.1 Concepts of water leakage management

Water leakage:-is treated water lost from the company's distribution networks and supply pipe losses from consumer's pipes (Wales, 2018) . it is an amount of water that is escaping from a pipe or container by means of a crack, hole, or other fault. Coherent leakage management strategies rely upon a uniform way of assessing water losses and setting economically and environmentally justified loss reduction targets (Pritchett, 2009) .

The International Water Association (IWA) defines two major categories under which all types of supply water loss occurrences fall:-

Real losses: - are the physical escapes of water from the distribution system, and include leakage from pipes, joints, and fittings; leakage from reservoirs and tanks; and water losses caused by reservoir overflows. Real losses occur prior to the point of end use.

Apparent losses: - are caused by inaccuracies associated with customer metering, consumption and billing data handling error, assumptions of unmeasured use, and any form of unauthorized consumption (theft or illegal use).

To avoid the wide diversity formats and definitions related to water loss, many practitioners have identified an urgent need of a common international terminology. International water association (IWA) recently produced a standard approach for water balance calculation with a definition of all terms involved as indicated below.

<table>
<tr><td rowspan="9">System input volume</td><td rowspan="4">Authorised consumption</td><td rowspan="2">Billed Authorised Consumption</td><td>Billed metered consumption</td><td rowspan="2">Revenue water</td></tr>
<tr><td>Billed unmetered consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorised Consumption</td><td>Unbilled metered consumption</td><td rowspan="7">Non-revenue water</td></tr>
<tr><td>Unbilled unmetered consumption</td></tr>
<tr><td rowspan="5">Water losses</td><td rowspan="2">Apparent losses</td><td>Unauthorised consumption</td></tr>
<tr><td>Metering inaccuracies</td></tr>
<tr><td rowspan="3">Real losses</td><td>Leakage on transmission and or distribution mains</td></tr>
<tr><td>Utility storage tanks leakage</td></tr>
<tr><td>Service connections leakage up to customer metering</td></tr>
</table>

Figure 2-1: IWA standards international terminology (Source, (Desalegn, 2005))

2.2 Leakage management concept

2.2.1 DMA

DMAs are discrete areas of the distribution system that are sufficiently small (500 – 3,000 customer service connections) to measure and segregate flow rates and quantify leakage events (DIAS, 2016) .

A District Metered Area (DMA) is defined as an area of the supply network having ideally about 2000 properties supplied preferably from a single entry point which is metered (water entering and leaving) and pressure controlled (Charalambous et al, 2014) .

According to different literatures District metered areas (DMAs) are increasingly being introduced into water distribution networks for improved demand management and the potential or leakage detection. It is generally accepted that efforts to reduce water losses and maintain them at acceptable levels will be more successful if water losses within small discrete areas are continuously monitored using district metering. The four strategies that are applicable in District Metered Area are:

Active Leakage Control (ALC): is vital to cost-effective and efficient leakage management mechanism. The concept of monitoring flows into zones, or district meter areas (DMAs), where bursts and leaks are unreported is now an internationally accepted and well-established technique to determine where leak location activities should be undertaken (Farely et al, 2008) .

Pressure Management: aims at minimizing excess (unnecessary) pressures in the water distribution system as well as removing transients. It should be borne in mind that simple and inexpensive pressure management activities can often lead to considerable reductions in Real Losses (Charalambous et al, 2014) .

Pipeline and Asset Management: deals with all network assets which should be regularly maintained in order to continue to provide the required service and of course replaced in a timely and programmed manner by the end of their useful life. Asset management is good engineering and business practice, and it includes all aspects of water utility management and operations (Charalambous et al, 2014) .

Speed and Quality of Repairs: aims to ensure timely and lasting repairs and is regarded as critical to the success of the overall Real Loss control program. The length of time a leak is allowed to run affects the volume of real losses, so repairs should be completed as soon as possible once a leak is detected. Repair quality also has an effect on whether the repair is sustained (Ison Simbeye, 2011) .

2.3 Water leakage management

In some countries, utilities address leaks reactively, responding to identified leaks and water audits. However, the UK has developed proactive approaches to prioritizing leak detection and controlling system pressure. In summary, isolating small areas of metered homes yields total leakage for a local area and allows more intensive detection methods to be targeted to key zones. Pressure management, lowering system pressures during times of low demand, can lead to a decrease in the long-term volume lost to leakage and extend the life of pipes (Thomson et al, 2009). However, 24-hour continuous pressure should be the first priority and pressure management should not be undertaken by utilities that struggle to maintain adequate 24-hr water pressure (Correlje et al., 2008).

Repairs to pipes with holes generally involve either covering the hole from outside the pipe or inserting a smaller pipe inside the one that is leaking. The complexity and time for repairs varies widely, from one employee tightening a loose nut to large crews and excavators spending days repairing a deeply buried main. Of course, an analysis of repair costs versus replacement costs should be conducted for older pipes (Farley, 2001; Georgia Environmental Protection Division, 2007).

High water pressure is required for leak detection equipment to be used effectively. Therefore, alternatives methods for leak detection in intermittent systems involve isolating a small zone of the network, closing the stop taps to customers, providing temporary water pressure to that zone, and then using conventional or modified leak detection methods (Farley, 2001).

Metered connections are essential for water conservation and they can also serve as a leak detection mechanism for pipe beyond customer meters. Customers will usually complain to the utility when they receive an unusually high water bill. Alternatively, an automated system to flag large increases in individual water bills or meter readings can alert utility personnel. A study conducted in the UK found that water consumption declined 10% following meter installation (Farley, 2001).

2.4 Theoretical review on communities water related knowledge

According to Dean et al, (2016) Citizen engagement in water related issues is vital for securing future water supplies and the Knowledge and understanding of community about water issues is considered a core ingredient of solving water-related problems. Knowledge is central to models of water-related engagement.

Engagement practices have particular value for the development of effective social innovations. In particular this report argues that some form of engagement will enable a better understanding of needs so that appropriate solutions can be developed. Participation practices can also introduce divergent thinking from unexpected sources which can help to uncover novel solutions to complex problems. And citizens can be the source of innovative ideas and if given the appropriate skills and tools co-innovators or innovators themselves also problem solvers (Davies, 2013) .

Public understanding of water management and water issues is basic to solving present and future water related problems. Unfortunately, most people are only vaguely aware of the role of water plays in their lives. Many of today's major issues focus on natural resources and the environment and indeed it would be difficult to find an issue that was not in some way related to water. It is also difficult to find a public that is well educated with respect to water. To many people including many those in decision making positions, simply do not understand where water supplies originate and the basic principles of wise water management and use, and as a result far reaching decisions spawned by ignorance, myths and politics have been implemented to the detriment of many. Examination of available literature reveals no reference to 'water literacy', let alone criteria for determining what a person needs to know to be totally 'water literate' (Daugs et al, 2009) .

Urban water has to date developed under a predominantly centralized model. The emerging emphasis on sustainable water management suggests that key areas of individual-level water knowledge include the urban water cycle and impacts of urbanization on water management (Marlow et al, 2013) .

While researchers have highlighted the pros and cons of limited versus extensive public engagement, the assumptions underlying various communication approaches have been largely neglected. Illuminating assumptions are important for scholarly understanding of what influences communication and for practitioner reflexive awareness in designing communication plans Initiatives that engage with communities are considered more effective when targeted and aligned with the communities' existing knowledge (Katarina et al, 2014) .

In addition, identifying strengths and weaknesses in community knowledge about water leakage provides an important foundation for initiatives that aim to increase knowledge. Different methods for controlling leakage from urban water supply systems have emerged, but it remains a challenge in developing countries, especially those with intermittent water supplies (Florian et al, 2019). Even though the leakage management programs didn't participate the community, it is important to gauge the level of knowledge of the community to take future initiatives.

2.5 Empirical related review

2.5.1 Water knowledge determinates

Despite the importance of assessing knowledge, most existing studies of water-related knowledge are confined to regions of the United States (Angela et al, 2016) .An early study, conducted well before the recent time, shows most respondents in a sample size of 1000 residents were unaware of water shortage and had poor understanding of terms describing water sources in California. In the past few years, considerable efforts have been done in the Central Valley in California to increase the awareness of water scarcity and water related knowledge. The effects of these efforts on saving residential water consumption, however, have not been systematically evaluated (Wang, 2017) .

A study conducted in USA indicates that there are individuals with little water knowledge and sophisticated water knowledge respectively, but the mass of respondents lie in between these extremes (Pritchett, 2009) .

Another survey whilst the argument for extending the constituency of consulters on water management is now widely accepted, further understanding is required of how the process of participatory planning and management can be best structured and facilitated. And it is indicated that less than half have knowledge on important features participative planning process and water management issues (Baggett et al, 2006). Similarly a survey, of South Carolina residents, reported that only 28% of respondents could identify the correct definition of a watershed (catchment) (KMC, 2010) .

Water management policies in Florida emphasize the need for public involvement in managing watersheds, yet little is known about the environmental literacy of key stakeholders. Most respondents had limited knowledge of the local water management (McDuff et al, 2008).

Less research has examined water knowledge in other contexts. Results from a survey study of 1495 people indicate that generally have very positive attitudes towards water conservation and water saving appliances however this positive attitudes are not consistently translated to actual behavior. The main barriers to adoption of water conservation behaviors identified in the study are: the perception of inconvenience and impracticality, as well as costs associated with purchasing water saving appliance (Association, 2010) .

Despite existing surveys reporting examples of poor water-related knowledge, little research has examined determinants of this knowledge. Understanding knowledge and its determinants can be guided by intelligence theories such as Cattel’s Investment Theory (Angela et al, 2016) .When you think of intelligence is more than simply the accumulation of facts. It also encompasses the ability to learn new things as well. When you think of intelligence, you might think of having a lot of knowledge about different subjects. But you also might consider quick thinking and the ability to reason. Such factors represent what psychologists Raymond Cattell refer to as fluid intelligence and crystallize intelligence. Fluid intelligence refers to the ability to reason and think flexibly. Crystallized intelligence refers to the accumulation of knowledge, facts and skills that are acquired through life. Within this framework, knowledge is not just influenced by educational achievement—and the factors that facilitate educational achievement—but also by diverse life experiences and personal interests that contribute to associative learning (Cherry, 2019).

It is found citizens knowledgeable about water related factors were most supportive of ocean and coastal protection; that somewhat malleable situational factors are important predictors of knowledge; and that some sources of information are more directly connected to knowledge than others. Public knowledge is a critical component of support for ocean and coastal management and that there are effective means of enhancing public knowledge (Brent et al, 2006) .

Adaptive management by definition requires the technical ongoing interaction with institutions and the public. Communication must flow in both directions, and scientists must be willing to prioritize their research with regard to critical management. Scientists have much to offer in the development of monitoring programs .Public outreach regarding natural resource management is critical to foster consensus among stakeholders and to minimize conflicts over resource use that threaten the long term sustainability of environmental resources (Christensen, 1996). A review of watershed management programs shows that public education and involvement are crucial to building sustainable systems and removing political gridlock (Lance Gunderson). Citizens involved in watershed management recognize their need for education and technical assistance to be successful in addressing watershed problems associated with the quality and quantity of surface and ground waters, as well as fish and wildlife habitat (Conway, 2003) .

According to a study held in north Florida on water shade management most respondents wanted to learn more about local ecology and preferred to obtain information about the local environment from television, newspapers, and direct mail. Consumptive users preferred to receive information from fish camps and sporting clubs, while non-consumptive users preferred to receive information from nature parks. On-site interpretive programming is needed throughout the basin, along with mass media outreach, to increase public knowledge of and support for sustainable watershed management. A range of life experiences or ‘situation-specific’ factors could influence water-related knowledge. These include: geographic experience, such as region of residence and experience Community Knowledge about Water Determinants and Impact of drought, or particular rainfall patterns; household context, such as homeownership or the presence of gardens; social experience such as participation in community groups, use of waterways or life satisfaction; and exposure to information Knowledge about catchments (Mallory, 2008).

There has been less research that examined the role of other types of life-experience in contributing to water-related knowledge. Some researches offers frameworks that links socioeconomic status such as life stress and in access of educational opportunities identified as having the potential to reduce resources available for knowledge acquisition(Von A, 2011).Social capital measured by involvement in community organizations, is positively associated with community support for informal learning. This association is mediated greater by water related social norms, water related knowledge, and information recall. The path ways between community involvement and policy support are not consistently observed in all social groups. The mediation pathways were weaker in urban settings and in those who spoke a language other than primary language (Angela et al, 2016) .

There has been limited research, however, examining whether factors such as these influence individual water-leakage knowledge. Other social factors that may influence knowledge, as suggested by health literacy research, include poorer reading skills, being an immigrant. In this context has received increased attention as it address citizens motivation and ability to gain access to, understand and use information effectively to alleviate water leakage problems (Anne et al, 2014). In the current research, it is aimed to examine how these elements of life experience contribute to water leakage management practice.

2.5.2 Water leakage management practice

Water leakage management practice has been done by AAWSA during the years 1995 and 1997. During the study, a minimum night flow monitoring was used to identify the loss .according to the draft report; an average $2m^3$/km/hr loss thought leakage was registered before maintained through the crash program during the same period. Thus a reference linear leakage index of 0.5 m^3/hr/km was set in order to take action accordingly.

While this leakage index is compared with the result of the total loss per kilometer length of the present study (1.91 m^3/km/hr), the present loss is found nearly equal to the figure before the crash program. This shows us that although much works might have been done during the crash program, the loss becomes nearly the same as before that of the crash program.

Assuming the same pressure regime prevails in the entire city, and annual net water leakage at city level being 29,717,692.04 m^3. From point of view of operational leakage control at city level, AAWSSA could possibly reduce real loss to 6,269,555.28 m^3/yr, provided it is economically justified with respect to the marginal cost of supply of the same volume of water.
It means that overall 23,448,136.76 m3 of the leaking water could have been saved annually
if appropriate leakage control measures were implemented; which is equivalent to 78.90% of the current leakage in the existing system; or 28.19% of the total annual water supply to the city. Thus, AAWSA shall strive for 28.19% reduction target in its strategy in the long run, even, without changing the current pressure regime (Gamtessa, 2008) .

2.6 Conceptual framework

There is less research examining the social determinants of water leakage management knowledge. The current study addresses this gap by surveying a district metered area, urban household representative sample that resides in Addis Ababa Bole sub city around water works enterprise and gauging community knowledge about water leakage management.

Knowledge and understanding of water issues in the community is considered a core ingredient of solving water-related problems. It has been argued that greater knowledge allows community members to contribute to innovation and problem solving. The concept of 'water literacy', and other forms of literacy integrate topic knowledge and the capacity to apply this knowledge to decisions. The emerging emphasis on sustainable water management suggests that key areas of individual-level water knowledge may impact the water knowledge development (Angela et al, 2016) .

There are three reasons why knowledge's influence on ecological behavior is underestimated systematically. First b it is not the mere amount of knowledge available that determines behavior. Second knowledge's effect remains undetected also, because some statistical procedures neither correct for measurement error attenuation nor uncover mediated influence accurately. Third, psychological factors such as knowledge apparently have limited influence on ecological behavior when strong situational constraints are effective (kaise, 2003) .

Factors that may influence pro-environmental behavior, social context, psychological factors such as environmental identity and values (Linda et al, 2014) , and water prices socio demographic characteristics on households decision making in water conservation (Dupont & Renzetti, 2013). There is a research that examines important associations between environmental values, knowledge, concern, and attitudes about water conservation policies (Marko et al, 2014). This study extend the water leakage management by gauging communities knowledge about water leakage by considering the above mentioned determinates.

Water-related knowledge was assessed using 5 items about influence of household activities on water leakage management practice. In (Fig 2-2)the items were adapted from a previous study , which included items based on what Australian water professionals identified as important for individuals to know about water (Angela et al, 2016) .

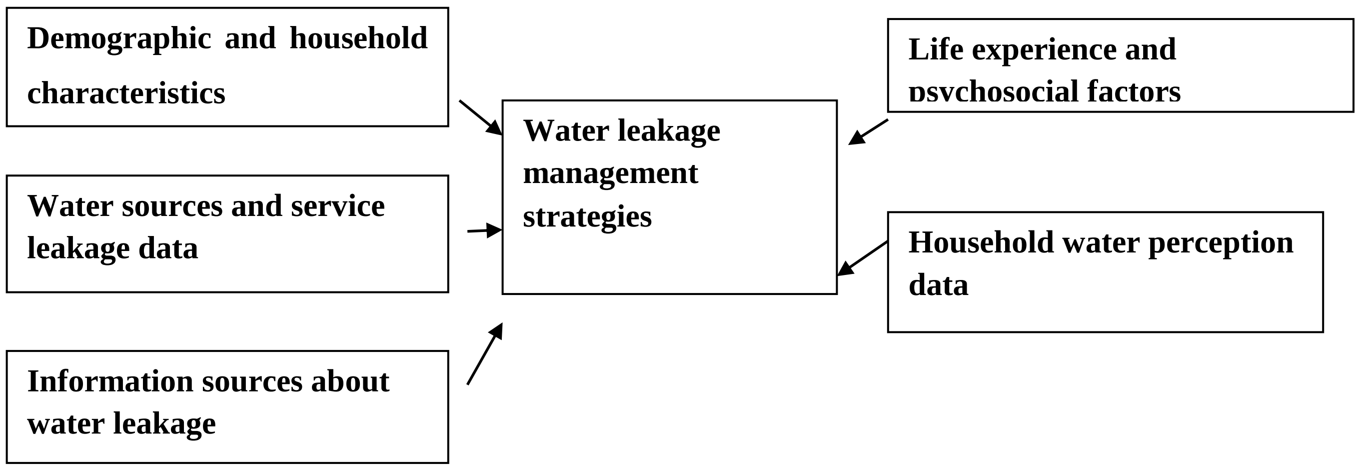

Figure 2-2: Conceptual framework for a successful water leakage management strategy (Angela et al, 2016) and own source

CHAPTER THREE

3 METHODS AND MATERIALS

This chapter includes the methodology used in this research work and provides information about the study area, the research design, study population, sampling techniques, research instrument, data collection, reliability and validity test, and method of data analysis. This gives justification in the choice of methods used to achieve the objective of the study.

3.1 Selection of Sample Study Areas

Availability of data was the major factor considered during selection of the sample study Area. The sample study areas information required for this study was available from AAWSA .The Addis Ababa Water and Sewerage Authority (AAWSA) is a public institution in the city, which is responsible for the supply of potable water and had a department that responsible for water leakage management. The Authority currently has eight branch offices and a head office at Megenagna. The branch offices are Gurd Shola, Megenagna, Arada, Gulele, Addis Ketema, NifasSilk, Mekanisa, and Akaki branch (AAWSA, 2017) .

3.2 Description of the study area

Addis Ababa is the Capital city of Ethiopia, and it is located at about 8 ^{o} 0' 7" northern latitude and 38 ^{o} 0' 45" eastern longitudes. The city is situated at the lower slopes of the Entoto Mountain having significant elevation differences within its perimeter ranging from 2080m at the north to 2090m in the southern areas. The total population of the city is 3,384,569 according to the 2007 population census, while the total area of the city is 540 square kilometres. At present the city is divided in to 10 sub-cities containing 116 woredas.

The study area that is the district metered area is located in bole sub-city around water works enterprise woreda 17 kebele 24. The area under study is dominated by domestic users with most users below 18.63m^3/month .Most of the pipes of the areas are old and they are susceptible to high leakage.

The study area topography has flat slope on the pilot area .There are a total of 500 customers in DMA pilot area. The study area water distribution system is 24 hours/day.

Water consuming structures (unbilled unmetered users) such as public fountains, fire hydrants, green areas, and large water towers are not located in the study area. The presence of the above structures has its own influence on the study of water loss because they do not have meter.

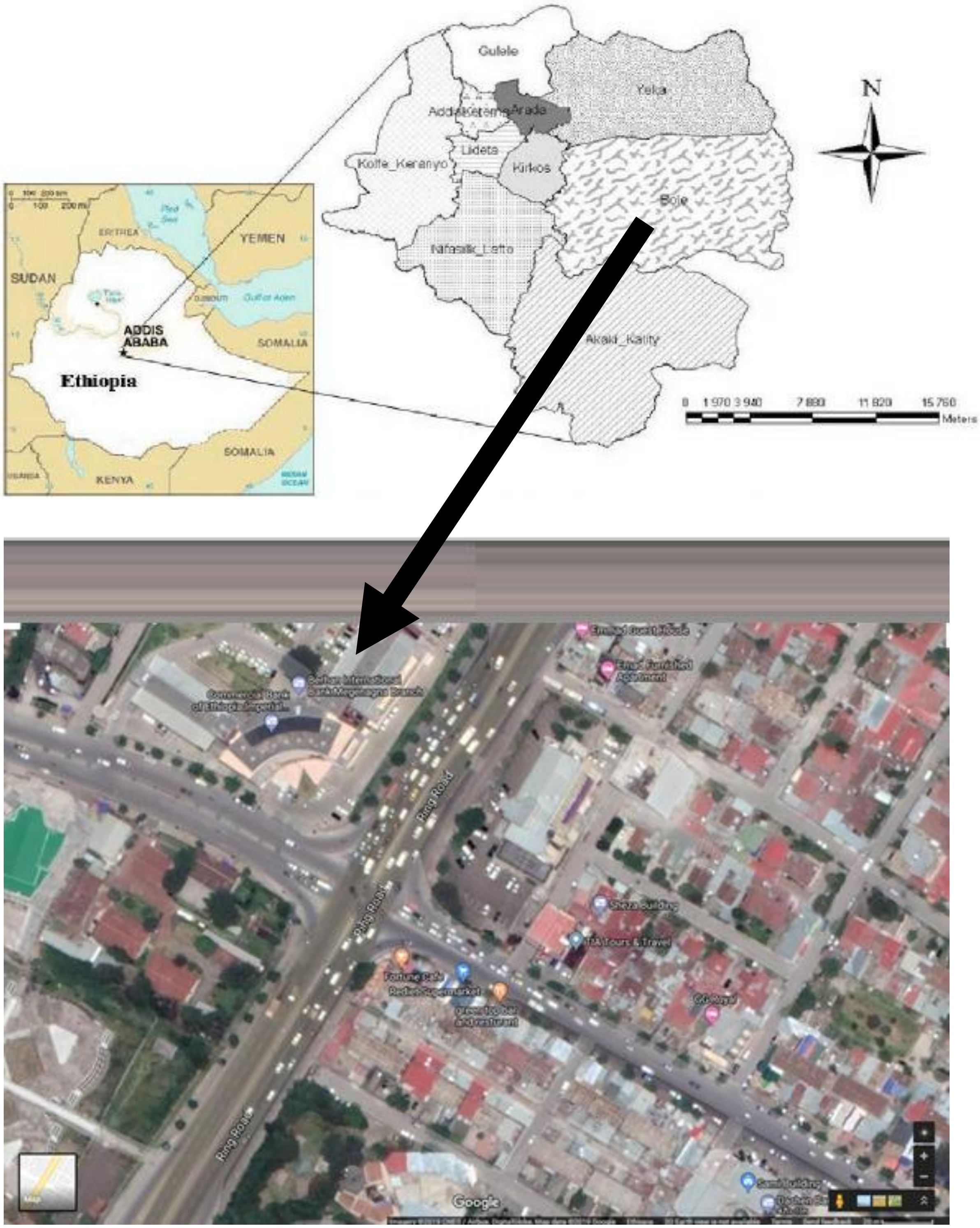

Figure 3-1: Map of the study area (water works enterprise)

3.3 Study Design

The concept of DMA, originated in early 1980s when Malcolm Farley proposed dividing an open system into smaller and more manageable metered areas or leak detection areas called district meter areas (DMAs), is an internationally accepted and well-established technique to manage losses and determine where leaks occur. There are district metered areas that AAWSA bounds to do water leakage management at time intervals. Accordingly there is a district metered area around water works enterprise and named water works enterprise DMA where water leakage analysis is conducted. . The households which existed with in this district metered area are the population to study. Questionnaires are distributed to the households to evaluate their understanding on water leakage management. The AAWSA of Megenagna branch is responsible to do water leakage management in this DMA. The District metered areas leakage management Site measurement data's are collected from site with the AAWSA experts.

The paper attempt to summarize the stakeholder's knowledge about the water leakage management and the water leakage management practices from a practical application outputs respectively.

In order to investigate the water leakage management knowledge of the population, descriptive research design is applied; for the purpose of data collection the researcher used structured questionnaire. Sample is also selected from the population by statistical techniques to infer for the population. To reduce the response error supervision was done by the researcher. And moreover, before the data was analyzed appropriate data editing activities have been carried out.
Such kind of research design is used because the researcher has no control over the variables, only a report of what has happened in the area where the research is conducted is taken. According to Kothari , the major purpose of descriptive research is to describe the state of affairs as it exists at present.

Furthermore, based on the time setting, the study has used cross sectional study design. Thus, the survey method gathers data from a relatively large number of cases at a particular time.

All in all, in order to achieve the objective of this research a descriptive type of research followed by cross sectional studies was used. Accordingly, this study is concerned to invest the water leakage management knowledge of the stakeholders and AAWSA‘s water leakage management strategies. Under the study, the existing knowledge of the communities about water related knowledge of Addis Ababa bole sub city was assessed.

In order to achieve the objectives of this study and thereby give answers for the basic research questions, both qualitative and quantitative research approach, i.e., mixed research approach was used. For analyzing the data gathered from questionnaire, the researcher used quantitative approach.

This method is selected to find out facts about a concept, question or an attribute and also to collect factual evidence and study the relationship between the facts. However, for the data gathered from interviews, and document analysis, the researcher used qualitative approach. It is selected to emphasize meanings, experiences, opinions, views, Perceptions and attitudes towards the objects.

3.4 Study population

3.4.1 Households

The study populations were the households which are found in zoned water works enterprise DMA boundary by AAWSA of Megenagna branch of bole sub city. According to the AAWSA data there are domestic users (Households selected for the study purpose) in this district metered area.

3.4.2 System

In addition the summary of the required actions for DMA boundary isolation is done by AAWSA as follows:

1. Testing of existing boundary and inlet valves.
2. Installation of new isolation valves at boundaries.

3. Confirmation of inlet connectivity

4. Installation of new isolation valves at inlets.

5. Installation of pressure measurement points.

According to AAWSA the customers around the water works enterprise district area are about 500(five hundred). Therefore, the target populations of this study are 500 customers of AAWSA.

3.5 Sample size and Sampling techniques

3.5.1 Sampling techniques

To select the required sample size, the researcher used both purposive and simple random sampling techniques. From the homogeneous list of households, samples were selected randomly. From them, the researcher took unites of the study.

Sampling is the process of selecting representative units of a household for the study in research investigation. The advantage of using a sample is that it is more practical and less costly than collecting data from the households in general. The sampling technique used is non-probabilistic, purposive sampling and probabilistic, random sampling techniques. The study area selected purposively around water works enterprise that have lines susceptible to high leakage while the customers in the selected district metered areas were selected as a sample for this study purpose by simple random sampling technique.

3.5.2 Sample size determination

In order to select the appropriate sample size, the researcher used the formula used by Yamane, (1967) with sample size determination system with the consideration of 95% confidence interval as presented below. The researcher selects this sample size determination method because it is one of the best methods in determining the sample size in probability sampling method

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

Where n = sample size

N = Total customers in the study area

e = Degree of precision = 9%

$n = \frac{500}{1+500(0.09^2)}$=99

Therefore, 99 sample of customer out of the total population by simple random sampling technique were selected.

Physical loss calculation

For calculating the physical loss of system the following formula is used.

Physical loss for reading 1and 2= $\frac{\{\sum \text{System input} - \sum(\text{ customer billed water} + \text{out flow})\}}{\sum \text{System input}}$

3.6 Source of Data

The study depended on both primary and secondary data. Primary data was made up of data collected by the candidate through the use of questionnaires, interviews and field observation. The secondary sources of data were obtained using AAWSA reports, relevant books, journals, magazines, and research papers

3.7 Research instrument

Multiple approaches were used for data collection. These are survey questionnaire, interview and field observation taking the site on which district metered area leakage management is applied.

3.7.1 Primary data collection

3.7.1.1 Questionnaire

Semi structured type of Questionnaire was selected as the research instrument owing to its suitability to the level of information required, cost and time limitations and the high number of respondents.

The semi structured questionnaire form, which was attended by a covering letter, consisted six parts. The first part sought Demographic and household characteristics information about the respondents profile and the second part assesses the Water sources and service leakage data .in the third part, participants were asked to tell if there are Information sources about water leakage. The fourth part the respondents requested to explain their Life experience and psychosocial factors when there is shortage of water. The fifth part the respondents requested to know about the Household water perception data. On the sixth part the respondents requested if they have understanding to take Measures of water-related behaviors and policy support.

3.7.1.2 Interview

The interviewees incorporate officials of AAWSA expert's. It is a face-to-face communication between interviewee and interviewer on certain area of inquiry, and thereby allows the interviewee to speak up freely and more data that are empirical might be directly obtained. Thus, using interview was important in order to support or strengthen the data gathered from the questionnaires. This data collection tool was also employing to gather detail information about the issue at hand from interviewee. This technique uses to find the problems on the management of water supply line leakage and to assess how much the problem is serious. Because of all the parties or concerned bodies might not be available samples interviewed will be selected using purposive sampling method. Apart from use of questionnaires, a key informant interview was conducted.

3.7.1.3 Field observation

This is done with AWWSA experts in the water works and enterprise DMA. The process of the experiment and output is recorded in the given time interval.

3.7.2 Secondary data

The documents were used to clarify information gained from interviews and questionnaires and to corroborate researcher's understanding of water leakages knowledge with regard to water leakage management strategies. The researcher conducted field observation with water leakage management experts of AAWSA within the water works enterprise. During the field survey the process and output of the experiment data were collected.

Most of literatures relating to this research topic are accessed from AAWSA documents and from other documents. For literature review; standards, journals, books, teaching slides and scientific magazines that are directly or indirectly related to this research topic a collected, referred and analyzed.

3.8 Data collection

The researcher adopted a three step data collection procedure. First, relevant literature was reviewed to get adequate information on the topic. Second, objectives and research questions were formulated to show the direction of the study. Third, data gathering tools were developed and a pilot test was conducted.

In addition, structured interviews were conducted and questionnaires were distributed by the researcher and by three data collectors so as to lead us to the desired point of information and to save time in line with the research design. Before the process of data collection began, the researcher gave training for the data collectors for one day. The development of the questionnaires involved the following steps: compiling a list of topics to be covered in the survey; and preparing a first and revised draft of the structured questions and the response formats.

The questionnaires were designed to gather both quantitative and qualitative data. After the data was collected using interviews; it was checked for its consistency and completeness before the final analysis was made.

3.9 Reliability and validity

Due attention was given to minimize the chance of getting higher errors. Hence, reliability and validity tests, which help to detect the presence or absence of those errors, have been carried out. To that end, the researcher has conducted pilot tests on 10 respondents after drafting the questionnaire to meet all the reliability and validity standards.

3.9.1 Validity Test

According to Kothari, (2004) validity refers to the extent to which the instrument measures what the researcher(s) actually wish to measure. Validity is the most critical criterion that indicates the degree to which an instrument measures what it is supposed to measure.

In order to ensure the quality of this research, content validity of the instruments of the research was checked. The content validity was verified by the advisor, who looked into the appropriateness of the questions and the scales of measurement. Peer discussion with other researchers was also conducted since it is another way of checking the appropriateness of the questions. Moreover, copies of the questionnaire were distributed to ten respondents as a pilot test. This was done to decide whether the developed instruments measure what it was meant to measure and also to check the clarity, length, structure and wording of the questions. This test has helped the researcher to get valuable feedbacks to modify some questions.

3.9.2 Reliability Test

Reliability is concerned with whether the procedures of data collection and analysis will generate the same results on all occasions and whether others can also make similar observations and arrive at the same conclusions from the same given raw data. In other words, it is an attribute in which data collection procedures can be repeated with the same results. According to Kothari, measuring instrument is reliable if it provides consistent results.

Moreover, in order to measure the consistency of the questionnaire a reliability test was carried out based on Cronbach‟s Alpha coefficient. Cronbach‟s Alpha can be interpreted as like a correlation coefficient. Its coefficient range lay on the value from 0 to 1. A reliability coefficient (alpha) higher than or equal to 0.7 is considered acceptable. That means, the formulated questions in the questionnaire are capable to meet the objective of the study. Therefore, the reliability test conducted by the researcher has proved that all the items or attributes of the pilot questionnaire has been reliable since the results of the test were higher than 0.7

3.10 Analysis of data

The collected data through questionnaire survey was analyzed using SPSS version 21.Excel spreadsheets were also used to tabulate different measurements of descriptive analysis. It was performed to give the detail description water leakage management knowledge of the community.

Descriptive explanations were also employed in making the analysis more meaningful. In other way direction, descriptive statistic such as mean, percentages and frequency distributions, were prepared before a deeper analysis of data. The questionnaires are given numbers for identification purpose. Each question is identified by a variable name and within variables there are values and values labels for identification of the respondent's responses. After coding the information from the questionnaire template for entering data in computer program was created .the data was interred in the SPSS computer program that was used in the analysis part of the study.

3.11 Ethical consideration

Ethical issues play a determinant role during data collection. Cognizant of this fact, the researcher has given due attention and implemented serious steps to meet the ethical considerations related to the study. In line with this, the first page of the questionnaires has included an introductory opening letter that requests cooperation from respondents and to provide the appropriate response for the study. They were given assurance that the information they provide would be kept confidential. When data collections were made from study participants, all potential participants of the study were informed about the procedure that will be used in the study; the researcher explained the objectives and significance of the study to the respondents. To ensure this, the researcher has removed information that relates to the respondents identity. Throughout data collection and any other activities that were related to the research, the researcher maintained positive relationship with the respondents.

Ethical clearance was obtained from Addis Ababa university college of Development studies. Permission was obtained from Addis Ababa Water and Sewerage Authority (Megenagna branch). Before starting the interview, oral informed consent was obtained from each respondent. Respondents were assured that individual information will be kept confidential.

CHAPTER FOUR

4 RESULTS AND DISCUSSION

4.1 Introduction

In this section, the study provided descriptive information on individual respondents and the Know how they have on water leakage and how it was incorporated with the community. Specifically, this section provides a breakdown on household's demographic condition, understanding of water leakage management practices, and the existing water leakage management strategy. This information was necessary to confirm the validity of the results obtained and to develop an understanding of the background of respondents and the understanding they have in water leakage management. Second the water leakage management field experiment that was done with AAWSA experts its process and outputs are analyzed.

4.2 Field measurement

Water works enterprise DMA

There are a total of 500customers in DMA pilot area. Source of exiting water supply condition is from Legedadi reservoir surface water. The study area water distribution system is 24 hours/day.

Water consuming structures (unbilled unmetered users) such as public fountains, fire hydrants, green areas, and large water towers are not located in the study area. The presence of the above structures has its own influence on the study of water loss because they do not have meter.

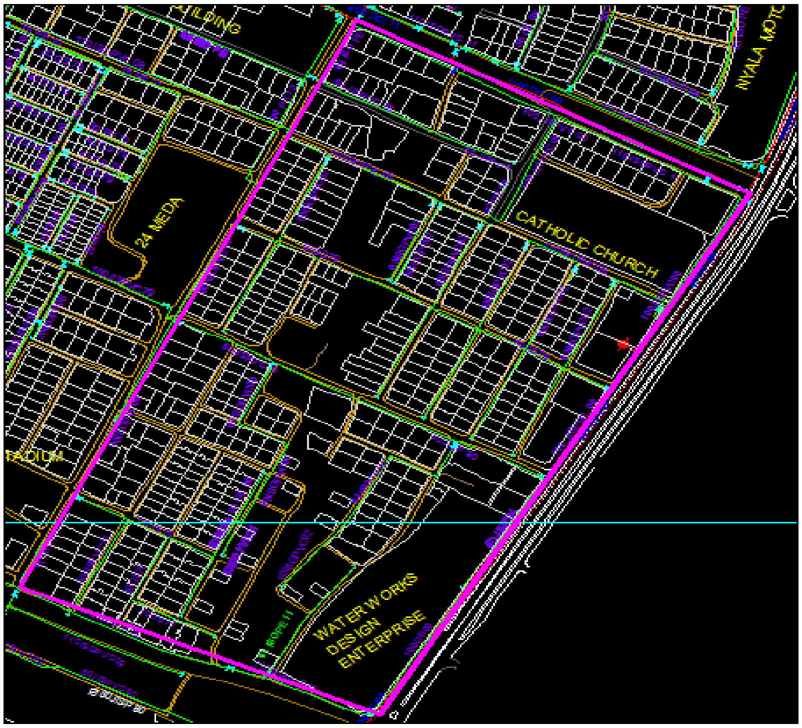

Figure 4-1 Water Works Design Enterprise

4.2.1 Data analysis and processing

4.2.1.1 DMA Pressure management

Pressure management is the simplest and most economical way of reducing a water network's real water losses. Pressure management proposals in the pilot DMAs made according to the results of the detailed DMA hydraulic models that are being developed in parallel as part of the project. The simulations for determining the need of Pressure Management at Pilot DMA network took place after the detailed for pressure measurement at DMA. The calibration metrology began as soon as the necessary flow and pressure acquired from field measurements. A prerequisite for the respective field survey conduct is the construction of the necessary works at the DMA inlets. The detailed network of the system pressure allows the pressure management to conduct, then a Pressure Reducing Valve installed in the DMA inlet access chamber. The benefit of real losses rate reduction because of pressure management is directly measurable by the Minimum Night Flow Analysis.

4.2.1.2 Customer metering inaccuracies and data handling errors.

The extent of customer meters inaccuracies, namely under or over registration, established based on tests of a representative sample of meters. The composition of the sample reflects the various brands and age groups of domestic meters. Based on the results of the accuracy tests, average meter inaccuracy values (as 336 m3 of metered consumption) is established for different user groups. Data handling errors are sometimes a very substantial component of apparent losses. Meter errors may be caused due to:

- Improper installation
- Low water quality (debris)
- Intermittent (discontinuous) water supply may cause formation of air
- Improper meter sizes (large meter sizes may not register smaller flows)
- Inappropriate class and type of meter

4.2.1.3 Active leakage control survey

As soon as the Minimum Night Flow Analysis has provided data on real water losses in the pilot DMAs, the conduct of Active Leakage Control Survey by the respective Case Team commence provided the following DMA preparation actions have been completed: Exposing all covered valves of the DMA water network and installation of valve cover assemblies. Updating of DMA network maps as to include common line information and exact valve location. The water network valves is the primary access points for the sounding equipment that is used by the Locate and Localizing Crews of the Active Leakage Control Case Team. Localizer indicates that the identified leak noise is not coming from the primary or the secondary network of the DMA. Data handling active leaks the DMA when we read door to door we get number of leaks is 20 corresponding losses is $84.7375m^3$ respectively.

Table 4-1 Active leakage control at water works design enterprise DMA (survey data 2010 E.C)

no	In (mm)	Meter	Q (m^3/hr)	Hr	no leaks	Volume (m^3)
1	20	0.02	1.5	2.4	13	46.8
2	25	0.025	2.5	1.235	5	15.4375
3	32	0.32	5	2.25	2	22.5
	Total				20	84.7375

Data analysis of the study starts with filling and correction of the customer meter readings. The readings are filled considering average monthly values of the respective meter from Water Meter Reading & Billing Sale Case Team. Since the study reading is taken two weeks interval the value found is divided by two.

Table 4-2 Water Balance at Water Works Design Enterprise (DMA)

input water ,billed and out flow	reading	Date	volume in meter cubic	d/c in volume in meter cubic	leakage in percent
input water of water works enterprise	reading1	12/2/2019	906705	11481	29.52%
	reading2	26/2/2019	918186		
	reading3	10/3/2019	926018	13541	water saved=13.35%
	reading4	8/4/2019	936328		
total billed water that consumed by the customer	reading 1	12/2/2019	1627619	8092	
	reading2	26/2/2019	1635180		
	reading3	10/3/2019	1275370	11351	16.17%
	reading4	8/4/2019	1288708		

For reading 1 and 2 Loss water $=\{\sum \text{System input} - \sum(\text{ customer billed water} + \text{out flow})\}$

- NRW= 11481–(8092)

  =3389m3

- % of Water loss = (loss water/ aver input source)*100

  = (3389/11481)*100

  =29.5173

  =29.52%

For reading three and four Loss water $= \{\sum \text{System input} - \sum(\text{ customer billed water} + \text{out flow})\}$

NRW = 13541-(11351)

=2190m3

% of Water loss = (loss water/ aver input source)*100

= (2190/13541)*100

=0.1617

% of water loss = 16.17%

Physical loss for reading 1and 2= $\frac{\{\sum \text{System input} - \sum(\text{ customer billed water} + \text{out flow})\}}{\sum \text{System input}}$

Physical loss for first and second reading=(3389/11481)*100=29.52%

Commercial loss for first and second reading=total loss-physical loss=29.52%-29.52%=0.0=0%

Physical loss for reading 3and4 = $\frac{\{\sum \text{System input} - \sum(\text{ customer billed water} + \text{out flow})\}}{\sum \text{System input}}$

Physical loss for third and fourth reading 2= Average system input – (Average customer metering inaccuracies+ Average customer billed water)/ aver input source

Physical loss for third and fourth reading = (13541-(11351+59))/13541*100=15.74%

Commercial loss for three and four reading=total loss-physical loss=16.17-15.74=0.0076=0.43%

In the DMA of water works (pilot area) the amount of total loss before maintenance are, 29.52% and the amount of total loss after maintenance are 16.17% respectively. This implies that in the study area there is leakage in the water line. The household's knowledge on water leakage in the study area was assessed as follows.

4.3 Demographic and household characteristics

4.2.1. *Response Error*

A total of 99 (100.0%) questionnaires have been distributed. Accordingly, 95 (96.0%) of the total respondents gave appropriate response for the given inquires. But, the remaining questionnaires have been found to be incomplete and insufficient for the analysis. Therefore in general around 4.0 % non-response error was considered.

Out of total respondents85 (89.5%) are house owners and 10(10.5%) lives in rented house. In this study area it is indicated the higher number of houses is occupied by the owners. This shows the higher number of owners helps to answer the study questions since being at this position have the chance to know more about their houses water related information than that of rented.

Table 4-3 Dwelling type of bole sub city around water works enterprise (survey data 2010 E.C)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Owned	85	89.5	89.5	89.5
	Rented	10	10.5	10.5	100.0
	Total	95	100.0	100.0	

As indicated in the table below 75(78.9%) of respondents are male while 20(21.1%) of the are female. This shows that the numbers of male respondents are much more than number of female respondents.

Table 4-4 Gender (survey data 2010 E.C)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	75	78.9	78.9	78.9
	Female	20	21.1	21.1	100.0
	Total	95	100.0	100.0	

According to marital status of household survey there were respondents who married, single, divorced, widowed, and separated. Out of the respondents of the survey 12(12.6%) were single, 71(74.7%) were married, 2(2.1%) were divorced, 6(6.3%) were widowed, 4(4.2 %) were separated. This shows that the majority of the respondents are married. Married respondents had good involvement up on community like participation in water related knowledge. This is because their water consumption and need is very high due to family size and ordered life but the singe, divorced, and separated respondents do not give much attention for water leakage management practice since their need is very low as well as consumption.

Table 4-5 Marital Status (survey data 2010 E.C)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Single	12	12.6	12.6	12.6
	Married	71	74.7	74.7	87.4
	Divorced	2	2.1	2.1	89.5
	Widowed	6	6.3	6.3	95.8
	Separated	4	4.2	4.2	100.0
	Total	95	100.0	100.0	

Water leakage management is very crucial for those who had great number of family size. The survey results shows that 19(20%) of the respondents are below 7 family size, 31(32.6%) of the respondents have 7-10 family size, 45(47.4%) of the respondents are above 10 family size. The survey result show almost higher number of respondent's family size is very high. It affects their daily income and the daily water consumption being high contributed for high water leakage.

Table 4-6 Family Size of the respondents in the study area (survey data 2010 E.C)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	below 7	19	20.0	20.0	20.0
	7-10	31	32.6	32.6	52.6
	above 10	45	47.4	47.4	100.0
	Total	95	100.0	100.0	

Education plays a significance role for water related knowledge and leakage management. 10(10.5%) of the respondents were illiterate, 5(5.3%) of the respondents can only read and write, 5(5.3%) of the respondents were 1-8 grade, 13(13.7%) of the respondents were preparatory (10+1-10+2), 62(65.3%) of the respondents were above grade (10+2). There for who learned more had good approach in management of water leakage management since they are more near to new technologies and practices from information gathered. See table below

Table 4-7 Education level (survey data 2010 E.C)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Illiterate	10	10.5	10.5	10.5
	Read and write	5	5.3	5.3	15.8
	Primary (1-8grade)	5	5.3	5.3	21.1
	preparatory (10+1-10+2)	13	13.7	13.7	34.7
	Above 10+2	62	65.3	65.3	100.0
	Total	95	100.0	100.0	

The work type of the respondents affects the income of the households. According to the survey result 31(32.6%) of the respondents were self-employed, 25(26.3%) of the respondents were government employees, 21(22.2%) of the respondents were NGO employees, 14(14.7%) of the respondents were private firm employees, 4(4.2%) of the respondents depend on other type of work for living including by house renting. There for, these result shows higher numbers of respondents were self-employed they have enough income and they can contribute to household water leakage management practice.

Table 4-8 work type (survey data 2010 E.C)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Self employed	31	32.6	32.6	32.6
	Government	25	26.3	26.3	58.9
	NGOs	21	22.1	22.1	81.1
	Employee of private firm	14	14.7	14.7	95.8
	Other	4	4.2	4.2	100.0
	Total	95	100.0	100.0	

Table 4-9 Monthly income (survey data 2010 E.C)

Monthly income of the respondent (Birr)	Frequency	Percent
500-1500	4	4.21
1501-2500	12	12.63
2501-3500	32	33.68
3501-5000	37	38.95
Above 5000	10	10.53
Total	95	100

4.4 Water knowledge assessment of the community

4.4.1 Water sources and service leakage data

Exiting water supply source situation is very important to understand or know the major problems of the urban water supply scenario in the study area. The survey result in the study area shows that majority of the respondents are using indoor tap water. The result of the respondents shows that 83(87.4%) of the respondents use indoor tap water, 12(12.6%) of the respondents used outdoor water tap because of different reasons.

The major water using appliance that existed in the household were tried to be address in this study .about 41 (43.2%) use shower, about 26(27.4%)use bath tub, about 6(6.3%) use flushing toilet, about 19(20%) use washing machine , about 3(3.2%) use dish washer. This indicates shower and bath tub are the major water using appliances. The respondents also asked if the appliances are safe from leakage. About 13 (13.7%) of the respondents strongly agree on the above argument, 25(26.3%) of the respondents agree if the appliances are safe from leakage, 41(43.2%) of the respondents strongly disagree if the appliances are safe from leakage, 16(16.8%) of the respondents said they do not know if safe from leakage. This implies that the majority of respondents disagree if the appliances are safe from leakage. Deterioration of this appliances and lines is the main factor for leakage and its frequency in the household. On the other hand, there are respondents who do not even consider the existence of leakage on their appliances.

The bathing frequency of the respondents is summarized as follows. Respondents who take a bath once a day are 12(12.6%), who take a bath within two days are 21(22.1%), who take a bath in three days are 36(37.9%), and within a week are 17 (17.9%). This shows the majority of the respondents take a bath frequently. When the frequency for bathing increase there might be increasing of leakage in appliances that does exist without the knowledge of the respondent.

Regarding the color of water, 22 (23.2%) respondents convinced that It was excellent while, 53 (55.8%) study participants said the color of water is very good, 16 (16.8%) of the respondents informed that the color of water is good,4 (4.2%) respondents argued on the color of the water. Prasad and Danso-Amoako (2014) analyzed six-years of water quality data from 176 DMAs from a United Kingdom water company covering 36 water quality parameters and customer complaints in order to detect parameters that most influence iron and manganese accumulation.

A comparative assessment of the water quality prior to community knowledge and DMAs installation overview was not an objective of this study; however these results show the existence of water quality issues on color of water has effect. Discoloration problems are common in DMAs; DMAs with high populations have a high propensity to present more customer complaints if it is identified.

Pressure of water is other item which considered in this section. About 15 (15.8%) of respondents responded the water supply pressure is excellent, while, 10(10.5%) of the respondents said it is very good and 22(23.2%) of the respondents said good, the majority of the respondents 47(49.5%) confirms the pressure is good. 1(1.1%) argues on the pressure of water supply as poor and very bad.

To evaluate the taste of the water 12 (12.6.3%) of the respondents acknowledged that it was excellent, likewise 27 (28.4%) of the participants said very good. But, majority of respondents, 55 (57.9.3%) said the taste of water is good, 1(1.1%) of the respondents said it is poor.

Other issues can be identified by consumers and be a cause of customer complaints such as poor taste impacting user trust in the water utility services ((USEPA), 2002) .

One indicator of leakage existence is if the color of water changed when there is broken pipes different dusts will get in through the pipes and this discolor the water. The respondent requested if they see brown water running out from their tap.13 (13.7%) respondents response yes they experience brown water running out, 30 (31.6%) respondents don't not see brown water running out from their tap, while 52 (54.7%) respondents responded they do not know if they experience brown water. Most respondents do not know the cause but those who experienced reported to the concerned body.

Participants asked if the water meter read regularly .83(87.4%) responded the water meter read in a regular pattern while 12(12.6%) said they do not give emphasis on the pattern of the water meter read.

Pipe age is one of the factors that affect the magnitude of losses especially that of physical losses .Aged pipes are more likely having more water loss through leakage than newly installed pipes. The participants were asked when their water supply lines was installed.

Table 4-10 age of pipe (survey data 2010 E.C)

When was your water line installed	Frequency	Percent
15-20 years ago	5	5.26
21-25 years ago	24	25.26
26-30 years ago	40	42.11
before 30 years	16	16.84
Do not know	10	10.53
Total	95	100.00

According to the table most of the pipes are aged more than 20 years. This shows that the line are more susceptible to high leakage.

The respondents requested to answer if they have timely maintenance whenever it is need and about 53(55.8%) responded they have timely maintenance whenever they need while 42(44.2%) said they don't get maintenance when they need. This shows there is a gap in maintaining the line because the community might not informed the concerned body timely or don't get response quickly as a results leaking water might not be saved timely and appropriately.

A participant asked during what times of the day is there no water or water pressure low assuming some degree of regularity. about 53.28(56%) of the respondent said that during all days of the week from time 7-12am there is no water or low pressure.

Table 4-11 water consumption (survey data 2010 E.C)

Monthly water consumption (m3)	Frequency	Percent
below 1.5	12	12.63
1.6-3.5	29	30.53
3.6-5	40	42.11
above 5	14	14.74
Total	95	100.00

From The amount of monthly water consumption about 12(12.63%) of the household use below 1.5m3 water per month, 29(30.53%) use 1.6 up to 3.5 m3 of water, 40(42.11%) responded that they use 3.6-5 m3 of water per month, while 14(14.74%) use above 5m3 per month. This shows most of the respondents use more than 3.5 m3 of water per month that is high consumption.

4.4.2 Information sources about water leakage

Many of the respondents do not give enough attention for water leakage. They didn't hear or see about leakage in recent times, didn't receive any trainings from AAWSA and don't know how much percent of water leaks from the line. Community participation in water leakage management has a considerable impact unless due attention is given like any other subjects. As per the feedback from the respondents to check their knowhow on the subject matter there is a gap between the problem and the community.

Certain information sources–newsletters from water utilities, water utility bills, and social media should associated with greater water leakage knowledge. This highlights the potential for information to enhance water leakage knowledge, and ultimately, water literacy. The potential for information provided by water utilities to build knowledge may be limited to experts. Additional channels need to be identified to reach the community. Different information platforms may vary in their capacity to build knowledge. The findings of the study indicate that exposure to water-related information via television or radio was not related to greater water-leakage knowledge. It is possible that active dissemination of information (via newsletters) may be more effective in building knowledge than the use of passive media such as radio or television. A number of studies report that exposure to television was not associated with knowledge, even after controlling for cognitive ability. Although sharing information via mass media may represent an appealing and highly-accessed media source, mass media such as television may not provide information of adequate quality, frequency or contextual relevance necessary to build broad-based knowledge.

4.4.3 Life experience and psychosocial factors

In the Life experience and psychosocial factors78 (82.1%) of the respondent experience restriction because of water shortage, while 17(17.9%) do not. In line with this it was asked if they change behavior in response to restriction and who said yes were also asked to explain how they changed their behavior. 16(16.9%) fetch from distance places, 78(82.1%) limit their usage 1(1.1%) reduce their consumption.

Likewise participants were requested if they are satisfied in different areas of their home water supply. 39(41.1%) of the respondents are satisfied with the bathroom water supply, 56(58.9%) of the respondents are not satisfied with the bathroom water supply. In the kitchen water supply assessment 70(73.7%) are satisfied while 25(26.3%) are not satisfied with the water supply of kitchen. 34(35.8%) are satisfied 61(64.2%) are unsatisfied in launder . this indicated most of the respondents in their bathroom or launder are not satisfied with the water supply since it consumes more water and might have implication that is related with many ignored leakages .

Rahmato (1999) indicated that the formation of civil groups in the water sector is a new phenomenon in Ethiopia, which is hoped to fill the gap left due to the institutional instability in the water sector. These societies are already gathering large pools of membership with diverse expertise and experience. Increased public participation in the water sector will greatly help expand the knowledge about the water sector and will serve as a public watchdog on governmental and business handling of the country's water resources (Rahmato, 1999).

Community participation is vital in management of water related knowledge. the respondents asked if they are members , participators or none of the two of the social unions (sporting club, cultural organizations, trade unions, professional organizations, religious organization, political party, aid/human right organization, environmental organization, community group) on average all the respondents 51.55(54.25%) are members of each group. By taking this advantage water leakage know how creation be conducted through this social unions.

It is important to recognize that knowledge is not just a product of exposure to information, but is influenced by a range of social factors such as life experience personal relevance. Individuals with poor topic knowledge may also exhibit characteristics such as poor information-processing skills or low personal interest in the topic which reduces the likelihood of information detection or retention. As such, engagement initiatives that provide information only—without addressing the broader social context or actively targeting disengaged subgroups—may not generate meaningful changes in behaviors or policy support (Katarina et al, 2014).

4.4.4 Household water perception data

In the water storing material out of the entire participants 25 (26.3%) of the participants use jars to store water and 70 (73.7%) said use tankers to store water. The usage of tanker is high since water supply is in limited amount.

Respondents asked to evaluate the existing water supply service. 10(11.1%) rated excellent,11(11.6%) rated very good , 36(38.9%) rated good while 38(38.4%) rated as it was bad this indicated relatively there is unsatisfaction with the water supply service. It was also requested if the respondents know how much they pay for cubic meter of water. 75(78.9%) no, 20(21.1%) said they know how much they pay for cubic meter of water.

Participants were asked from the parameters of water supply which one needs improvement .10(10.5%) said it needs improvement on pressure, 63(66.3%) said it needs improving in reliability, 1(1.1%) say on billing system, 14(14.7%) perceived needs improvement in service quality, 7(7.4%) said needs improvement in maintenance. From this we can see that reliably is the major one that needs improvement from other aspects.

Respondents were asked if they know about DMA only 15(15.8%) of the respondents said they know about it from the total sample respondents. Furthermore respondents are asked if they are willing to cooperate with AAWSA experts to let them do water leakage assessment in their property majority of respondents 80(84.2%) are willing, 15(15.8%) are not.

If the government offers subsidies to households almost all respondents are willing to cooperate with the program.

4.4.5 Measures of water-related behaviors and policy support

In up taking of water saving device strategies for fixing leaks, using not leaking pipes, using not leaking faucets, proper fitting, reporting main brake, putting rubbish in dust bin, and waste prevention from water the mean values are moderate in likert scale.

Respondents were asked if they support communication media coverage of leakage management and awareness creation is important. 78(82.1%) support the communication media coverage and awareness creation while 17(17.9%) do not support it at all.75(78.9%) of the respondent convinced that DMA is use for leakage management purpose while 20(21.1%) are not.

It is observed that water-related knowledge was associated with a variety of behaviors and support for policies relevant to sustainable water management. This is consistent with other research linking greater knowledge with adoption of water-related attitudes and behaviors (Dean, Lindsay, & Smith, 2016), and reinforces the importance of knowledge as a necessary ingredient contributing to policy support or behavior change. Whilst provision of information can increase knowledge and support for policies (Daugs et al, 2009),Knowledge may influence household or civic behaviors via many pathways–not only by raising awareness or concern. For example, an individual with poor water-related knowledge may: (i) avoid seeking advice about water due to shame or poor issue awareness; (ii) have difficulty processing information, which may limit engagement with water organizations; or (iii)avoid informal conversations about water, limiting informal information sharing or activating social norms about water use .Knowledge about how to act (procedural knowledge) or the effectiveness of actions (effectiveness knowledge) may have a stronger influence on environmental behavior than general awareness (declarative knowledge) (Association, 2010). Similarly, experiential and active learning of skills may generate greater change in behavior than passive acquisition of knowledge. The concept of water literacy–with its focus on processing information, acquiring knowledge and applying knowledge to decisions–allows us to recognize the importance of different types of knowledge and the importance of life experience in acquiring and retaining knowledge (Davies, 2013).

4.5 Water leakage management practice in AAWSA

As shortage of water is crucial problem in the city, great attention is given to the issue of water loss by the water authority. a water leakage detection study has been conducted by consultant in collaboration with the Addis Ababa Water and Sewerage Authority(AAWSA)

Furthermore, a new department of research and water leakage assessment has been established that its responsibilities are to reduce water loss. As per the information found from the experts of the department, the newly established department works the leakage management activity by using DMA .the non-revenue sub process department 80% of its fund covered by Vitens and Evides international cooperation. One DMA cost up to 750,000Birr.

The existing distribution network is old and poorly maintained, resulting in low quality of water in tap. The concept of DMA management was first introduced to the UK water industry in early 1980s, where a district is an area of a distribution system which is specifically defined, e.g. by the closure of valves, and in which the quantities of water entering and leaving the district are metered. The subsequent analysis of flow particularly of the night flow calculates the level of leakage within the district. This is to determine not only whether work should be undertaken to reduce leakage, but also to compare levels of leakage in the different districts to assess where it is most beneficial to undertake leak location activities. Leakage in the pipes can be easily detected thus necessary steps are taken to reduce leakage. When fully developed enabled a leakage practitioner to monitor a large number of DMAs effectively.

Physical losses reduction in the case of water works enterprise segment is implemented scrupulously in conformity with the DMA management process developed by the AAWSA. Advises are made to carry out thorough investigation and leak detection in north of the DMA, locate all other leaks and perform timely repair. Eventually, it is anticipated to establish a leakage warning and monitoring mechanism in the DMA.

The establishment of this new department might be a good opportunity to strengthen the research activities in the water demand management in general and the water loss in particular. As it was seen during field observation there is a great effort especially with young professionals this demarcates the water leakage management get emphasis from the authority. Besides to these, much works has been done recently to improve the service delivery activities. AAWSA also has a free telephone service that can support to get information from the community in case of leakage and breakage pipes.

Record keeping is an essential part of water network management and is also the base for GIS .supply zone and district meter areas (DMA) records should relate to both physical records and records for leakage analysis. If the network records are poor network survey is essential before zoning and DMA design can take place. And for accurate leak detection and location to be carried out, AAWSA has done a lot with this aspect that most of the network records like the pipe sizes, material types and years of installation are collected and stored in AutoCAD format.
Testing of customer water meters decentralized to the branches and this can enhance possibly of checking and testing more meters with DMA boundary. The major constraints still observed in the authority is lack of information and integration among different activities within the authority itself as well as other utility providing institutions like power, road and telecommunication authorities.

Monition the flow by introducing zoning and district meters is important in order to measure the loss and leakage and prioritize for leakage detection activities. Unless the existing systems are further subdivided into smaller and manageable areas it is difficult to identify and characterize the spatial distribution of water leakage.

During the meter readings cross checking between some previous duration is important and those meters having significant differences need to be reported for further investigation. After characterizing the water loss it is possible to evaluate the cause of the loss based on the specific character tics of the areas like the ages of the pipes, pressure condition, and meter accuracies.

CHAPETER FIVE

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The main objective of this research paper was to evaluate the community water related knowledge specifically about water leakage management knowledge end explore leakage in the water supply line .The analysis divided in into two parts the first part focused on evaluation of community knowledge on water leakage management and the second part focused on evaluation leakage in district metered area.

- Knowhow and also participation of community on water leakage management practice is low. The participation of the community in decision-making processes including user participation, and the employment of different instruments regarding water leakage management is important. Thus, water leakage management combined with decentralized management and service delivery structures are important elements for addressing importance of community participation issues.

- Identifying factors associated with poorer water related knowledge may facilitate better targeting of certain community sub-groups for information or engagement-focused campaigns.

- Although knowledge and literacy can be cultivated, certain target groups may require more intensive interventions to create meaningful engagement. It remains unclear whether solely focusing on knowledge improvements would translate into increased uptake of behaviors in these groups.

- It is important to recognize community's participation on leakage issues, when planning engagement or education initiatives. Poor understanding of leakage management is a reminder to AAWSA to be focused on community's participation in water leakage management.

- The total water loss is found to be high. The total water loss computed by subtracting the consumption from the water supplied. There was difference in leaking water before and after maintaining the supply line.

- The principle of zoning and DMA is a hierarchical way of evaluating and managing losses that covers a number of levels beginning with measurement at the supply and ends at the customers meter for an estimate of consumption. The network system of the entire city has to be sub-divided into different zones and sub-zones. Implementation of a zoning scheme whereby the complete water distribution network is broken down into manageable segments enables easy metering, monitoring and analyzing; it also creates better ground for further operations related to loss analysis and control.

5.2 Recommendations

- There is a need for the creating awareness on the communities about water leakages. There is a need to establish a connection with AAWSA and the community about water leakage management practices.

- In order to provide an improved quality of water for the city residents, the Authority has to undertake water leakage management practices effectively and reviewing its management practices, and efficient management water supply a must be addressed.

- The effective management of water is a core issue for the provision of reliable and safe water supply. By recognizing the reality of key water leakage management practices from the study, alternative options can be identified to propose effective management of leakage and better arrangements to address participation of community.
- in order to provide an improved quality of water for the city residents, the Authority has to undertake different water leakage management strategies by District Metered Areas.

- Investigate the possibility of reducing the household water leakage by using different methodologies.

- A holistic approach to water leakage management is an important in water development schemes. If water schemes are to be managed efficiently and are to be sustainable, it is important to promote beneficiary participation. To meet this goal, participation by all stakeholders is essential.

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APPENDIX

APPENDIX A

March 15, 2019

Questionnaire

For household dwellers

Cover letter

Dear Sir or Madam,

I am a graduate student in water resources management at Addis Ababa University. I am conducting a survey on water leakage management for my graduate thesis work. I would like to invite you to take part in this research. With your participation, I hope I will understand the water leakage management practices in the study area. I am asking you to look over the questionnaire and, if you choose to do so, please complete the questionnaire. The survey might take about 20 minutes of your time. Your answers are anonymous; All answer will be kept confidential will be used only for academic purpose and analysis without mentioning the names of individuals and companies involved. Only group results will be presented or documented, not individual answers. Your help with this research is strictly voluntary. You do not have to answer any questions you don't want to. Return of an answered survey will indicate your consent to participate in this study. . I would like to extend my gratitude for taking your precious time to respond to this questionnaire. If you have any inquiry please contact through the following addresses.

Thank for your time and consideration.

Sincerely,

Rahel Mamo

Post-Graduate Student at Addis Ababa University College of development studies

rahel.mamo @yahoo.com

GUIDELINES FOR COMPLETING THE QUESTIONNAIRE

- Only one answer is required for each question
- For questions which require an opinion, there is a blank space provided.
- Please circle the letters that most closely fits your opinion.
- If you do not understand a question or it is unclear please omit the question and move on to the next.

1. Water leakage

Water leakage is treated water lost from the distribution system.

2. Water leakage Management

Management of water leakages is a key strategic undertaking that ultimately reduces water losses considerably; hence improve customer satisfaction and subsequently service delivery by water utilities.

3. District metered area

District metered area is defined as a discrete area of a water distribution network created by closing boundary valves so that it remains flexible to changing demands. Water flowing into and out of the DMA is metered and flows are periodically analyzed in order to monitor the level of leakage.

Part I: Demographic and household characteristics

1. Name of the respondent (if willing) ____________
2. Date of enumeration____________
3. Keble ____________ Woreda ____________
4. House no ____________
5. What is the dwelling type?
   A. Rented B. owned
6. Head of the household A. Yes B. No
7. Age __________
8. Sex: A Male B. Female
9. Marital Status A. Single B. Married C. Divorced D. Widowed E. Separated
10. Family size A. below 7 B. 7-10 C. above 10
11. Religion A. Christian B. Muslim C. If other specify__________
12. Level of education A. Illiterate B. Read and write C. Primary (1-8grade) D. Secondary (9-10grade) E. preparatory (10+1or 10+2) F. Above 10+2
13. What type of work do you have?
    A. Self employed
    B. Government
    C. NGOs
    D. Employee of private firm
    E. If other specify___________________________
14. What is your monthly income?

    ____

Part II: 1. Water sources and service leakage data

1. What is the major source of household water supply?
   A. indoor tap water B. outdoor C. if other specify___________________________
2. What are the major water using appliances?
   A. shower B. flushing toilet C. hand basin D. bath tub E. washing machine F. dish washer G. if others specify___________________________

3. The appliances are safe from leak.

   A. strongly agree   B. agree   C. strongly disagree   D. do not know

4. What is the frequency of bathing?

   A. once a day   B. Within two days   C. within three days   D. within a week   E. if other specify_______________

5. How is the current water supply service?

	Color	Taste	Pressure
Excellent			
Very good			
Good			
Poor			
Very bad			

6. How many tapes are there in household?

   A. One   B .two   C. three   D. More than three

7. Do your taps usually have brown water running out?

   A. yes   B. no   C. do not know

   If your answer is yes what do you think the cause is and what measures do you take?

   ____

   ____

8. How often is water meter read?

   A. once a month   B. twice a month   C. if other specify_______________

9. Before how many years does your water supply line installed in your property?

   ____

10. Do you have a timely maintenance whenever it is needed?

    A. yes   B. no

11. On what days of a week and during what times of the day, is there no water or water pressure low assuming some degree of regularity?

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
AM 7-12 o'clock							
PM 1-6o'clock							
PM 7-12o'clock							
AM 1-6 o'clock							

12. Can you guess how many cubic meters of water do your household use each month?

    ____

2. Information sources about water leakage

13. Have you heard or seen any information about leaking water in the last six month(radio, television, newspapers, or no information)?

    A. Ye s B. no

    If your answer is yes, explain where have you seen or heard?

    ____

    If your answer is yes, do you start to give concern after knowing about water leakage?

    ____

14. Have you received invitation for meetings , trainings or awareness creation programs from AAWSA about water leakage management practices?

    A. yes B. no

15. Do you have any information about how much percent of water leaks from supply line?

    A. yes B. No

3. **Life experience and psychosocial factors**

16. Have you experienced water use restrictions because of shortage of water supply?

    A. yes B. no

17. If you answer is yes had you changed behavior in response to restrictions?

A. yes B. no

If your answer is yes please explain?

____

18. Are you satisfied in different areas of your home water supply?

	bathroom	Kitchen	launder
satisfied			
Not satisfied			

19. Are you participating in the following social unions?

	Member	participator	None
Sporting club			
Cultural organization			
Trade union			
Professional organization			
Religious organizations			
Political party			
Aid/human rights organization			
Environmental organization			
Community group(edir,ekub)			

4. Household water perception data

20. What do you use for storing water during the water shortage season?

A Jar B. tank C. bucket D. if others specify_______________

21. How would you rate the existing water supply service?

A. Excellent
B. Very good
C. Good
D. Bad

22. Do you know how much do you pay for each cubic meter of water?

    A. Yes   B. no

23. Compared with other utility payments such as electricity fee, what do you think about the current water tariff?

    A. Too high
    B. Normal
    C. Too low

24. Which of the following aspects of your water supply do needs improvement in the future?

    A. Pressure
    B. Reliability
    C. Billing system
    D. Service quality
    E. Maintenance

25. Do you know about district meter area leakage management

    A. Yes   B. no

26. Are you willing to cooperate with AAWSA experts to let them do water leakage assessment in your property area?

    A. Yes   B. no

27. If the water company further improves its service for example by providing better quality and pressure that you could drink directly from the faucet would you be willing to pay more for your water supply system?

    A. Yes   B. no   C .Other please specify_______________

28. Have you ever noticed any advocacy on water leakage management?

    ____

29. If the government offers subsidies to households to improve the existing water system leakage management would you be willing to participate in the program?

    A. Yes   B. no

5. Measures of water-related behaviors and policy support

30. Uptake of water leakage saving devices: whether you had purchased or installed particular water leakage -saving devices in the home?

	Very Unlikely	**Unlikely**	**Moderate**	**Likely**	**Very Likely**
Not leaking faucets					
Not leaking pipes					
Proper installation of fittings					

31. Use of everyday water-saving strategies: whether you engaged in household water-saving behaviors?

	Very Unlikely	**Unlikely**	**Moderate**	**Likely**	**Very Likely**
Fixing leaks					
Reporting main breaks					

32. Water Pollution-reduction behaviors: whether you engaged in pollution reduction behaviors?

	Very Unlikely	**Unlikely**	**Moderate**	**Likely**	**Very Likely**
preventing waste from entering water					
putting rubbish in the bin					

33. Support for water leakage management policy

	do not support at all/unwilling	completely supportive/very willing
Communication media coverage		
Awareness creation		

34. “A District meter area is a useful for water leakage management process in the district area.

A. yes B. no C. do not know

APPENDIX B

Interview

Water leakage management in Addis Ababa the case of Bole sub city (Addis Ababa university college of Development studies department of water resource management M.Sc program)

For Addis Ababa water And Sewerage Authority water leakage department experts.

Part I 1. Personal Background

A. Name: ____

B. Responsibility/Position: ___________________________________

C. Educational Background: __________________________________

D. No. of year served in AAWSA: ___________________________

E. Total work experience (relevant): ____________________________

Part II 1. District area description

1. What are the major components in this district meter area?
2. How many residential service connections do you have?
3. How many inlets are there?
4. How many outlets are there?
5. What is the total cost for this district metered area segment?
6. Other descriptions you would like to share: _____________________________

2. General information?

7. What is the **source of fund** for water leakage management department?

8. How frequent do water **meters** become defective? Do the customers report on time in case of defective water meter? If yes, do they report equally for both in case of the defect causing over readings and under readings? In case they didn't report how do you monitor it?

9. Does your agency have a regular **schedule** for water distribution system **replacement** and **upgrades**? (Yes / no)

10. How do you identify leakage or breakage of water pipes? How do the **communities support** in reporting leakage or breakage of pipes?

11. Does your company follow the water leakage management strategies? (Yes / no) if your answer is please explain the strategies briefly: pressure management, active leakage control, pipe line and asset management and speed and quality of repairs?

12. Do you keep records of the **material** and **age by location** of various parts of your distribution system? (yes / no) What is the pipe material that your system uses?

13. What is the **average life** in years for pipes in your system? Which specific **factors** affect pipeline life in your system? (E.g. other construction works, corrosion, material, earth movement, etc.)

14. Do you report your system losses from water supply to any **government agency** in addition to the AAWSA? If yes, what parameters pertaining to system losses do you report?

15. In your opinion, what requires to be done **to improve** water distribution efficiency across various agencies in Addis Ababa?

APPENDIX C

Materials and methodologies of field work

DESK WORK

- Isolation DMA place using map on desk.
- Identify the inlet and outlet source into and out of the DMA using map.
- Specify the metrology place in order to measure a zero pressure tested for isolation purpose
- Identify and in stole bulk flow meter using map.

FIELD WORK

- Selecting and identifying system boundary
- Installing bulk flow meter to control system input discharge.
- Placing of Metrologs in 8 different places.
- Check a zero pressure at night flow.
- Taking each customer reading two times in to two weeks intervals.
- Door to door sounding followed by inspection of water meter and line for recommending to change and maintenance.
- Taking another two reading after maintenance for each customer in two weeks intervals.

OFFICE WORK

- Changing the hard copy of the customer reading to soft copy.
- Calibration the metrology before installing
- down load the result of zero pressure test from metrology
- Determine amount of total loss in DMA from total inlet to consumer reading (the first and second).
- Determine amount of loss in from consumer reading after water meter change and maintenance of line (third and fourth).

- Calculate the final loss from inlet ((inlet minus second and first), (the inlet minus fourth and third)).

MATERIALS

- Water meter
- Metrology
- Stick sound rode
- Geophone
- Valve locator
- Flow metre