JIMMA UNIVERSITY

JIMMA INSTITUTE OF TECHNOLOGY

SCHOOL OF GRADUATE STUDIES

FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING

HYDROLOGY AND HYDRAULIC ENGINEERING CHAIR

MASTER OF SCINCE IN HYDRAULIC ENGINEERING

Modelling of Urban Water Demand Assessment and Existing Supply System: Case of Awaday Town

BY:

MOHAMMEDAMIN ADEM AHMED

A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES OF JIMMA UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTERS OF SCIENCE IN HYDRAULIC ENGINEERING

December, 2019

Jimma, Ethiopia

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Main Advisor **Dr. Eng. Fikadu Fufa (PhD)**

Co-Advisor **Tolera Abdissa**

December, 2019

Jimma, Ethiopia

DECLARATION

I, Mohammedamin Adem Ahmed , declare that this research is my own original work that has not been presented and will not be presented by me to any other University for similar or any other degree award. A research submitted to the School of Graduate Studies of Jimma University in partial fulfillment of the Master of Science degree in Hydraulic Engineering.

Mohammedamin Adem Ahmed

Signature ____________

Date __________________

This thesis entitled with "Modelling of Urban Water Demand Assessment and Existing Supply System" (The Case of Awaday town, Oromia, Ethiopia) has been approved by the following advisors and recommended for acceptance by Jimma University in the partial fulfillment of the requirement for the degree of Master of Science degree in Hydraulic Engineering.

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1. Dr. Ing. Fekadu Fufa _____________ _______________
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APPROVAL PAGE

The following examiners have approved this thesis entitled **"Modelling of Urban Water Demand Assessment and Existing Supply System" (Case of Awaday)** together with chairperson and department head in the partial fulfillment of the requirement for the degree of Master of Science degree in Hydraulic Engineering at Jimma University.

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   Chairperson Signature Date

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ACRONYMS

BOD	Biochemical Oxygen Demand
CBOs:	Community-Based Organizations
EWRMP	Ethiopian water resource management policy
FGD(s)	Focus group discussion (s)
KII	Key informant interview
HHs	Households survey
CSA:	Central Statistical Authority
CDR	Council for Development and Reconstruction
DSS	Decision support System
GIS	Geographical Information system
GPS	Global Position system
IWRM	Integrated Water Resources Management
L/p/D	Liter per Person per Day
MDG	Millennium Development Goal
NGOs	Non-Government Organizations
UN	United Nation
WEAP	Water Evaluation and Planning
WHO	World Health Organization
WTP:	Willingness to Pay
WUP	Water Utility Partnership

ABSTRACT

The study area, Awaday Town, does not have its own water sources rather the town gets water for drinking from Harar water supply. Harar water supply allocates one borole for Awaday town on top of this, fast population growth and establishment of different public centres are putting more pressure on water supply and causing major water shortages in the town. This research is thefore, focused on modelling urban water demand assessment and existing water supply in Awaday town. Specifically it aims to analyze the existing water distribution system ,estimating current and future water demand and supply as well as water sources.A sampling procedure with purposive sampling method was used to identify out of two kebeles those who have high number of house connection and critical difference in topography four administration unit were selected purposively, and the survey was carried out with 111 household. using simple random sampling were no significant differences within the house hold as long as their mode of water consumption is considered while for the water demand assessment Water Evaluation and Planning (WEAP) model was used. WEAP modelling that aided to evaluate water resources management options for Awaday town. As a result indicated that access to the water supply ware an irregulaway. So that most of the respondent households were not satisfied by the service provided in town. Well water is the major source as the potable water supply is frequently irregular. Results show that the actual demand-supply situation is unbalanced and the deficit percentage estimated 38%. Using the WEAP model the current and future water supply demand assessed along with an evaluation of future scenarios. The water supply demand in the current account year 2016 is 440022 cubic meters while this demand in the future grows to 16376256 million cubic meters in the year 2036; which corresponds to 26.8% increment. The per capita water availability will decrease approximately 28.9 l/c-d by the end of the year 2036 if the available water remains unchanged this due to climate change. *The results show that the unmet water demand will continue to increase over the coming years. This is mainly due to the increase in population with limited water resources. Therefore, securing additional water supplies, the option of using stormwater harvesting becomes an essential issue to meet the increase in water demand. Development of additional groundwater wells is a preferable to address the water supply problem in the town in the `period indicated.*

Keywords: Water supply, production, distribution, unmet demand, WEAP model

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1. INTRODUCTION

1.1 Background

The issue of water permeates all aspects of life on Earth. Water is one of the most important necessities of life, without which there will be no existence on Earth. Access to safe water is, therefore, a fundamental human need and a basic human right (World Health Organization, 2000)

The continuously intensifying shortage of drinking water supply is a crucial problem in almost all contemporary societies. Even in areas where there are adequate quantities of water, the problem of shortage is usually challenged through the deterioration of water quality resulting in increasing costs for certain water uses (Bithas and Stoforos, 2006). This situation is not peculiar to Ethiopia since research has shown that, the global consumption of water is doubling every twenty years, more than twice the rate of human population growth (Francis, 2010).

The ideal way to develop a water distribution system would be to construct a distribution network of pipe that would adequately serve the short term and long term developments of the service area. But individual construction projects, developments, subdivisions, and industrial complexes then could be developed without checking for adjustments to ensure that the original design plans remain adequate for all projected consumers and fire protection demands (Harry, 2008).

Water supply scheme for a town or city is necessary to determine the total quantity of water required for various purposes. In the framework of demand management, it is vital to analyze and to understand the characteristics of water demand, how demand is formulated, which factors determine it, how demand responds to changes in income and relative prices and eventually how future demand will be shaped as these are all changed from time to time(Bithas and Stoforos, 2006).

According to Beatrice (2008), the variation in water demand is weather related. And some other research has been conducted to capture the nonlinear relationships between water demand and other exogenous variables. However, randomly fluctuating daily water demand is also influenced by local behaviour and regulations. With a changing climate and increase of population, water demand may become more temporal and spatial aspect (Beatrice, 2008).

Water demand forecasting is based on the three approaches: end-use forecasting, econometric forecasting, and time series forecasting. End-use forecasting is an approach that bases the forecast of water demand on a forecast of uses for water, which requires tremendous amounts of data and assumptions. The econometric approach is based on statistically estimating. Time series approach forecasts water consumption directly, without having to forecast other factors on which water consumption depends (Vairavamoorthy et al., 1998).

The future changes pressures; such as climate changes and variability, population growth and urbanization, changes in public and socio-economic condition, technological development, increased the demand for water to maintain in stream ecosystems. Consequently, without dealing with these future change drivers and associated uncertainties, the predicted forecast will not be reliable and sufficient for the planning and management of water supply system (Vairavamoorthy et al. 2009).

The present water supply system of the town is from the Harar Water Supply which is 10 km from Ifaa bate borehole. The estimated maximum daily demands for the years 2016 and 2035 are about 50 to 100 l/s respectively. Even the design demands for the year 2016 are above the minimum discharge of the Harar Water Supply as a previous study (HWSSA, 2017). Therefore, there is a high pressure in the future to provide supplementary supply from groundwater or surface water to the increasing demands.

1.2 Statement of the problem

Water is one of the most crucial and non-substitutable environmental resources. Adequate, safe and affordable supply of drinking water is a basic need for human life. However, many people across the planet do not have access to safe and adequate water supply services which affects their life in various ways (Yibeltal, 2011).

The availability of drinking water is the major problem not only in Ethiopia even throughout the world. A huge amount of money is invested for searching for groundwater, for treatment of surface water and for distribution of the water to the users. Fast population growth of towns and cities, a new settlement of residential and public centres and establishment of new factories are the major challenges and causes of drinking water shortages (Beatrice 2008, Harry 2008, Vairavamoorthy et al. 1998).

According to Brocklehurst (2000) and Vairavamoorthy (2007), in the last 50 years, the world's urban population has increased fourfold, and now about 50% of the world's population lives in urban centres. While urban populations grew rapidly, expansion of water supply and sanitation services did not. Spending on water supply and sanitation has not kept pace with growth, and there are dramatic differences in infrastructure expenditure between cities in low and high-income countries. As a result, it is estimated that between 30% and 60% of the urban population in most nations is not being adequately served. By 2025, urbanization in Africa will have progressed from about 32 to 50 % with the urban population increased from 300 million to 700 million (WUP, 2003). If current trends prevail, majority of urban dwellers will be living with poverty in unplanned or informal settlements without access basic services such as water and sanitation affecting public health adversely (Nyarko et al., 2006).

The situation in Ethiopia is not different from what has been reported above. Even the situation in Ethiopia is dire as most of the population does lack access to safe and adequate water supply and sanitation facilities across the country (Getachew, 2002). Shortage of safe and adequate water supply can have caused various social burdens on the community notably in terms of economy and health problems. Therefore, it is imperative to study water demand and supply system of a given town like Aweday which has active economic activity and as a result attracts a large population and registered development in all social spheres. Since the town does not have its own water supply system the demand and supply rarely matches.

There were studies to assess the challenges of domestic water supply in the Gimbichu town (Gelamo,2014); Assessment of urban water supply and sanitation the case of Ambo town (Chala, 2011); Urban water supply, the case of Assosa town (Assefa, 2006); Household supply and factors affecting for consumption, Mekelle town (Bihok,2006) and Analyses of affordability and determinants of willingness to pay for improved water supply service in urban areas (Alebele, 2002). Moreover, other towns but as per the researchers knowledge and also information collected from the office of the water supply and sewerage service, municipal and Zone water mines and energy offices indicated there was that majority of the households in shortage of domestic water provision. Although, its cost and the investigator had gave emphasis to solve the poor quantity of production and quality of distribution of water supply in the town to the dwellers (elders and municipality head communication). Therefore, by assessing the magnitude of water supply and its sources as well as the challenges with possible recommendation that the community of the town and service

Even though Awaday is famous for its economic activity, many of its social problems rarely attract equal attention and been the focus of studies. In particular, little has been studied in terms of modelling water demand and supply system of the town apart from a single survey which depicts the mismatch between demand and supply and further characterized the supply system as highly irregular, supplying poor water quality and lacking proper distribution (Mekonnen and Uttama Reddy, 2014). This study will be the first in its kind by attempting to model the town's water demand and supply system to forecast both current and future water demand of the town. Further, this study will utilize the Water Evaluation and Planning System (WEAP) to assess disparity in water demand and supply in the town. This study will try to answer the following three basic research questions:

1.3 Research Questions

This study will try to answer the following basic research questions:

- How much is the current and actual water demand of the town?
- What is the trend in terms of water consumption rate change in the town?
- What will be the impact on water supply and unmet water demand assessed?

1.4 Objectives

1.4.1 General Objective

The general objective of the study is to model water demand using major water demand factors and assessment of the existing water supply system of Awaday town.

1.4.2 Specific Objectives

The specific objectives of the study are:

- To investigate water service coverage, consumption, and accessibility of the town.
- To estimate the current and future water use demands in the town and
- To show Scenarios their impacts on water supply and unmet water demand assessed were

built using WEAP model.

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1.5 Significance of the Study

The study area at present is under serious water supply problem in providing the required amount of water with acceptable quality. Identifying the cause forexisting water supply problem and recommending sustainable solution is the concern of this research paper. In doing so it avails information on the best practices to improve the existing water supply system, and it also helps theconcerned management bodies to refer to this work on their future plan.

1.6 Scope of the Study

Water as a natural resource is utilized in two ways as consumptive and non-consumptive use. Consumptive water use includes water for a domestic activity such as drinking, washing, and irrigation. Whereas non-consumptive water use includes water used for power generation, navigation and recreation. However, due to the major global challenge with ever-increasing proportions of the world's population, domestic water use must come first. Therefore, the scope of this study is limited to water use for the following purpose: domestic, commercial/industrial, public, business or trade and losses.

1.7 Limitation of the study

The main problem faced by the research process is the lack of finance and time. It is impossible to conduct such kind of research without a sufficient amount of money and time resource. The other problem faced in the course of this study is associated with getting adequate and reliable primary data. For instance, the purpose of the study was made clear to the Respondents; however, most people were not voluntary to give the correct information especially about the income of the household. Regarding secondary data collections, the problems encountered include the following: Some government offices were not voluntary to give the required information;

Even those that were willing to give their data did not have complete information and the available data lacks quantity and quality. Due to poor documentation of the data in the government offices, it was laborious to get the necessary and relevant information; The structural reform of the public sectors had also an influence on data gathering.

2. LITERATURE REVIEW

2.1 Theoretical review

The literature part subdivided into two main sections. The first section deals with a theoretical review which provides conceptual background regarding the topic of the study and main variables. The second section is an empirical review and contains a review of some recent studies conducted on similar issues with the current proposed study.

2.1.1 Overview of Water Supply

The available water sources throughout the world are becoming depleted and this problem is aggravated by the rate at which populations are increasing, especially, in developing countries. Currently, some 30 countries are considered to be water stressed, of which 20 are absolutely water scarce. It is predicted that by 2020, the number of water-scarce countries will likely approach 35 (Rosegrant, 2002). It has been estimated that one-third of the population of the developing world will face severe water shortages by 2025 (Vairavamoorthy 1998; Seckler. et al., 2007)

Consequently, in many low and middle-income countries service providers have failed to provide consumers with adequate water supply. Despite some recent progress - between 1980 and 2005 were an additional 2.7 billion people have gained access to water supplies, more than 1.1 billion people have no access to safe water (WSM, 2010).

The existing situation of inadequate service provision is exacerbated by the fact that population growth and increasing urbanization have offset much of the gains in service coverage. Many utilities, therefore, face new and increasingly difficult challenges in providing services to those living in per/urban areas.

In addition to problems of service coverage and service expansion, many water utilities face a variety of other problems. These include high unaccounted for water (UfW) loss rates (often averaging 40-60%), financial problems, and human resources problems, including overstaffing (sometimes with five to seven times more staff than what is considered 'efficient'), lack of motivation, and lack of capacity to provide services(WSM, 2010b).

Financial problems, for example, often appear to be due to a combination of low tariffs, poor customer record keeping, inappropriate technology choices, the fact that many urban poor are unable to pay for services, inefficient billing and collection systems, and subsidy schemes that benefit the richer rather than the poorer sections of society (WSM, 2010a).

2.1.2 Water Supply Condition in Ethiopia

Ethiopia faces a major water supply challenge. For many years, Ethiopia has remained at the bottom of the international league tables for access to clean and safe water. In response, the country has launched the universal access plan (UAP) an ambitious plan to ensure access to safe water by all by 2012, which the government revised and confirmed (UNICEF, 2008; Brighid et al., 2009).

However, Ethiopia is one of the few countries with a constitutional provision to a formal right to water. This has not helped to achieve in increasing the water coverage of the countries. Only 39.4% of the population currently (2005 statistics) has access to safe drinking water, one of the lowest coverage levels worldwide (UNDP, 2006; WSM, 2010).

Ethiopia has abundant water resources, including 12 river basins and 22 natural and artificial lakes that make her as the water tower of Africa. Why then, do over 45 million people lack safe drinking water? According to (WHO, 2006b) reasons include only a minority of water resources are utilized, however, according to (IRC, 2003) it has also been suggested that lack of safe drinking water supply services is not related with the size of the project on the number of beneficiaries of the schemes. But it depends on the level of involvement of the communities in setting up of the water supply system.

Water's unique properties as a finite but renewable resource lie at the heart of many of the problems associated with its management. Essentially, it is the rate at which water is used in a particular place in comparison with the rate at which it is replaced that determines whether there is a scarcity or a surplus. In global terms and on an accumulative basis, there is no shortage of fresh water. The world's fresh water crisis is one of water resource distribution in space and time (Christine, 2002).

A uniform spatial water distribution system will help in distributing domestic water equally to all places with proper pressure (Durga, 2004). However, according to Ethiopian water resource management policy (1999), the big and main water resources problem in Ethiopia is the uneven spatial and temporal occurrence and distribution. Between 80-90% of Ethiopia's water resources are found in the four river basins namely, Abay (Blue Nile), Tekeze, Baro Akobo, and Omo Gibe in the west and south-western part of Ethiopia where the population is no more than 30 to 40 percent. On the other hand, the water resources available in the east and central river basins are only 10-20 percent whereas the population in these basins is over 60 percent.

The figures indicated above attempt to show the spatial uneven water distribution. The temporal distribution poses no lesser trouble. Ethiopia gets plenty of annual rainfall on the aggregate. It falls either ahead of time or comes too late or even sometimes stops short in the mid-season; the required amount is not available at the right time (EWRMP, 1999).

Consequently, for all the water development activities achieved so far, the average access to the clean and safe water supply is about 17% of the total population of Ethiopia. This can be cited as an example of a very low supply and coverage level even by Sub-Saharan African standards (EWRMP, 1999).

In General, Ethiopia's water problem is thus essentially two-fold: low coverage levels and poor water quality. And to lessen associated health and social implications: Ethiopians are highly susceptible to numerous water-related diseases, from diarrhoea and dysentery to Schistosomiasis and malaria, accounting for the exceptionally high Infant Mortality Rate (UN, 2006). Moreover, women and children spend hours a day collecting water: time that would be better spent on education or employment. Therefore, the need to improve Ethiopia's water supply sector is obvious (Brighid, 2009).

2.1.3 Urban Water Supply Problem

According to Bernd and Jone (1963), urban water supply problems include, limited national economic resource, shortage of investments capital, inept and inadequate operation and management, lack of training facilities, inadequate financial support of water system and insufficient action on the parts of the government. Lack of effective administrative machinery and of technical staff to promote and design new urban water supplies or to improve existing schemes are other factors to be added to the handicaps already listed. These result mainly from a lack of training facilities and they are frequently due to the influence of conflicting local interest and politics (Bernd and Jone 1963).

Water and Sanitation in the World's cities, (2003) summarized the key issues contributing to the poor performance of water supply facilities as follows: inadequate data on operation and maintenance and inefficient use of funds, poor management of water supply facilities, inappropriate system design, low profile of operation and maintenance, inadequate policy, legal frameworks, overlapping responsibility and political interference. The constraint identified causing the failure of water supply system includes a poor organizational structure in the responsible agency, lack of spare parts, inappropriate technology, lack of trained staff, lack of motivation by sector personnel, noninvolvement of the users, inadequate tariff collection system and negative political interference.

On the other hand, Lifuo (2005) considers poor governance and low tariff as core problems to urban water. Degraded watershed results from illegal logging, human occupation of the catchments, lack of revenue that can be used to reforest the land and overexploitation of groundwater which can be traced back to lack of monitoring and control.

In this respect, Hndipuro and Indriyanti (2009) indicate in their study that more than 75% of the African population uses groundwater as the main source of drinking water supply. To meet their demand users try to extract as much groundwater as possible before the resource exhausted. Excessive pumping clearly has a severely detrimental effect on groundwater reservoir; water table drops significantly and alters groundwater flow direction.

According to, WUE (2006), the technical problem such as unaccounted for water is a major water supply problem in many African cities. Most of this water is lost through leaking pipes or overflowing service reservoir, pumping or treatment, or during distribution.

Regarding this, Lifuo (2005) reported that irrespective of whether these losses are due to leakage or due to theft, they translate into an inadequate quantity of water being received by the household. As a result, households are expected to be supplemented from other sources such as unprotected spring, ponds, and unprotected dug wells, in doing so many urban poor are liable to a water-related disease. According to, WHO (2006b) statistic out of 1.1billion people who do not have access to any type of water, 2 million people die every year due to water-related diseases. Khatri and Vairavamoorthy, (2007) on their discussion draft paper explain that the causes for urban water supply problem include climate change, population growth, urbanization, and the ageing and deteriorating of existing infrastructure.

United State population prospect report (2006) illustrates that there is a higher rate of population growth in urban areas in developing countries. In less developed countries, the urban population will grow from 1.9billoin in 2000 to 3.9 billion in 2030, averaging 2.3% per year. On the other hand, in developed countries, the urban population is expected to increase, from 0.9 billion in 2000 to 1 billion in 2030 over the growth rate of 1% (Brocklehurst, 2000; Vairavamoorthy, 2007).

Unfortunately, the development of urban water supplies has generally failed to keep pace with the rapid expansion of cities (Lifuo, 2005). This is partly due to the fact that water resources have often been undervalued. Water is seen as a free commodity provided by governments and is subsidized by governments through general taxation. This has led to a false sense of security with respect to the value and availability of water

It is estimated that there are almost a billion poor people in the world; of this, over 750 million live in urban without adequate shelter and basic services. Population growth and rapid urbanization will create a severe scarcity of water as well as the tremendous impact on the natural environment. Owing to this, cities in developing countries are already faced by enormous backlogs in shelter, infrastructure, and service and confronted with insufficient water supply (Khatri and Vairavamoorthy, 2007).

Concerning infrastructure ageing; in most cities worldwide, there has been years of neglected maintenance to water storage, treatment, 85 distribution system. Poorly maintained water supply system can generally be traced to insufficient financial resource and poor management. This deterioration in the water infrastructure threatens the quality and reliability of all water services (Khatri and Vairavamoorthy, 2007). A large proportion of this infrastructure is over 100 years old, placing it at increased risk for leaks, blockages, and malfunctions due to deterioration.

These deterioration processes are more severe for developing countries, due to the aging of the system, poor construction practice, little or no maintenance 86 rehabilitation activities due to the limited financial resource, operation at higher capacity than designed similarly, there is a little knowledge about specific classes of asset deterioration, the technical service life, and insufficient database to know the extent and/or the value of their infrastructure assets. Further, there are not efficient decision support tools available to the infrastructure manager and decision makers (Misiunas, 2000; Khatri and Vairavamoorthy, 2007).

As the review articles show different researchers studied problems of water supply in different urban cities. A problem which is significant in one urban city may not be significant to others. In addition to this, it is not possible to adapt their study without scaling down the problem and solution to the local context. Therefore, this study will fill the gap in the study area by identifying the possible cause of the existing water supply problem and recommend a sustainable solution

2.1.4 Water demand and use

Water demand is defined as the volume of water requested by users to satisfy their needs. In a simplified way, it is often considered equal to water consumption, although conceptually the two terms do not have the same meaning. (Ashton et al., 2003).

Water demand forecasting is a process achieved through several techniques and is typically used to predict future water requirements for different uses including hydropower, domestic and agriculture water demands. The type of technique used depends on the availability of the data needed, the general scope of the region for which the forecast is being conducted, and the resources available to the organization for which the forecast is being conducted. For all intents and purposes, future water demand is derived from basic functions. For instance, municipal demand is generally projected using population size and the number of households, industrial demand is often based on a number of employees, and agricultural demand commonly relies on crop type and irrigated land (Water Resources planning (Dzurik, 1996).

The key variables such as population growth, urbanization and the water demand for the environment and pollution controls were considered in estimating future water demand. The amount of water that people use depends on minimum needs, amount of water available for use, level of economic development and extent of urbanizations. There are three categories of freshwater use globally: for agriculture, industry and domestic (personal, household and municipal) of which h agriculture dominates (Gleik, 1996).

Over the years, population growth, urbanization, industrialization and the expansion of irrigated agriculture are arresting rapidly increasing in demands and pressure on the water resources, besides contributing to the rising of water pollution (Global Water Partnership 2000).

2.1.5 Domestic water demand

Public water companies provide water for different use as the following categories: - Domestic use by households, Municipal use by government agencies for public functions, e.g. watering public lawns, Commercial use by all kind of public and private offices, agencies and institutes, Industrial use by factories.

The following deals with the demand of the first three categories; domestic, municipal and commercial water demand. These demands depend, among other things, on Number of people within the considered area. Connection rate for different types of supply; e.g. standpipe, piped supply. Per capita consumption, which depends on such factors as level of development, type of supply and price of water. Losses in infrastructure for transport, treatment, and distribution. (Van der Zaag et al., 2003)

Municipal water use is directly related to the quantity of water withdrawn by populations in cities, towns, housing estates, domestic and public service enterprises. The public supply also includes water for an industry that provides directly for the needs of urban populations and this demand also consumes high-quality water from the city water supply system. In many cities, a considerable quantity of water is used in market gardening and for watering vegetable gardens and domestic garden plots.

The volume of public water use depends on the size of an urban population and the services and utilities provided, such as the extent of pipe networks for supply and sewerage, or centralized hot-water supply where available. In addition, much depends on climate conditions. In many large cities, present water withdrawal amounts to 300-600 litres per day per person. By the end of this century, the specific per capita urban water withdrawal is expected to increase to 500-1000 litres per day in the industrially developed countries of Europe and North America. On the other hand, in developing, more agricultural countries found in Asia, Africa, and Latin America, public water withdrawal is a mere 50-100 l/day. In certain individual regions with insufficient water resources, it is no more than l0-40 l/day of fresh water per person.

A greater part of the water that has been withdrawn from the urban water supply system is returned to the hydrological system after use (purified or not) as wastewater if urban sewerage networks operate effectively. The major sources of actual consumption consist of water lost through evaporation from leaking supply and sewerage pipes, from watering plants and recreational areas, washing streets, and garden plots. Thus, largely, the extent of the loss also depends on climatic conditions. In hot, dry regions, losses are certainly larger than those are where it is cold and humid: water consumption for personal needs is insignificant as compared with water losses through evaporation.

Relative values for consumption are usually expressed as a percentage of water intake and depend to a considerable extent on the volume of water withdrawn for public supply. Thus, in modern cities equipped with centralized supply and efficient sewerage systems, the specific water withdrawal can be 400-600 l/day, and consumption is usually not above 5-10% of total water intake. Small cities with a large stock of individual buildings not fully provided with a centralized system may have a specific water withdrawal of l00-150 l/day.

Consumption increases significantly in this context and can reach 40-60%, with the lesser values occurring in northernmost and the larger values in the dry, southernmost regions. The modern trend in the development of public water supply all over the world is the construction in both large and small cities of effective centralized water supply and sewerage systems, connecting together an even greater number of buildings and populated areas. In the future, however, the specific per capita water withdrawal is expected to increase, while water consumption per second, expressed as a percentage of water intakes, will decrease considerably. (UNESCO, 1998).

2.1.6 Urban water demand

By definition, the term ‘urban water demand’, is usually taken to mean the amount of water required by the residential, industrial, commercial and public use on the daily, monthly or yearly basis (Froukh et al., 1996). Urban water demand is highly elastic and responsive to many of the factors including, population and commercial or industrial growth trends, weather phenomena, price changes, technological influences (Horgan, 2003). Young (2003) predicts that water demand and use generally exceed greatly the minimal amounts actually required for daily needs. Urban water demand can be broken down into residential, commercial, industrial, public and losses (Bernd and Jone, 1963).

Global Water Assessment Report 2000, cited by (Assaf, 2008) also estimated that over one-third of the urban water supply in Africa, Latin America and the Caribbean and more than that, half of those in Asia, operate intermittently. Intermittent water supply is a significant constraint to the availability of water for hygiene and encourages the low-income urban population to turn to alternatives such as water vendors. These water vendors often charge many times more than the formal water tariff for water that often is of doubtful quality and not available in adequate amount.

As a result, the water supply in the developing world is still very inadequate. In Africa, for example, more than 47 percent of urban households are without access to safe water. The condition is worsening in rural areas (Grace, 2003). In Nigeria cost estimates and household Willingness to Pay (WTP) estimates are used to determine what proportion of households would sign-up for each service level at various prices, given the household income.

Ethiopia has one of the highest urbanization growth rates in the Developing World. According to data obtained from the Central Statistical Authority, the country's urban population was growing at 4.8 percent per annum from 1995 to 2000. The urban population in Ethiopia in 2007 was 16.1 percent of the total population. Available data also indicate that in the next 25 years (1994-2020), nearly 30 percent of Ethiopia's population will live in cities. Awaday is one of the newly growing towns in the country with rapid urbanization, high population growth which resulted from high immigration and growth rate but low investors flow to the town to due to lack of basic urban infrastructure and services like water supply, better school, and health centre

From the study, it was observed that Awaday town faces the water problem in terms of supply and demand. So model water demand by Water Balance using WEAP should be done for better decision making.

2.1.7 Urban water supply

Safe drinking water is the birthright of all humankind as much a birthright as clean air (Rao, 2002) while access to clean water can be considered as one of the basic needs and rights of a human being. The health of people and dignified life is based on access to clean water (Korkeakoski, 2006).

Alaci and Alehegn (2009) stated that water is important in a number of ways; these include domestic and productive uses. Domestic water use takes the form of drinking, washing, cooking, and sanitation, while productive water uses includes those for agriculture, beer brewing, brick making, etc. Safe drinking water matched with improved sanitation contributes to the overall well being of people; it has a significant bearing on infant mortality rate, longevity, and productivity. However, the majority of the world's population in both rural and urban settlements does not have access to safe drinking water. According to WHO (2006b), only 16% of people in sub- Saharan Africa had access to drinking water through a household connection (an indoor tap or a tap in the yard). Not only their poor access to readily accessible drinking water, even when water is available in these small towns there are risks of contamination due to several factors like inappropriate waste disposal and lack of water supply infrastructure such as pipeline for water (Mengesha, 2008).

According to Water Utility Partnership (Africa, 2003), the primary goal of all water supply utilities is to provide customers with a 'private' connection to the piped water supply network. For many public officials, policymakers and politicians a household or yard connection (hereafter referred to as a private connection) is considered the most satisfactory way to meet.

2.1.8 Sources of water

According to Sijbemsa, (1989) and UN-HABITAT (2003), water sources fall into three general categories.

Rainwater: Rainwater refers to rain that is collected or harvested from surfaces (by roof or ground catchment) and stored in a container, tank or cistern until used. Rainwater is the purest water in nature but it tends to become impure as it passes through the atmosphere. It picks up suspended impurities from the atmosphere such as dust, soot and microorganisms and gases such as carbon dioxide, nitrogen, oxygen, and ammonia.

Surface water: Surface water originates from rainwater. It is the main source of water supply in many areas. It includes rivers, tanks, lakes, manmade reservoirs and seawater. Surface water is prone to contamination from human and animal sources. As such it is never safe for human consumption unless subjected to sanitary protection and purification before use.

Groundwater: Groundwater is water used by humans comes mainly from the land such as wells, springs, etc. It tends to be of higher microbiological quality (having undergone natural soil filtration). However, it is relatively difficult to extract. More technology and energy is needed (compared with other water sources) to bring water from within the earth up to the surface.

UN-HABITAT (2006) stated that water service provision options are standpipes, yard and house connections.

Household connection: Household connection, is a water service pipe connected within house plumbing to one or more taps (e.g. in the kitchen and bathroom) or tap placed in the yard or plot outside the house.

Public tap or standpipe: Public tap or standpipe is a public water point from which people can collect water. Many low-income households that are unable to afford a household connection are relying on public water points.

Domestic reseller: Increasingly, households with a private connection are selling water to their neighbours.

Intermediate service providers: this includes private providers or community-based organizations delivering water in unserved areas.

2.1.9 Water accessibility

The concept of accessibility is the framework for the research discussion. To understand the best location, define accessibility and this is probably the most complex and important of all tasks facing those concerned with the provision of any social service. The task is a two-dimensioned problem organizing a limited set of resources in a way, which is efficient, yet equitable. In real terms, it ultimately declines to the basic dilemma of having to rationalize the supply of services yet ensuring improved accessibility of these services to the consumer (Adeyemo, 1989). Accessibility, therefore, connotes the physical availability of a service or facility. It establishes the extent to which factors like distance, time and cost have decayed. Optimum accessibility in the case of water means effectively overcoming access indicators of distance, time and affordability (Alaci and Alehegn, 2009).

Accessibility must be seen within the context of the ease with which people can obtain the services of a facility and function. Accessibility increases with decreasing constraint both physical and social. According to Adeyemo and Afolabi (2005), accessibility is the balance between the demand for and the supply of consumer services over geographic space and narrowing or bridging the gap between geographic spaces is all significance of transport. Access to essential resources and services has come to be recognized as positively related to development such that inaccessibility or lack of access is cited as lack of development or symptom of underdevelopment (Ayeni, 1987 and Moseley, 1979 cited in Alaci, 2004). To the extents that improved access to essential services has become an accepted part of the rubrics or measure of development and standard of living (Alaci and Alehegn, 2009).

According to (UN-HABITAT, 2003), access to safe water is the share of the population with reasonable access to an adequate amount of safe water. Safe water includes treated surface water and untreated but uncontaminated water such as from springs sanitary wells and boreholes. In urban areas, the water source may be a public fountain or a standpipe not more than 200 meters

Away from households, an adequate amount of water is that which is needed to satisfy metabolic, hygienic and domestic requirements usually about, 20 litters of safe water per person per day. This minimum quantity, however, varies depending on whether it's an urban location or rural and whether warm or hot climate. Perhaps this is why the African Water Development Report (2006) described basic human water need to be 20 to 50 litres of uncontaminated water daily.

UNICEF (2006) stated that, population using improved sources of drinking water are those with any of the following types of water supply: piped water (into dwelling yard or plot), public tap or standpipe, tube well or borehole, protected well, protected spring and rainwater collection while unimproved sources are unprotected dug well, unprotected spring, surface water (river, dam, lake, pond, stream, canal, irrigation channel), vendor-provided water (cart with small tank or drum, tanker truck), bottled water, tanker truck-provided water.

2.1.10 Water accessibility indicators

According to WHO (2004), they are basic indicators for measuring water accessibility These indicators show four paramount levels of water accessibility that include optimal access, intermediate access, basic access, and no access. These are indicative of the level of water availability, which is a measure of the quantity available for use. Basically, they reflect the extent to which accessibility challenges such as time, distance and affordability are formidable or otherwise.

Table 2.1. WHO water accessibility indicator

Travel distance to collect water	WHO standard	Average time spent to collect water	WHO standard
Water supply through taps continuously	(Optimal access)	Water supplied through multiple taps Continuously	Optimal access
< 100m	Water supplied through multiple taps continuously	Within 5 minute	Intermediate access
101-200m	Between 100 and 1000m	5-30 minutes	Basic access
201-500m			
501-1000m	(Basic access)	30 minute-2 hours	No access
		2-4hours	
1 .2-2km(1 .5km)	More than 1000m (No access)	>4 hours	
>2km(3km)			

Source: WHO, (2004)

Affordability: The affordability of water has a significant influence on the use of water and selection of water sources. Households with the lowest levels of access to safe water supply frequently pay more for their water than households connected to a piped water system. The high cost of water may force households to use small quantities of water and alternative sources of poorer quality that represent a greater risk too (Public Health Protection, 2000). Private access to tap water is the cheapest for the consumer. Dependence on a shared standpipe increases prices almost four times. Private water delivery through tanker service (or sachet or bottled water) is the most expensive and tanker water delivery costs many times the tap water price. Thus, the consumers paying the most for water are the ones with the lowest income (Alaci and Alehegn, 2009).

Time and distance travel to fetch water: Time and distance travelled to fetch water are also key indicators of water accessibility. To most communities of Africa, long-distance travel to fetch water is common. Hence, they spend much time and money. According to WHO (2004) standards, if households travel more than 200 meters far away from the house in urban, there is no access. Distance travel to fetch water is also one of the indicators of water accessibility. WHO standards in relation to time, more than 30 minutes no access 5 minutes - 30 minutes basic access and within 5 minutes intermediate access

2.2 Applications of the Water Evaluation and Planning (WEAP) Model

Environment Institute-Boston, TELUS Institute, U.S.A. It is an integrated Decision Support System (DSS) designed to support water planning that balances water supplies and multiple water demands. WEAP incorporates issues such as allocation of limited water, environmental quality, and policies for sustainable water use, unlike the conventional supply oriented simulation models. It gives a practical integrated approach to water resources development incorporating aspects of demand, water quality and ecosystem preservation (SEI, 2012).

WEAP is a river basin simulation model with geospatial capabilities that is capable of simulating the allocation on water throughout a river basin based upon a user-specified time step. WEAP is a laboratory for examining alternative water development and management strategies. As a policy analysis tool, WEAP evaluates a full range of water development and management options, and takes account of multiple and competing uses of water systems (Yates et.al, 2005).

WEAP can address a wide range of issues, e.g., sectorial demand analyses, water conservation, water rights, and allocation priorities, groundwater and streamflow simulations, reservoir operations, hydropower generation, pollution tracking, ecosystem requirements, vulnerability assessments, and project benefit-cost analyses. One of the strengths of WEAP is that it is adaptable to whatever data is available to describe a water resources system. That is, it can use daily, weekly, monthly, or annual time-steps to characterize the system's water supplies and demands. This flexibility means that it can be applied across a range of spatial and temporal scales. Indeed, WEAP has been used throughout the world to analyses a diverse set of water management issues for small communities and large managed watersheds alike. WEAP operates always in an optimization water allocation mode, based on priorities set for each demand site. This makes WEAP unique in comparison to other water allocation tools (SEI, 2012). WEAP applications generally include several steps. The study definition sets up the time frame, spatial boundary, system components and configuration of the problem. The current accounts provide a snapshot of actual water demand, pollution loads, resources and supplies for the system. Alternative sets of future assumptions are based on policies, costs, technological development and other factors that affect demand, pollution, supply and hydrology. Scenarios are constructed consisting of alternative sets of assumptions or policies. Finally, the scenarios are evaluated with regard to water sufficiency, costs and benefits, compatibility with environmental targets, and sensitivity to uncertainty in key variables.

Since the first version of the model was developed in 1990, it has been applied in a lot of research work conducted in quite a number of basins in different countries worldwide. The Map below shows a selection of WEAP projects from different regions of the world. In Africa, WEAP model has been applied in a different part of the continent specifically; it has been applied to Lake Naivasha in Kenya to develop an integrated water resource management plan for economic and ecological sustainability (Alfarra, 2004). In South Africa, it was applied to a water demand management scenario in a water-stressed basin. In the River Basins in Zimbabwe and Volta in West Africa, it was used for Planning and Evaluating groups of small, multi-purpose reservoirs for the improvement of smallholder livelihoods and food security tools. In Ethiopia, the WEAP model was used for evaluation of current and future water resource development in the Abbey and A wash basin for water allocation. Also, WEAP has been applied in complex situations such as the Aral Sea to evaluate water resources development.

2.2.1 Overview of Water Demand Assessment using WEAP Model

Of the factors that determine development potential in a given geographic area, the availability of water for residential, commercial, and industrial purposes is a primary indication of prospective growth. Governmental bodies at the regional, state and federal levels often need to identify water supply availability in order to identify growth potential (Wallace, 2001).

According to Flint, (2004), the demand for water resources of sufficient quantity and quality for human consumption, sanitation, agriculture, and industrial uses will continue to intensify as the population increases and global urbanization, industrialization, and commercial development accelerate.

Computer-based Decision Support Systems (DDS) are being used worldwide in order to manage more wisely our water resources (Simonovic 1996; Arranz 2006). A Decision Support System allows decision-makers to combine personal judgment with computer output, in a user- machine interface, to produce meaningful information for support in a decision- making the process. Such systems are capable of assisting in the solution of all problems (structured, semi-structured, and unstructured) using all information available on request. They use quantitative models and database elements for problem-solving. They are an integral part of the decision maker's approach to problem identification and solution. A DSS must help decision-makers at the upper levels, must be flexible and respond questions quickly, must provide for "what if" scenarios and must consider the specific requirements of the decision makers. Additional important characteristics are accessibility, flexibility, facilitation, learning, interaction, and ease of use (Simonovic, 1996).

According to (DFID, 2003), the main factors in estimating water use will be urban population growth and the level of unaccounted for water. In many urban areas in Africa unaccounted for water levels can be as high as 50%. Demand management measures including leakage reduction programmers and other water conservation measures can often significantly reduce the level of unaccounted for water. In some European countries unaccounted for water levels are of the order of 10%. In any demand forecasting that is carried out for urban areas, it is important that estimates are made concerning the reduction in unaccounted for water levels in the future.

If assessing water demand in a given basin is essential as discussed but; what available models are there which are capable of modelling water demand and which is best suited to model water demand in the study area (Haremaya and Awaday catchments river basin) is a crucial question anyone can ask. Off course there are various models which are capable of modelling water demand in a given catchment or basin. The relevant models which are commonly used in modelling water demand all over the world along with their suitability and limitations are presented here to reach a conclusion that WEAP model was selected as the best suitable to model the water demand in my study area.

A large variety of generic simulation models within interactive graphics-based interfaces has been developed by public and private organizations. They all are designed to study water-related planning and management issues in water systems and to satisfy the needs of those at different levels of planning and decision-making process (Assaf, 2008).

Water Resources Graphical Interface – Simulation Tool (WARGI-SIM) developed at University of Cagliari, Italy, is a user-friendly tool specifically developed to help users understanding interrelationships between demands and resources for multi-reservoir water systems under water scarcity conditions, as frequently occur in the Mediterranean regions. The DSS makes it possible to take into account a large number of system components that typically characterize water resources models. The tool is flexible and generalized in the system configuration and data input, in the attribution of planning and operating policies and in processing output (Sechi and Sulis, 2010). Water Evaluation and Planning (WEAP) model is a generic simulation model developed at the Stockholm Environment Institute, Boston, Massachusetts. It integrates some physical hydrological processes with the management of demands and infrastructure to allow for multiple scenario analysis, including alternative climate scenarios and changing anthropogenic stressors. WEAP model simulations are constructed as a set of scenarios with different simulation time steps. The physical hydrology model updates the hydrologic state of the system at each time step, and thus provides mass balance constants used in the allocation phase within the same time step. A groundwater module in WEAP allows for the water transfer between stream and aquifer. The main point of the water management analysis in WEAP is the analysis of water demand configuration. These demand scenarios are applied deterministically to a linear programming allocation algorithm where each demand and source is assigned a user-defined priority. The linear program solves the water allocation problem trying to maximize the satisfaction of demand, subject to supply preferences and demand priorities, and using reservoir operating policies to minimize the distance to ideal conditions. The water allocation problem is solved at each time step using an iterative, computationally expensive approach. Traditional target storage levels, multiple zones, and reduced releases by a buffer coefficient are implemented in WEAP.

As mentioned by Mouni (2011), Water Evaluation And Planning (WEAP) model provides seamless integration of both the physical hydrology of the region and water management infrastructure that governs the allocation of available water resources to meet the different water needs. It is a priority driven software, employs a priority based optimization algorithm as an alternative to hierarchal rule-based logic that uses a concept of equity group to allocate water in time of inefficient supply.

According to (Wallace, 2001), with supply and demand data in a base year, projections of future water supply availability can then be made. A detailed projection of future water demand must account for changes in the amount of water use activities and the rates of water use within those activities, but a simplified procedure was applied here. Total of Groundwater use was averaged over the population in the base year to determine per-capita off person use, which is assumed to remain constant in the future in this preliminary assessment procedure. The population was then projected and demand was forecasted as a function of the projected population. The supply quantity was projected assuming each flow parameter derived from the historical record will remain constant in the future year. By comparing projected supply and demand estimates, water supply availability in future years can be anticipated in the planning area.

But in this study, the projected supply which was done using WEAP model was taken as the water supply demand in the future without comparison as there are no official estimates of water supply demand as USGS in the basin. As indicated by (Mounir et al., 2011), in WEAP the typical scenario modelling effort consists of three steps. First, a current accounts year is chosen to serve as the base year of the model; two a Reference scenario is established from the Current Accounts to simulate the likely evolution of the system without intervention; and thirdly "what-if" scenarios created to alter the "Reference Scenario" and evaluate the effects of changes in policies and/or technologies.

In this study, the current accounts year was chosen to serve as the base year for the model with input data, reference scenario was developed from the base year without intervention and finally "what if "scenarios were developed using high population growth rate to show how the water supply demand behaves as the population growth rate changes and climate consider.

2.2.2 Reviews of previous studies

Charlotte et al., (2006) use WEAP in the Rio Grande/Bravo Basin. The Rio Grande/Bravo basin is located in North America between two riparian nations, the United States and Mexico. This river basin is currently considered a water scarce area with less than 500 m3 per person per year of available water. Throughout decades, there has been a lot of population growth in the basin, with the population expected to double. The study describes the basin-wide WEAP model that was constructed to help evaluate stakeholder driven scenarios to more.

Assaf and Saadeh, (2006) used WEAP for the development of an integrated decision support system for water quality control in the upper Litany basin. The study was developed to control water quality in the upper Litany basin in Lebanon due to the current practices of discharging untreated sewage into the river causing wide-scale pollution. A decision support system (DSS) was developed using WEAP to help decision makers.

Stakeholders assess alternative water quality control policy options to mitigate water pollution in the river. It was used to assess water quality conditions under three scenarios; the reference scenario where no water quality measures are introduced, another one considers adoption of an environmental master plan (the Council for Development and Reconstruction (CDR) plan), which is the construction of seven secondary wastewater treatment plants to serve seventy-five towns, and the third scenario represents a small scope plan which is the construction of six secondary wastewater treatment plants to serve eleven towns. The three selected scenarios were run against three hydrological records representing low, average and high river flows. The three scenarios were assessed only in terms of the Biochemical Oxygen Demand (BOD) using WEAP. The results showed that the CDR plan is effective in improving water quality.

Lévit et al., (2003) developed water demand management scenarios in a water-stressed basin in South Africa using WEAP. This study was done for the water resources of the Olifants River Basin which is almost fully allocated. It flows from the highly populated and industrialized Gauteng Proven to Mozambique. To get a rapid and simple understanding of water balance at different levels in the basin and equity needs in water allocation, the study was done using WEAP model as a mean of addressing water allocation question in water-stressed river basin.

The use of WEAP allowed the simulation and analysis of various water allocation scenarios, by representing the system in terms of its various sources of supply (rivers, groundwater), water demand sights, reservoirs (location, capacity, operation), and the major water users. For each user, the activity level, the water demand, and return flow were introduced. Water demand management options can be included in WEAP either at specific sites (for example, by studying the possibilities for saving water by individual users) or globally. The study chose to consider the effect of the overall efforts of all users. Three options of water demand management were included in WEAP (at 10, 20, and 30 % of saving water by users). The simulation results demonstrate that with no water demand management efforts, the requirements of up to 15 users would not be met. Moreover, for certain users, even extreme water demand management efforts (30% of saving water) would not be enough. This is possibly a consequence of their position in the basin, on the other hand, at certain other locations; limited efforts appear to be sufficient to meet local requirements.

Using WEAP, (Alfarra, 2004) developed an IWRM model that can help to better understand the situation in the whole catchments and identify where problems do exist. The system of uncoordinated water resources management in the basin of Lake Naivasha in Kenya cannot sustain the ever-increasing water needs of the various expanding sectors. Such an increase in water needs includes the increased water demand throughout the region because of the increase in the human population, which causes a strain on agricultural production, larger flower farms, industrial and other sectors. This may lead to the dry up of Lake Naivasha during droughts. The WEAP model shows that the main problem in the area is caused by a number of identified water uses in the agricultural sector. According to the study, water is misused by over-irrigation in fodder, grass, vegetable farming, and flower farm. Scenarios were built (reference, water year, water demand and supply, water balance, net evaporation scenarios, etc.) and then the analysis of the results of the scenarios was carried out. Modelling demand and supply helped to observe and understand a wide long-term vision of the problem.

Cities are undergoing deep transformations throughout sub-Saharan Africa. Ethiopia Town Their populations are growing rapidly and their physical boundaries are expanding. Socioeconomic shifts – including the rise of an urban middle class are leading to new patterns of production and consumption. Along with these shifts is a changing climate FDRE (the Federal Democratic Republic of Ethiopia. 2011) (FDRE 2011).

Addis Ababa is no exception according to the 2007 census, the city had a population of about

2.74 million (CSA, 2007) (excluding informal settlements in the 10 sub-cities within the administrative boundaries) and it was anticipated to grow to more than 3.1 million currently. Unofficial estimates suggest that more than 1 million people move in and out of Addis Ababa daily. The current area of Addis Ababa is approximately 518 km2 (as per geographic information system (GIS) delineation). Land use has changed from being largely unbuilt areas (about 85% in 1984) to largely built-up areas (more than 57% of the area in 2002), with impervious areas increasing rapidly.

The finding of Mekonnen, (2014), indicates that only 39.4 of the respondents had access to water either from house connection or from public tap water sources at a short distance. Among these householders, 15.3% of them get daily access, but only 6.5 % of them were satisfied and considered as normal phenomena. Out of 86.5% respondents who had water constraints 62.4% did not know the causes of the constraints and interruption of the service and also 66.5% of the respondents' or their family members' caught water born disease in the last two years. The study area, Awaday town due to expansion and establishment of different private and public centres and colleges and within a few years. Besides, the existing demand-supply system is not comparable.

From this review of related literature, we would understand general water resources available globally with an emphasis on Ethiopia, Oromia Regional State at Awaday Town the changing supply and demand trends, in recent times, attributed to climate change. To conclude, WEAP was used usefully in water demand management, developing an integrated decision support system to control water quality in basins, developing IWRM models to identify the water allocation problems between users and thus to identify where is the misuse of water, and development of sustainable management options for water resources.

3. MATERIAL AND METHODS

3.1 Description of Study Area

3.1.1 Location

The study was conducted in Awaday town, Sub-catchment, Wabe-Shebele River Basin of Haramaya Catchment in Eastern Hararghe zone of Oromia Regional State. Awaday situated along Finfinne/Addis Ababa to Harar highway at about 500 km at East of Finfinne and 12 km west from Harar city. Geographically Awaday town is located at 9° 20' 5'' N to 9° 23' 9'' N latitudes and 42° 04' 52'' E to 42° 00' 50'' E longitudes (Figure 3.1).

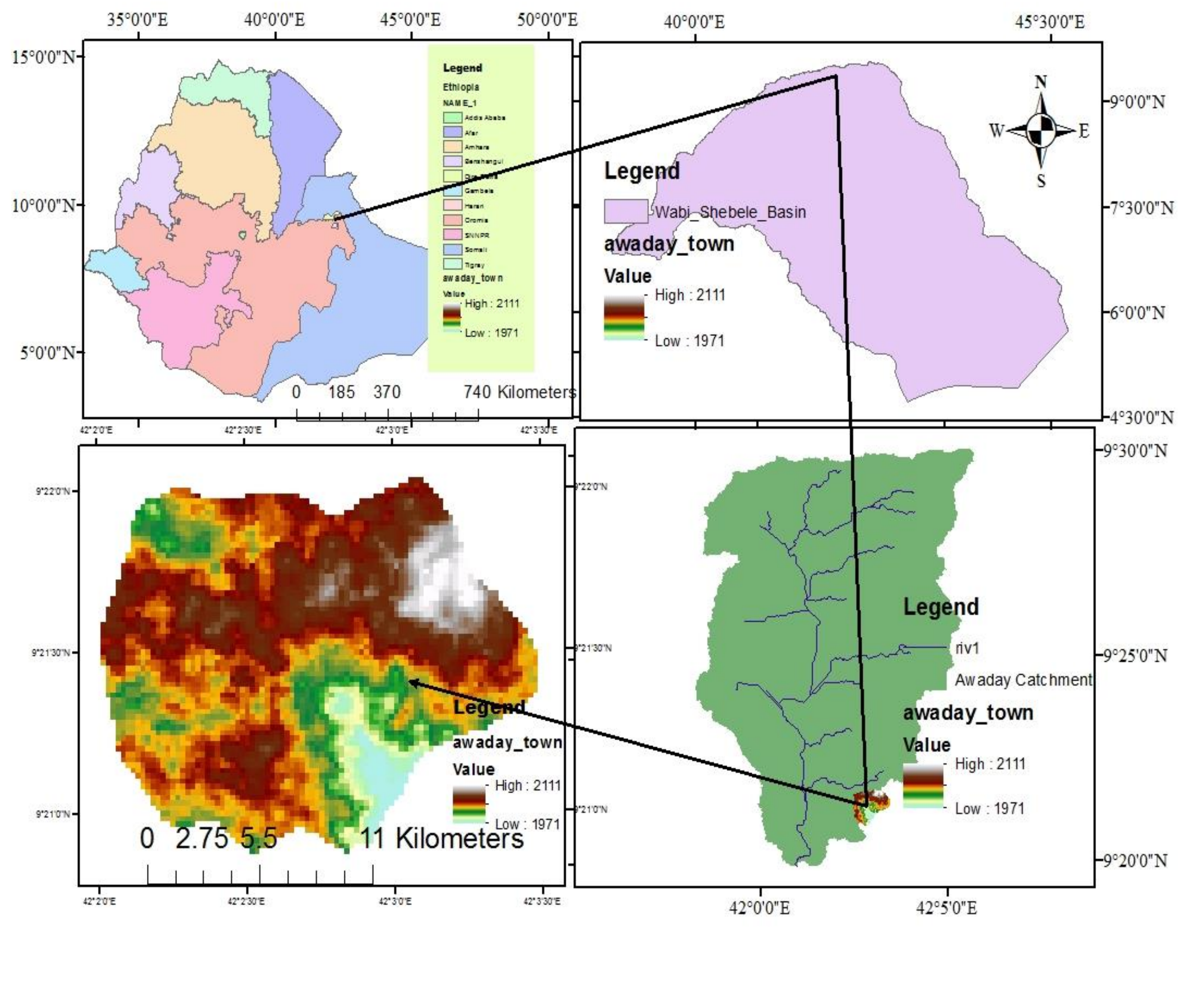

Figure 3.1: Location Map of Awaday Catchment Area

3.1.2 Description Geomorphological and Climate of Awaday Catchment

The geological formation of the study area is bounded with elevated volcanic rocks formation that divides Wabe-Shebele River Basin and Awash River basin at the north where its lower elevation is bounded with Gobble River catchment (Sub-catchment of Erer Mojo River subbasin, Wabe-Shele River Basin) of the Mesozoic sedimentary rocks watershed at the south.

The topographical elevation of the study area ranges in the interval of 1,943 to 2,149 ma.s.l. The total area of the catchment is 17,933.7 hectares in which its land use is majorly characterized by the midland environmental condition. Off this total catchment area, Awaday town share __ % (hectares).

The catchhment land use was mainly consisting of Agricultural land > 60% (open and closed shrub land), with nearly 3% of bare land (soil). Agricultural land occupies about 21% of the watershed area with perennial and annual crops. Densely and sparsely forested land cover is less than 5% of the total area of the watershed. The wetland and water body including the driest Haramaya-Adele natural lake covers about 0.4% of the watershed area. The rest of these lands cover grasslands including natural grass vegetation area with less than 10% of total sub-basin (figure 3.2).

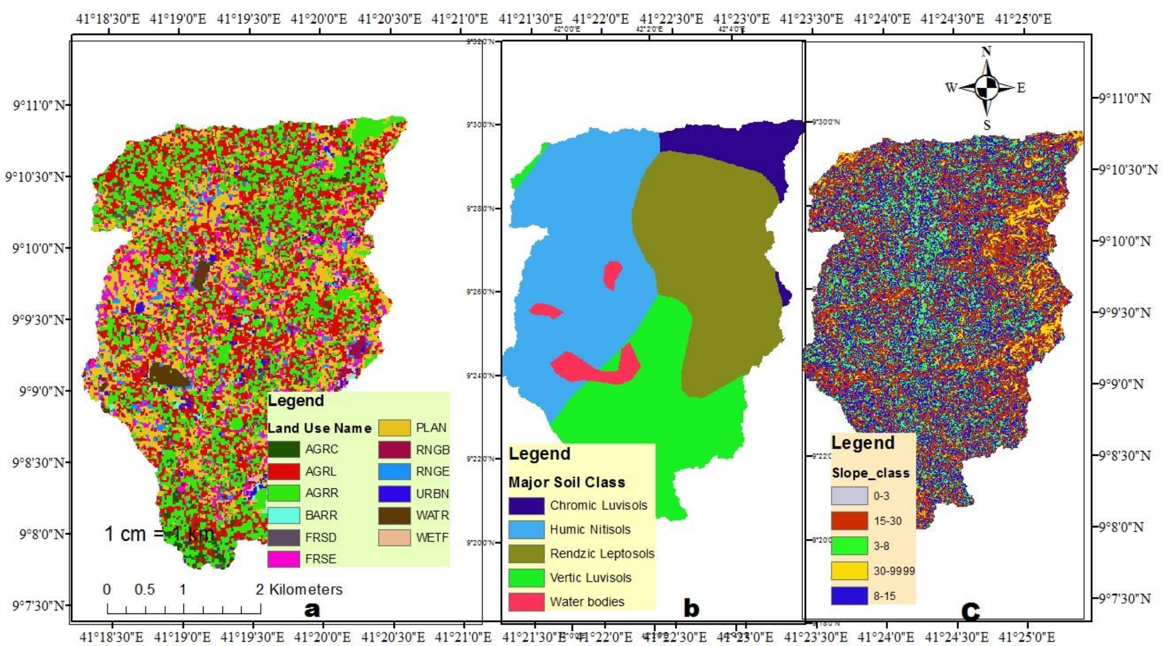

Figure 3.2: land use land cover with its slope

The spatial variation of the rainfall is influenced by the changes in the intensity, position, and direction of movement of rain-producing systems over the country. The rainfall pattern distribution of Awaday catchment is varying since it has a bi-modal rainfall system in which the highest rainfalls occur in March-May and August-September. The average annual rainfall over the upstream of the catchment area is about 786.5 mm. The mean, maximum and minimum annual temperatures of the project area are 16.8, 25.4, and 3.4 ℃ respectively. The maximum temperatures occur in the months from January-May where the minimum temperature occurs from June - September. The total annual potential evapotranspiration (PET) is 1137.8 mm. Monthly wind speed variation is from 0.6 - 1.2 m/sec; in which the yearly average is 0.83 m/sec. The maximum solar radiation (Solar) of 24.6 MJ/m^2 occurs in February whereas the minimum of 17.6 MJ/m^2 occurs in July. The maximum relative humidity (RH) is being happened from April to September. The yearly average relative humidity of the study area is 64.6 % (see Figure 3.3).

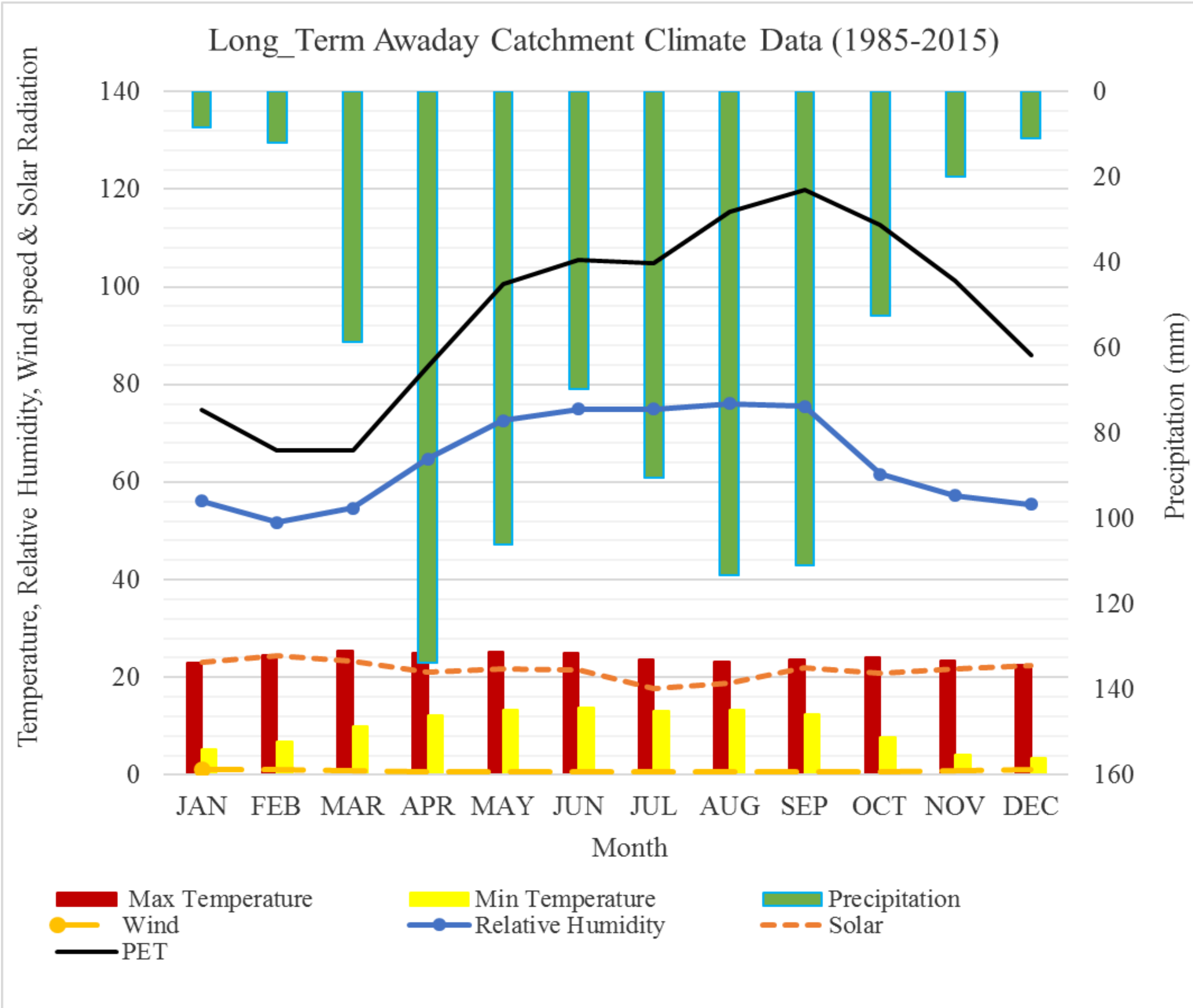

Figure 3.3: Awaday catchment climate data

3.1.3 Socio-economy of Awaday town

3.1.3.1 **Existing Land use of the town**

The master plan of Awaday town was prepared in 2004 by Oromia Urban Development Bureau. The town was built up on total area of 394 ha.

Tabale 3.1 Existing Land use of the town

No	Type of Land use	Area(Ha)	Area (%)	Standard (%)
1	Residence	111.33	37.11	
2	Mixed	9.18	3.06	40-45
3	Administration	0.86	0.28	
4	Commerce	41.26	13.75	5-10
5	Social Service	12.02	4.01	5-10
6	Manufacturing&Storage	-	-	5-10
7	Recreation& Open spaces	104.37	34.79	15-20
8	Special Function(river)	0.43	0.14	
9	Transport& Infrastructure	20.54	6.85	15-25
	Total	300	100%	

Source Awaday town administration ,2016

3.1.2.2 **Population Characteristics**

The first, second and third censuses carried out at national level in 1984 ,1994 and 2007; put the population size of Awaday town at 3,486 and 3,925, and 7,686 respectively. The Analytical statistical report released by CSA in 2011 provides population size at 9,096. Out of the total 7,686 people counted during the 2007 census, the number of male and female population was 3,975 (52%) and 3,711 (48%), respectively.Based on the trend observed in the past, and incorporating the population from the expansion area the current (2017) population size of the town is reckoned to be close to **23,863** including the population of expansion area. Awaday town tow kebale then divided 4 administrative unit that jewaro, walenbo ,maya and new expention site (Awaday administarion , 2010). Each administration unit jawaro the number of male 3574, female 2383 , walenbo male 3812 , female 3335 ,maya male 2859, female 1906 and new expansion male 2382 and 3574 the total of four administration unit male 12626 and female 11196.the town administration unit residence , school , government institution , commercial center, reservoir ,health post and water supply layout (Figure 3.5 and Figure 3.6) for detail information .

3.2 Data Used

In the Modeling of urban water demand assessment and Existing water supply system of Awaday town.

The materials used for this research were Hydrological data (Groundwater data) from monthly pumping from borehole, meteorological data (daily Rainfall, Temperature, RH, sunshine hours, wind speed), 90 by 90m DEM data was used as an input data for Arc GIS to delineate the town sub-catchment, Arc GIS 10.2.1 was used to obtain hydrological and physical parameters and spatial information, to locate geographical location of the study area, to classify land use land cover map SPSS version 20 (Statistical Package for social science) software and simple statistical computation such as frequencies, percentage and mean were produced for assessment existing supply system and WEAP (Water Evaluation and Planning) to estimate water requirements and demand assessment for different uses in the town. GPS and Google Earth were used for allocation of administration unit.

3.3 Methods

For different research, there are different methods. For this research, the following method were used.

3.3.1 Assessment of Existing supply system

3.3.2 Data Source

Data collected from the household were aimed at identifying their attitude and knowledge towards the scarce resource, willingness to pay for improved service, level of participation as stakeholder and their satisfaction level toward the service.

3.3.3 Sampling Techniques and Sample Size

This study used multi-stage sampling technique in which both purposive and random sampling techniques was applied to select the required sampling units from the total population under study.

In first stage, one Town was selected purposely from East Hararghe zone based on disparity in water demand and supply in the town.In the second stage, out of twokebeles those who have high number of house connection and critical difference in topography four administration unit were selected purposively and methods to restrict the number of respondents for effective management and analysis and also it was based on the potential availability of different category of the respondents in the study areas. Sampling was employed in order to obtain representative sample unit from the total population under study. In the third stage,selection of the households in the areas were done using simple random sampling technique;this method was selected since there were no significant differences within thehouse hold as long as their mode of water consumption is considered.

This study applied a simplified formula provided by Yamane (Yamane, 1967) to determine the required sample size at 90% confidence level, degree of variability=0.05 and level of precision= 9% (0.09).Then sample respondents were selected using the following formula with confidence interval of 90%, it was selected randomly using probability proportional to the size of the population of each kebeles from which the sample respondents were drawn.

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

Where, n= sample size, N=population size, e=sample error (0.09)

Here again, proportional probability to sampling size technique was employed to select the required number of the households from each kebeles files, which consists of recent lists of kebeles households. Experts and different stakeholders were consulted to discuss and reduce sample bias information regarding to provision of service.From the selected kebele, with 90 % confidence interval and 10% margin of an error sample size of 111 were calculated. To reconcile the available time of these studies with calculated sample size, 10% of the targeted population was considered. Therefore, out 1100 of beneficiaries in both kebeles 111 of them selected proportionally.

3.3.4 Data Analysis

The study depends on both types of data i.e. qualitative as well as quantitative data. Therefore, depending on the nature of the data different data analysis methods were used. Data collected from the household survey were entered into Statistical Package for Social Science (SPSS) software and simple statistical computation such as frequencies, percentage and mean were produced.

On the other hand, data collected from FGD, KII, physical observation, and secondary source were used to triangulate the survey information through different interpretation.

3.4 Model Selection Criteria

Several lumped models exist and the following points guide the selection of models for use in this study. There are a number of criteria, which can be used for choosing the right model. These criteria are mainly dependent on the use of the model. Furthermore, some criteria are also user dependent such as personal preference; computer operation system; input/output management, etc. Thus, the WEAP model was chosen for this study.

WEAP was chosen in this research due to the following reasons: Recently, WEAP received a great deal of attention where it is being applied at national and international levels; WEAP can be used at different levels spatially and temporarily; Its capabilities promote using it as a Decision Support System (DSS); Ease to use; The developers of WEAP can provide technical help; Public domain for academic use and capability to simulate conveniently hydrology, groundwater utilization, and wastewater treatment.

The research methodology is comprised of three main phases as shown in Figure 3.4. The first phase includes data collection mainly from Awaday Municipality, Awady Water supply, Sewage Authority and AWSSA, relevant reports and studies, and information from the internet.

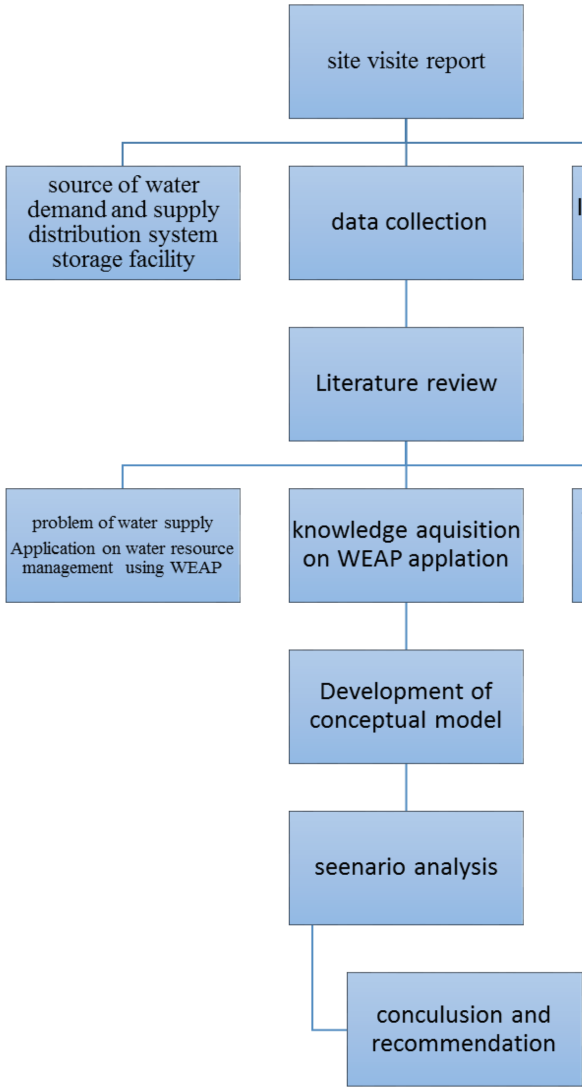

Figure 3.7: Depiction of research methodology

The second phase implies knowledge acquisition in WEAP and its applications. The training manual accompanying WEAP was used to improve and direct my skills in using WEAP and to get acquainted regarding WEAP main functionalities. The third phase entails the development of the conceptual model using WEAP. The conceptual model matches the existing conditions. Potential scenarios were proposed and were utilized in the research to explore the outcomes that correspond to the different applicable management options. As such, the planning and management alternatives were conceptualized (adapted from the Awaday water supply, sewage, and authority Awaday town and were later processed using WEAP.

3.4.1 Water Demand Assessment in the town

For this research only assessment of water demand at domestic uses. According to the information collected from Awady Water Supply, sewage office and minister of water and mining the towns which serve from the groundwater supply at if abate Haramaya town. These towns water supply is derived from the nearby Haramaya University with direct pumping to the treatment plants. Average monthly well data for town water supply (Appendix table 1).

3.4.2 Water Supply in Awaday Town.

Water supply in the city comes from the well located within the Haramaya Town boundaries located outside the city boundaries (Figure3.5).

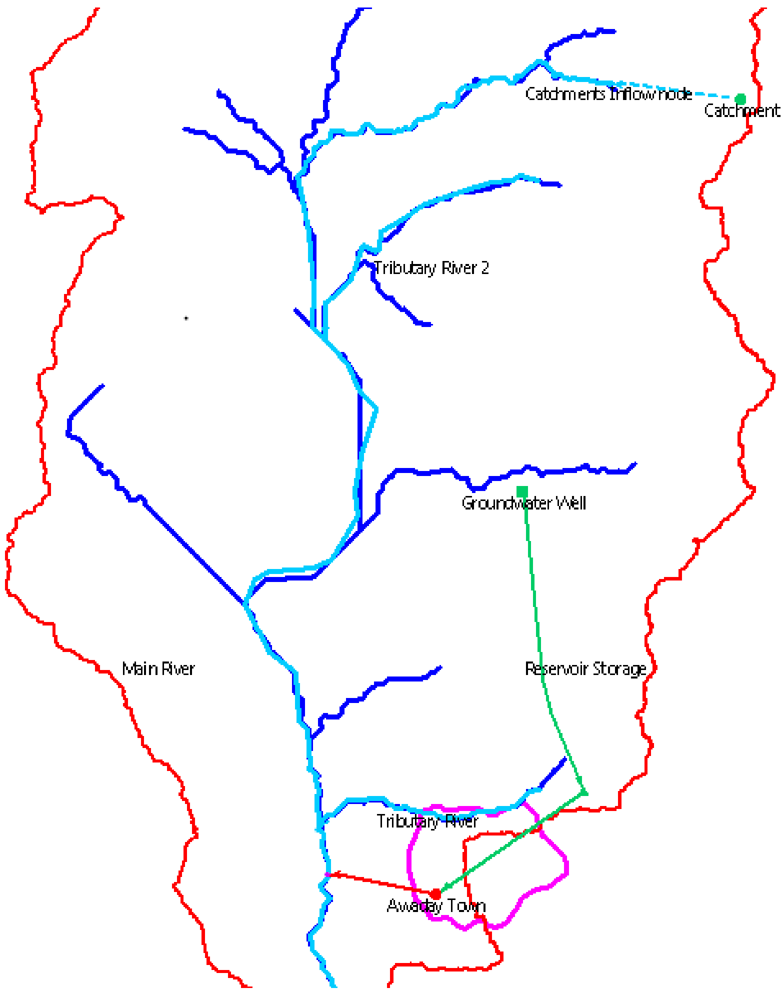

Figure 3.5: Location of the water sources of Awaday Town.

The Town has no water office and they have been using the office of Haramaya water sewage and authorities for a long time until know. The wells for Awaday is from Iffa bate groundwater. Figure 3.8 shows the location of the water sources. Therefore, there are fluctuations in good yield from month to month, season to season, and year to year. This variability relies largely on the groundwater recharge which in turn depends on the total rainfall and level of urbanization.Outside Awaday Town, there are one operating storage reservoirs that are fed from wells (Figure 3.8). Storage reservoirs are combined with the pumping stations. There are one pumping stations distributed throughout the town and provide water to fulfill the demand.

Water Distribution System

The water distribution network of the city consists about 32 km of water pipes ranging in diameter from 2 to 6 inches. Recently, 8-inch transmission link was constructed between Iffa bate well and service reservoir.

The existing distribution system consists of a variety of pipe types: steel, cast iron, ductile iron, and galvanized steel. Lately, the polypropylene and HDPE pipes were used. The unaccounted for water is currently about 23% (unpublished AWSS on Jan 8, 2016).

Water supply data

Most of the water supply data for Awaday town were collected from Haramaya water supply office, which included water supply schemes, pumps type and capacity, population size and design period of the schemes. For the other towns, the necessary data were collected from the master plan studies. The annual per capita water demand was taken based on the national Growth and Transformation Program 2 (GTP-2), which states generally 25 l/cap for rural and 30 l/cap for urban water demands. But urban water supply access with GTP-2 minimum service level of 100 l/c/day for category-1 towns/cities

Thus, the annual per capital demand for a person is about 36.5 m^3. However as current town consumption rate 50l/c/day thus annual percapital demand for aperson 36.5 m^3.

Table 3.6: water supply input data for the project in the basin.

Towns	Annual activity (people)	Population growth Rate	Annual water use (M^3 per
Awaday town	29480	3.5	25.118

3.4.3 Method of Data Analysis

Various data, which were used for the W EAP model to estimate water demands, were collected from different source like population data, domestic monthly variation demands, water requirements per person for estimation of future water demands for town projects which are fed by a respective borehole or well.

The monthly inflow, storage capacity, and net evaporation for each reservoir (which is zero because they are closed) were defined. Table 1 in Appendix A, shows the monthly pumping amounts to the several zones which were used in the model as the monthly inflow to the reservoirs.

The above data collected from different sources were analyzed with Water Evaluation and Planning (WEAP). Each demand site had its own input data and the analysis was done based on the current account year of 2017. The Current Accounts represent the basic definition of the water system as it currently exists, and forms the foundation of all scenarios analysis.

3.4.4 WEAP Model Input and Setup

After collecting all required data, WEAP software was used to estimate for one existing town's domestic water demands in the basin. In WEAP software, the typical scenario modelling effort consists of three steps. First, a Current Account year, which is chosen to serve as the base year of the model; second, a reference scenario that is established from the current account to simulate likely evolution of the system without intervention; and third "what-if" scenarios created to alter the "reference Scenario" and evaluate the effects of changes in policies and/or technologies.

3.4.5 WEAP Model Input

In WEAP, models are called "areas". The background raster data of the study area, which was created by GIS software, was added to the model. Once the area is open, the years, time steps and units are set. In this study, the current account is set to be the year 2017 with the last year scenarios to the year 2036. The time steps per year were set to be 12 and the time step boundary “based on calendar month”, starting with the month of January was selected.

The assessment model was constructed using WEAP, which operates on the basic principle of water balance for every node and link in the system subject to demand priorities and supply preferences.

Figure 3.6. Shows Awaday WEAP model which consists of 4 demand sites represented by the red circles (nodes) and one water supply sources. The supply sources are one reservoir represented by green triangles Demand sites are connected to the water sources by transmission links (the green lines).

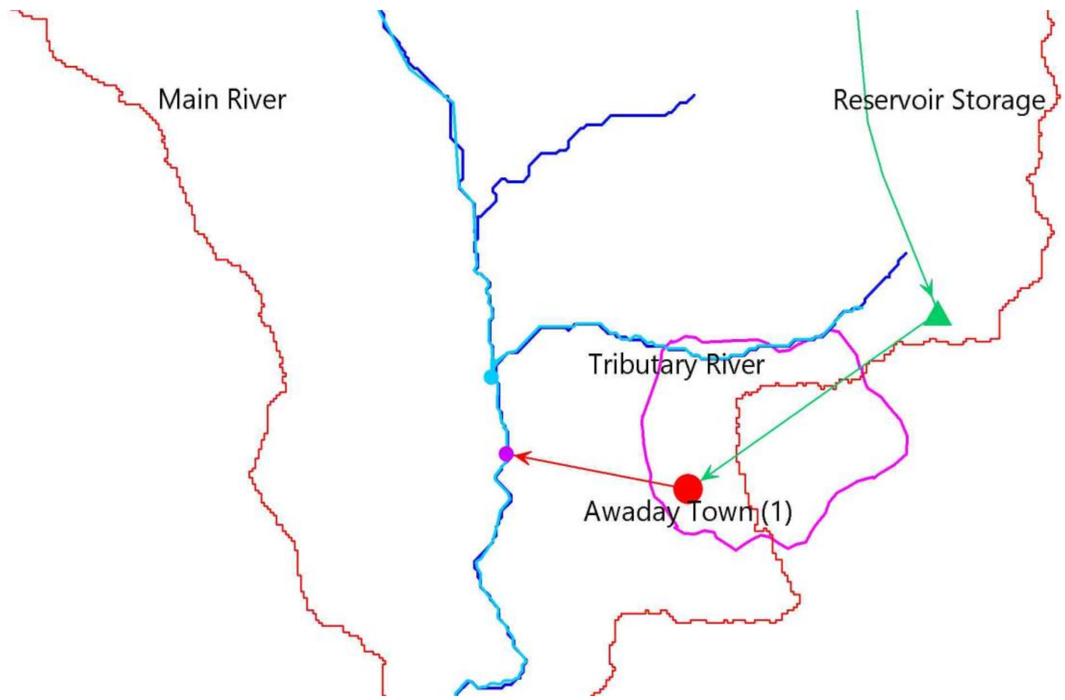

Figure 3.6:Awaday City WEAP model

3.4.6 Population Data and Population Projection

One of the basic inputs in the WEAP model is the population data. The population data collected from Central Statistical Agency is based on census 2007, and the population growth rate of the basin is found to be 3.5% which shows a reduction as compared to the last population growth rate before 1994 which was 4.2% in the study area. Hence the census 2007 population is projected to the suitable year 2013 which is the current account year in my model. The populations of the selected sites with their projections are given in table 4.3.

Table 3.7 Population projection for different water supply schemes

Water Supply Schemes	**Base Year**	Population Projections				
		2017	2022	2027	2032	2036
Awaday water supply	23863	23863	36188	42980	51046	58577

The annual water use rate per person which is calculated for the specific basin ($82m^3$/year) and the projected population is finally used for the WEAP model.

3.4.7 Annual Water Use Rate

The WEAP model needs annual water use rate as a basic input. Based on the specific guidelines given by Ministry of Water, Irrigation and Energy for the Awaday town basin (given in section 3.3.8. above), the annual water use rate per person in the town basin is calculated below: Domestic Water Demand (DWD) = 50lpcd = 0.05 m^3/c/d

CIWD = 5% DWD = 0.05 x 0.05 = 0.0025 m^3/c/d

IWD = 10% DWD = 0.10 x 0.05 = 0.005 m^3/c/d

LWD = 2 x 15 lpd = 30 lpcd = 0.03 m^3 pcd

System Losses = 20% (DWD + CIWD + IWD)

= 20% (0.05 + 0.0025 + 0.005)

= 0.2 x 0.0575 = 0.0115 m^3/d

Average Daily Demand (ADD) = 0.05 + 0.0025+ 0.005 + 0.03 + 0.0115

= $0.099m^3$/c/d

Maximum Daily Demand (MDD) = 1.15 ADD

= 1.15 x $0.08m^3$/c/d

= $0.1m^3$/c/d

Maximum Demand per person per year = 0.1 x 365 m^3

= 36.5 m^3

Therefore, take annual water use rate per person in the basin as 36.5 m^3 which is the input for WEAP model.Structure of Scenarios in WEAP

3.4.7 Current Accounts in WEAP

The current accounts represent the basic definition of the water system as it currently exists. In our case, the model simulation period is taken from 2016 to 2036, and the year 2016 was selected as the current year. The first step in this work was the development of WEAP schematic that shows all components needed in the model (water resources which are reservoirs that are connected to the demand sites by transmission links, in addition, to return flow links). The data used in the model were for the year 2016, by defining the water uses in each demand site and for each user, the population or the number of devices, the population growth rate, and the Per capita water use rate was defined, also monthly inflow and storage capacity for reservoirs were considered. Identifying current water uses: Existing water uses that are used in the WEAP model can be classified as follow: Residential, School and Institutions or administration.

Activity levels are used to describe the demand sites. If the demand site represents a residential site or a school, then the activity level is the number of people. If it is a health care centre, then the activity level is the number of beds. For other institutions, it is the number of buildings. Water use rate is the average annual water need per unit of activity. Demand in WEAP: The demand represents the amount of water needed by the demand site for its water use.

Supply Elements: These elements will be defined by the main reservoirs; the monthly inflow, storage capacity, and net evaporation for each reservoir (which is zero because they are closed) were defined. Table 1 in Appendix A shows the monthly pumping amounts to the reservoirs. Where used in the model as the monthly inflow to the reservoirs. Supply and preference: If a demand site is connected to more than one supply source, choices for supply where a specific supply is preferred to be used firstly may be ranked using supply preferences.
Transmission links: There is a need to connect supply sources to each demand site in WEAP model to satisfy the demand through creating a transmission link from supply nodes to demand sites to satisfy final demand at the demand sites. These transmission links are subject to losses that are about 23%from AWSSA. As such, the total amount delivered to the demand site equals the amount withdrawn from the source minus the losses. Return flow links: Receiving water bodies. Priorities for water allocation: Competing demand sites allocate water according to their demand priorities. These priorities are useful during a water shortage where

sites with higher priorities are satisfied as fully as possible before lower priority sites are considered.

3.4.8 Scenarios in WEAP

Four main scenarios were considered in the assessment:

Scenario 1 (Reference scenario): This scenario represents the current system conditions with its water supplies (reservoirs) and demands sites (with population, annual use rates). It starts from a common year for which the model current accounts data are established. In this study, the current year is 2016.

Scenario 2: Population growth increases by more than 3.5% to be 4.2%. This increase is due to the assumption of improving the city conditions (economic and political conditions) Which encourages people who immigrate to another city or country to return to the city. In addition, the placement of people from villages to the city is another cause of the increase in population growth.

Scenario 3: Climate change which is the change in the magnitude of a single climate parameter such as temperature. The assumption that there will be a decline in the yield of the water resources can be attributed to the potential impact of climate variability which may lead to a decline in well yield and groundwater recharge below the average values In this scenario the effect of climate change on water resources and the yield, and how this change will affect water supply and the unmet water demand were considered.

Scenario 4: This scenario uses the WHO standard for daily use rate which is 150 l/c-d. Thus, this scenario shows how is the unmet demand will increase under the existing.

4. RESULTS AND DISCUSSIONS

4.1 Demographic Characteristics of the participants

4.1.1 Age and household size

The average age of the respondents in the town was 42.88 with a standard deviation of 11.59 and ranged from 20 to 70 years. The average family size of the sampled household was found to be 5.86 with standard deviation of 2.66. The family size of the household was ranged between 0 and 19.

Average age and family size of the respondents

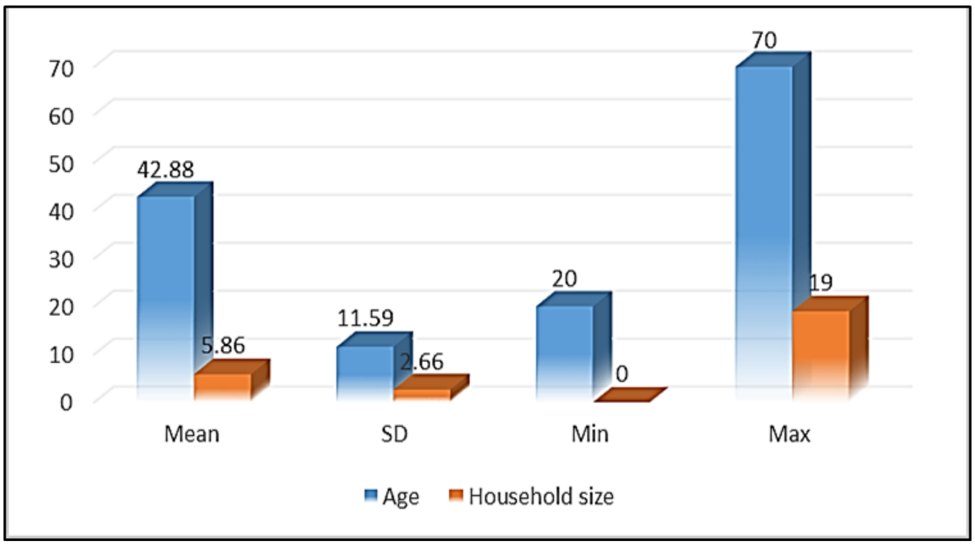

Figure 4.1: Demographic description of the respondents

4.1.2 Marital Status, religion, and education of sampled household

As indicated in Table 4.1, the majority of the respondent households (82.0%) were married while 9.0% of them were divorced whereas both single and widowed 4.5%. Comparison of marital status across Peasant Associations (PAs) of water resource utilization also indicated that there was a statistically significant difference at less than 10% among the four PAs. Religious gathering believed to be one of the opportunities to disseminate information and different religions may have different work ethics. The respondent households were categorized into Muslim, Christian and Traditional believers. The survey result indicated that 100.0% of the respondents were Islam religion followers. As a result, chi-square test showed that there is no significant relationship among religions and across PAs people distribution.

Table 4.1: Description of marital status, religion and education of sampled household (N=111)

Zone of the Town											
Marital status	Walenbo		Jawaro		New expansion site		Maya		Total		X^2
	N	%	N	%	N	%	N	%	N	%	
Married	27	79.4	21	77.8	14	66.7	29	100.0	91	82.0	16.145*
Separated	1	2.9	3	11.1	1	4.8	0	0	5	4.5	
Divorced	5	14.7	1	3.7	4	19.0	0	0	10	9.0	
Widowed	1	2.9	2	7.4	2	9.5	0	0	5	4.5	
Total	34	100.0	27	100.0	21	100.0	29	100.0	111	100.0	
Religion											
Muslim	34	100	27	100	21	100	29	100	111	100	Constant
Christian	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	
Traditional	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	
Total	34	100	27	100	21	100	29	0.0	100	100	
Education											
Illiterate	7	20.6	9	33.3	5	23.8	1	3.4	22	19.8	13.475^{NS}
Non formal	9	26.5	5	18.5	6	28.6	13	44.8	33	29.7	
Primary	10	29.4	10	37.0	8	38.1	10	34.5	38	34.2	
Middle/JSS	7	20.6	3	11.1	2	9.5	4	13.8	16	14.4	
Secondary	1	2.9	0	0.0	0	0.0	1	3.4	2	1.8	
Total	34	100	27	1000	21	100	29	100	111	100	

NS = Not significant, * Significant at less than 10% probability level

Education is very important for the communities to understand and interpret the information coming from any direction to them. Community education is also pivotal for the effective work of extension personnel because if the individual has better education status he/she can have a capability to understand and interpret easily the information transferred to them from any aid agents. Of the total respondent households, 34.2% were educated at primary school and 19.8% were illiterate whereas 29., 14.4 and 1.8% were educated at in informal, junior secondary and senior secondary school education respectively. The statistical test analysis revealed that there is no significant difference in education level between PAs (Table 4.1).

4.1.3 Household occupation

Occupation is the main thing that communities rely on their livelihood. The communities were categorized into farming, trading and self-employed working activities. As indicated in (Table 4.2), most of the Aweday communities (83.8%) participated in the trade activities whereas the least communities (0.9%) participated in self-employed activities. And also the chi-square test showed the insignificant relationship among the main occupation and across PAs people distribution. The statistical test analysis described that there is no significant difference among the main occupation across Pas people distribution (Table 4.2).

Table 4.2: the Main occupation of the respondents (N=111)

	Zone of the Town								Total		X^2
Main occupation	Walenbo		Jawaro		New expansion site		Maya				
	N	%	N	%	N	%	N	%	N	%	
Farming	6	17.6	2	7.4	6	28.6	3	10.3	17	15.3	9.498^{NS}
Trading	28	82.4	25	92.6	14	66.7	26	89.7	93	83.8	
Self employed	0	0.0	0	0.0	1	4.8	0	0.0	1	0.9	
Total	34	100.0	27	100.0	21	100.0	29	100.0	111	100.0	

NS = Not significant

4.1.4 Household income

Income received from different jobs can play a great role in the community's livelihood. The finding result indicated that there is a high proportion of income received between the range of 1000-1500Br and low proportion of income received less than 200Br. This shows that the average income of the communities was different across PAs. When the PAs considered independently in income received, Walenbo 1000-1500Br high (38.2%) and less than 200Br lowest (2.9%), Jawaro 1000-1500 high (37.0%) and less than 200Br lowest (0.0%), New expansion site 500-1000 Br high (42.9%) and less than 200Br lowest (0.0%) and Maya 1000-1500Br high (34.5%) and less than 200Br lowest (0.0%). However, the chi-square test showed the insignificant relationship among income levels and across PAs people distribution (Table 4.3). Therefore, this shows that the income level of the respondent households was close income source across PAs.

Table 4.3: Average income per month for different PAs (N=111)

The average income per month	Zone of the Town								Total		X^2
	Walenbo		Jawaro		New expansion site		Maya				
	N	%	N	%	N	%	N	%	N	%	
<200 Br	1	2.9	0	0.0	0	0.0	0	0.0	1	0.9	15.096^{NS}
200-500 Br	1	2.9	5	18.5	3	14.3	1	3.4	10	9.0	
500-1000 Br	8	23.5	6	22.2	9	42.9	10	34.5	33	29.7	
1000-1500 Br	13	38.2	10	37.0	4	19.0	10	34.5	37	33.3	
> 1500 Br	10	29.4	5	18.5	3	14.3	7	24.1	25	22.5	
Other	1	2.9	1	3.7	2	9.5	1	3.4	5	4.5	
Total	34	100.0	27	100.0	21	100.0	29	100.0	111	100.0	

NS = Not significant

4.1.5 Tenancy arrangement in the community

83.6% of the tenancy arrangement was self-owned whereas 7.3% and 9.1% of tenancy arrangements were shared by rent and state-owned respectively. When the PAs considered independently on self-owned, it is higher observed in Walebo (97.1%) while lower in new expansion site (50.0%). This showed that there is high illegal resettlement in Walenbo than others PAs. But it was better legal resettlement in the new expansion site as compare to other PAs. Chi-square test was run to test the mean difference between different PAs of water utilization and the result revealed statistically significant at less 1% probability level.

Table 4.4: Tenancy arrangement across different PAs (N=111)

Tenancy arrangement	Zone of the Town								Total		X^2
	Walenbo		Jawaro		New expansion site		Maya				
	N	%	N	%	N	%	N	%	N	%	
Rent	1	2.9	`5	18.5	0	0.0	2	6.9	8	7.3	55.796***
State owned	0	0.0	0	0.0	10	50.0	0	0.0	10	9.1	
Self-owned	33	97.1	22	81.5	10	50.0	27	93.1	92	83.6	

Total	34	100.0	27	100.0	20	100.0	29	100.0	110	100.0	

***= Significant at less than 1% probability level

4.2 water service coverage, consumption, and accessibility of the town;

4.2.1 Production

The current production of water depends on 1 borehole, all of which are integrated into HWSSA, one water supply system and are administrated by Awaday town Water Supply and Sewerage Service Office. The gross water production capacity of these boreholes is 8.2 litres per second (l/s) or 270,864 l/day (270.86m^3/day).

However, the actual production of water has been lower than the maximum capacity mentioned above, because the boreholes do not work for 12 hours /day without break. Considerable discrepancies have been observed between actual water production and the expected yield. It was observed that the boreholes produce under their capacity. Production data computed for 1 borehole showed that total actual production of water from wells accounted for 56.3% of their capacity (480360l/d) (Table 4.6).

Table 4.5: The Installed Capacity and Actual Yield of Boreholes

Sr. No	Boreholes at operation	Installed capacity	Expected Yield (m3/day)	Actual Yield (m3/day	Percentage of actual to capacity
1.	BH6	8.2l/s	480.36	270.86	56.3
	Total	8.2l/s	480.36	270.86	56.3

Source: Computed from unpublished data of AWSS office,.

This implies the amount of water that can reach individual persons in the town per day excluding non-domestic users of water is 26l/d/c. The figure falls down when non domestic use is included. In absolute terms the actual production capacity of four boreholes is 270.86m^3/day, but the boreholes do not operate without break even at their actual rate of production. As a result, of under-capacity production rate and frequent interruption in the operation time of wells, the actual production of water is substantially lower than the expected amount. Production of water also varies with the season due to seasonal variability of yield and total well hours worked. Generally, Water production depends on yield, operation time and a number of wells on the operation. According to the data obtained from WSS office (1999/2000- 2004/05) in addition to under capacity rate of production, limited number of boreholes, and operation time of wells which lower down the actual production of water, the high percentage of water loss (15%) has further reduced the actual amount of water supply to 480360 m^3 from 270860 m^3. In line with this, Sharma and vairavamoorthy(2008) stated that leakage from the water distribution system and lack strong management are the leading source for non-revenue water. They specifically suggested in a developing country such as Asia and Africa, its ranges from 20 to 70% . The amount of water, which actually reached the consumers, therefore, accounts for only 85.5% of the total production (Table 4.6).

Table 4.6: Annual water production and loss (1999/2000- 2004/05)

Sr/No	Year	Production (m3)	Loss (m3)	Actual amount reached consumers	Percent age of loss
1	1999/2000	81,256	14,650.00	66,606.00	22
2	2000/01	76,314	14,958.00	61,356	24
3	2001/02	70,289	13280	59,507.00	22
4	2002/03	67,356	10,275.00	63,900.00	16
5	2003/04	74,560	12,980	69100	19
6	2004/5	78,875	14,280.00	70,990.00	20
Total		448,650	80,423.00	391,459.00	21

Source: - Computed from unpublished data of WSS office,

As can be understood from the preceding discussion, the production and distribution systems of the town's water supply are generally inefficient and tied up with serious problems. The following table 4.6 depicts the response of respondents upon their satisfaction with the existing water supply.

Table 4.7: Satisfaction Level of the Existing Water Supply Service of Awady Town.

Existing water supply is	Zone of the Town								Total		X^2
	Walenbo		Jawaro		New expansion site		Maya				
	N	%	N	%	N	%	N	%	N	%	
Very satisfactory	0	0	1	3.7	0	0	0	0.0	1	0.90	31.608^{***}
Satisfactory	1	2.9	0	0.0	0	0	0	0.0	1	0.90	
Unsatisfactory	30	88.2	14	51.9	9	42.9	27	93.1	80	72.1	
Non respondents	3	8.8	12	44.4	12	57.1	2	6.9	29	26.1	
Total	34	100.0	27	100	21	100	29	100	111	100	

*** Significant at less than 1% probability level

Source: Own survey 2016

As indicated above from the table 4.9, above The analysis result tells that 72.1% of the respondents were not satisfied by Existing water supply whereas only 0.9% of the households were satisfied with water service provided by governments. Therefore, this implies that it is a weak water service provision by the government the study area in general. The result indicated that there was a statistically significant difference at less than 5% probability between the four Administration units.

4.2.2 Coverage

The distribution system covers mainly the central part of the town and government built residential areas in 'Kebele' o4 with total coverage of 68 percent. As per the official data of AWSS office, there are 1100 domestic, 116 private or commercial organizations 32 governmental organizations and institutional connections and 8 public points of which three is non-functional. They are estimated to serve 315 HHs or 1,575. However, according to the standard set by World Food Organization 24 standpipes can serve a maximum of 4,800 people, i.e. one for 200 people or 40 HHs.

Most of those inhabitants who do not have access to the piped system draw their water from private hand-dug wells or collect from rivers or springs or buy from vendors who collect water from nearby river on donkey back or buy from their neighbors or somewhere else who have their own private connection and selling it at higher price.

A meter-connected system of water supply includes both the residential (household) and non-residential (private, public and governmental organizations) consumers. In this study, household meter connections are considered. Residential meter connection system again includes house and yard connections. Yard connections are quite similar to house connections except that the taps are placed in the yard, outside the house.

Distributing water through house connection use is obviously the most convenient system of water supply for households. However, the installation of the residential meter connection involves much higher cost which most of the households in the community under consideration (the poorest of poor) could not afford. Because of financial and other socio-economic factors, the rate of private meter connection for household service in Awaday town is very low (Table 4.9).

Table 4.8: Number of Sampled HHs without and With Meter Connection.

No.	Type of meter Connection	Zone of Town								Total		X^2
		Walenbo		Jawaro		New expansion site		Maya				
		N	%	N	%	N	%	N	%	N	%	
1	Private	20	58.9	20	74.1	1	4.8	18	62	59	53.2	70.945***
2	Shared	14	41.1	4	14.8	0	0	11	38	29	26..1	
3	Without PMC	0	0	3	11.1	20	95.2	0	0	23	20.7	
	Total	34	100.0	27	100.0	21	100.0	29	100.0	111	100.0	

As can be seen from Table 4.9 above out of total sample households only 53.2% of these households have private meter connection and 26.1% of the total households have shared meter connection. 20.7% of the sample households are without private meter connection.

The implication of this finding can be expressed in terms of principles of optimal use of water: equity of access, the efficiency of use and sustainability of the source. The first implication is that high variation in a number of households with and without meter connection shows there is no equity of access to the potable water supply. The second implication is that available water is distributed to few numbers of the community in large amounts rather than administering to the majority of the community in small amounts so that the few communities with a large amount of water supply can use /consume water as they wish without giving due consideration to waste of water. Eventually, such unequal/unfair distribution of water leads to inefficient use of water by a few numbers of the community. Last but not least, the majority of the people did not get adequate potable water means they are forced to use other alternative sources. This consumption of water from heterogeneous sources leads to depletion of water resources and implies the absence of optimal use in terms of sustainability of the source.

The rate of meter connections also varies from one Administrate unit ' to another. From the following Table 4.10, below, the percentage of HHs having their own meter connection ranges from 77.8 in jawaro, 96.6 in 'maya, 97.1 in Walenbo and New expansion site are 4.8%. This implies people in ' Walenbo ' have the ability to afford private meter connection than other 'kebele'

Table 4.9: Number of HHs with and without private meter connection in Administration unit.

No. of Respondents	Zone of the Town								Total		
	Walenbo		Jawaro		New expansion site		Maya				
	N	%	N	%	N	%	N	%	N	%	X^2
with PMC	33	97.1	21	77.8	1	4.8	28	96.6	83	74.77	70.945***
without PMC	1	2.9	6	22.2	20	95.2	1	3.4	28	25.2	
Total	34	100.0	27	100.0	21	100.0	29	100.0	111	100.0	

It also indicates the fact that, Walenbo which is the new establishment area in which government built residential areas are found possessing private house/yard connection rate of more than new expansion site which is slum area in which relatively poor segments of the society are found.

Such an inter - 'kebele' variation in the proportion of households with meter connection service might have emanated from differences in income level of HHs, pipeline density and distance from the source of water supply. Due to such constraints, households face serious shortages of water supply. They, therefore, collect water for any kind of household use from other sources or from water vendors which obviously costs them a considerable time, energy and money. The impact of this is that households lost their income and time which led to low productivity, the burden on home duties and drudgery especially on girls and women. However, the issue of fairness and full cost recovery is still paradoxical to solve such problems of variations in access to social services including potable water. Charging high tariff to cover full cost means the poor cannot afford the charge. Again when low price is set or water is provided freely, revenue becomes low thereby resulting in an inability to cover the full cost and to sustain the service unless it is subsidized by the government.

The Ethiopian Water Resources Management Policy has also clearly emphasized on the implementation of cost recovery tariff structure as government subsidy is becoming out of question. This modality is in order to provide efficient and sustainable service through a sound financial and technical management of the system. The policy has also given concern to the ability of the poor to pay by the term (category of) “social tariff” in which the poor are charged less by assuming that the well-to-do consumers will cross-subsidize water supply.

The position of the researcher here is that water supply should be charged rather than being free, but the way of charging customers should be based on their self-selection of the service and volume of water consumption. This means the poor and other customers should select the service type in accordance with their income level and the price would be charged based on the volume of their water consumption. This can enable efficient use and sustainability of water supply.

Figure 4 2.:Withdrawing water from traditional hand dug and

As a result of this sample survey, the number of households that consume pipe water (who have access to pipe water) compared to other sources also constitute 44.1% of the households. But this does not mean this 44.1% of households is using pipe water only. They also use other sources such as traditional hand-dug wells, river, springs and rainwater. The statistical test analysis revealed that there is a significant difference in source water level among PAs at the probability level of less than 5% (Table 4.10)

Table 4.10: Number of HHs Using Different Sources of Water.

No.	**Source of water**	Zone of Town								Total		X^2
		Walenbo		Jawaro		New expansion site		Maya				
		N	%	N	%	N	%	N	%	N	%	
1	Piped Water	15	44.2	17	63	1	4.8	16	55.2	49	44.1	70.945***
2	Private hand dug well	17	50	7	26	18	86	11	38	53	48	
3	River	1	2.9	2	7	0	0	2	6.8	5	4.5	
4	Rain water	1	2.9	1	4	2	9.2	0	0	4	3.6	
	Total	34	100.0	27	100.0	21	100.0	29	100.0	111	100.0	

The remaining inhabitants collect water either from one or a combination of sources for their household consumption. This implies there is an absence of regular water supply in the town, that is, more interruption takes place and also the other sources are not reliable. This implies households should have reservoirs to gather water such as pipe water and also construct ponds to collect rainwater to solve the shortage of water during the unexpected interruption. Generally, the distribution of water through pipe water system covers only 44.1% of the town's population and not only its efficiency but also its equity in the distribution has been limited by the problems so far discussed.

The survey result also showed the existing public water point users constitute only 17.1% of the sampled households while those without private meter connections use meter connections of their neighbours, and water from other sources (Table 4.12). According to the data obtained from AWSS office, at present, one public water point stands for 720 people, excluding private meter connection owners, which is twice more than the standard set for public water point users, 30-40 HHs or 150-200 people.

Based on the above maximum population limit the existing public water points in Awaday can serve 2700 people accounting for only 24.5% of the population without private meter connection service. The remaining 75.5% is not covered with the recommended reasonable population load per a single water point. The percent age gap between the official data and sample survey may be the coverage would not only depend on a number of public water points but also on its regular service provided for a long time insufficient amount of water without interruption and using a shifting system of water supply as well. However, a shifting system of the water supply has got advantages as well as disadvantage. Its advantage is that it can solve the problem of absolute absence of water supply by providing water turn by turn for different areas of the town when there is a shortage of water from the source. Moreover, it can encourage efficient use of water and adoption of container which could be a guarantee during the interruption. In contrast, its disadvantage is that customers would be exposed to the use of other unprotected sources and incur high costs by buying water from vendors during the interruption of water in their turn.

In addition, it should also be noted that the built-up area of the town is growing fast. The fast spatial expansion of the town creates additional demand for water, which calls for the extension of pipelines to the newly incorporated areas. The best possible system of water supply to meet such a growing need will still be through expanding the number of standpipes with an efficient system of distribution (taking density of the population into consideration and distance between standpipes during allocating water points) and adequate supply from the source. In such circumstances, it is important to mobilize the community, CBOs, and self-help with groups that can help the installation of public water points through labour and financial contribution.

Figure 4.3:Public water point

Table 4.11: The number of HHs using Private Meter Connections, Public water points, and Other Sources.

No.	Type of Water Supply System	Zone of Town								Total		X^2
		Walenbo		Jawaro		New expansion site		Maya				
		N	%	N	%	N	%	N	%	N	%	
1	Private connection	20	58.9	17	63	1	4.8	15	51.7	53	48	70.945***
2	Public water point	7	20.6	4	14.8	0	0	8	27.6	19	17.1	
3	Private connection shared with neighbor	3	8.8	3	11.1	0	0	2	6.9	8	7.2	
4	Other sources	4	11.7	3	11.1	20	95.2	4	13.8	31	27.9	
	Total	34	100.0	27	100.0	21	100.0	29	100.0	111	100.0	

4.2.3 Water consumption

In urban communities, the problem related to household water consumption patterns involves various components even though its effects vary from one urban centre to the other and among communities. Among other factors, physical and socioeconomic factors are the major ones. The rate of water consumption in a particular area is a function of various factors. The first and the most influential factor which has been affecting water consumption in Awaday town is the nature of the source of water with respect to quantity. The low quantity was expressed as a more serious problem by different sections of the society interviewed for their water consumption. The other physical factor which affects the use of water within each household is the physical distances of housing units from the water point. For instance "Bono water" users walk an average distance of 357.8 m for a single trip. The total number of standpipes in the whole town is not more than 30, which mean that almost one for an Administrative unit in the previous system of the town's administrative division but the worst thing is from these currently only 5 of them are giving service. Thus this distance is greater than the reasonable access defined by the World Health Organization (WHO) in Assefa (2006) to safe drinking water in urban areas i.e. 200 m for the housing unit. It is observed that the average water consumption per individual per day for houses with private meter house connection is 37.06 litres whereas, for houses using public standpipes it is only 26.1 litres. From this, it can be concluded that physical distance of the housing units from the water point had an inverse relationship with the amount of water consumption despite other factors affecting water consumption such as purchasing power, household size, and household income.

The average per capita water use of a member of each household was calculated and it was found that 31.29 litres of water per day. This amount is almost similar to the per capita amount the AWSSO indicate in the 2012 yearly report, which is 32 litre. The rate of water consumption also depends on the pressure of the water system, which is dependent on continuous power supply. One of the problems of water supply system in Awaday town is the inadequacy of Pressure to satisfy the need of people.

Pumping distribution method needs the energy to force the water from the sources to the mains and then to the consumers even though the gravity system is there also. This incurred power cost. In addition to this, power failures mean a complete interruption in the water supply system and then less consumption. There are also other factors mentioned as reasons for water interruption in Awaday town. These include: break down of pipes,the official decision for both electric and diesel motors to take a rest per day, technical problems such as inability to fit the spare parts, lack of spare parts and skilled manpower. These factors affect the amount of water supplied and then the amount of consumption. Table 4.18 below shows the frequency of interruption in pipe water supply system. These problems can be curbed by staffing the WSS office with skilled technical personnel and material resources. But the more serious problem faced by AWSS office is decreasing water table, especially during peak dry season.

Unlike other resources, we have no substitute for fresh water.

Thus, to overcome such a serious problem due to consideration should be given to the conservationandassuranceosupply.Onemore
an important way is conserving and recharging the natural ground aquifer by afforesting water catchments that can regulate the flow of water as well as helps to reduce the transfer of sediment into the reservoir. Moreover, waste curbing and introducing reuse of wastewater for purposes such as gardening non-edible flowers, using for cleaning latrine and etc. through continuous education programme might help the conservation effort of water resources.

Table 4.12: Frequency of Interruption of Water Supply

Frequency of interruption	Zone of the Town								Total		X^2
	Walenbo		Jawaro		New expansion site		Maya				
	N	%	N	%	N	%	N	%	N	%	
Once a week	1	2.9	0	.0	1	4.8	0	.0	2	1.8	
Twice a week	2	5.9	1	3.7	0	0.0	0	0.0	3	2.7	
Monthly	10	29.4	7	25.92	6	28.5	11	37.9	31	30.6	35.774***
Seasonally	21	61.7	16	59.2	4	19.04	17	58.6	58	52.2	
None	0	0.0	3	11.1	10	47.6	1	3.4	14	12.6	
Total	34	100.0	27	100.0	21	100.0	29	100.0	111	100.0	

However, the problems are less in new expansion site with that of 47.6% share for irregular water supply per week whereas none water supply per week is 47.6%. Therefore, this result revealed that the old PAs needed to maintenance or change whereas the new resettled PA was needed to expand the water supply system. Access to water supply per week across PAs of water resource utilization also indicated that there was a statistically significant difference at less than 1% probability between the four PAs.

When we observe the frequency of interruption from the 4.13 Table above more frequent interruption occurs seasonally (Varying between "bega" and "kiremt"). 52.2% of the respondents justified this interruption whereas 30.6 per cent of respondents responded that the interruption occurs monthly. High percent age of respondents for seasonal variation can attribute the fact that the water table of boreholes decreases in dry seasons. The survey result also showed 58.5% of informants responded to the water supply interrupts during 'bega' season and 27.02% responded interruption occurs in 'kiremt' season (Table 4.13) .

Table 4.13: Seasonal Variation in Water Supply Interruption

More interruption takes place in	Number of respondents	Per centage of Respondents
'Bega' Season	65	58.5
'Kiremt' Season	30	27.02
Non Respondents	16	14.48
Total	111	100

When such unexpected power cut or failure occurs and complete interruption is caused, the households faced different challenges that in turn lead to low productivity, low income, and poverty. As the population size is an increase, the water demand will be high. This shows that water and population size have directly proportional to their relationship. The water demand in the country is very high and the same to the specific study area. Out of the sampled households, 39% of the sampled households were between 200 – 300 Lit of the water demand per day in community with high per cent scoring whereas 0.9% of the households were more than 400 Lit water demand per day with low per cent scoring. The water demand in the Maya PA was very high as compare to others. Low water requirement is households were found in Jawara with less than 50 Litter water demand per day. Water demand per day across PAs on relation to water resource utilization indicated that there was a statistically significant difference at less than 5% probability between the four PAs. It can be visualized that the households in the study area get a very little amount of water for their daily water needs and in any criteria, these per capita water use values are very little (Table 4.14).

Table 4.14: sampled household on water demand in the area (N=111)

Water demand per day	Zone of the Town								Total		X^2
	Walenbo		Jawaro		New expansion site		Maya				
	N	%	N	%	N	%	N	%	N	%	
Less Than 50 Lit	2	5.9	7	25.9	5	23.8	1	3.4	15	13.5	
50-100 Lit	5	14.7	4	14.8	6	28.6	3	10.3	18	16.2	
Over 100 but less than 200 Lit	4	11.8	6	22.2	4	19.0	2	6.9	16	14.4	25.23**
200 - 300 Lit	16	47.1	7	25.9	3	14.3	13	44.8	35.1	39	
301 - 400 Lit	7	20.6	3	11.1	3	14.3	9	31	19.8	22	
More Than 400 Lit	0	0.0	0	0	0	0	1	3.4	1	0.9	
Total	34	100	27	100	21	100	29	100	111	100	

** Significant at less than 5% probability level

It can be visualized that the households in the study area get a very little amount of water for their daily water needs and in any criteria, these per capita water use values are very little. According to UN-HABITAT (2003, a household needs a minimum of 150 l/ day and for good hygiene up to 600 l/ day. Obviously, domestic consumptions in cities differ mainly due to climate, the standard of living, household size, etc. But from this study, it can be concluded that the per capita water usages of the study areas are rather very low and needs to be improved.

4.2.4 Water Accessibility

Water accessibility is an adequate amount of water, which is needed to satisfy metabolic, hygienic and domestic requirements at least 20 litres of safe water per person per day (UNHABITAT, 2003). In urban areas, the water source may be a public fountain or a standpipe at least 20 litres of safe water per person per day and not more than 200 meters away from residence (WHO 2004). In addition to the adequacy, affordability of water also has a significant influence on the use of water and selection of water sources. Households with the lowest levels of access to safe water supply frequently pay more for their water than these households connected to a piped water system. Beside high water cost forces households to use small quantities of water and alternative sources of poorer quality that represent a greater risk to (Public Health Protection, 2000).Furthermore, high costs of water may reduce the volumes of water used by households which in turn may influence hygiene practices and increase risks of disease transmission. In line with this, the situation of potable water accessibility in Awaday town is discussed as follows.

4.2.5 Water collection journey

As stated earlier in this paper, distance travelled is one basic accessibility indicator. The information collected from households on the distance traveled to collect water from their primary water sources is shown in figure 4.13. According to the consultations made with the households of the three kebele residents, they travel long distances that take more than 30 minutes return trip for water collection. When it is not a day that they will get water according to the program, they travel long distances to farthest kebeles for over an hour. The respondents pointed out that many of the public taps are closed for the reason they do not recognize. On the discussion made with the key informants, it has been realized that most of the standpipes are not working because of lack of customers. salaries of workers who were working on the standpipes were believed to be paid on the profits gained on the sale of water on the standpipes but because of the low selling of water on the pipes the office exposed for extra expenditure, to cover salaries of these workers. As a result of the budget deficit every year the office has been facing, to minimize the problem most of them decided to be closed for four years. On the other hand, in areas where the pipes are working, because they were only open for a few hours, the respondents said that many people collect there to fetch and even it was common that the sellers leave before their turn reaches. Therefore, most people prefer to buy from water vendors than waiting for standpipe workers for getting not more than a Jerri can Those people who are old and cannot go for long distances may pay up to ETB 2 per Jeri can (20 litres) to get water. They reported that it is very difficult to get continuous water supply in the area and women discussants added that they are always bothered about the continuity of supply.

Table 4.15: Source of water and distance from respondents

The distance of water source from home	Zone of the Town								Total		X^2
	Walenbo		Jawaro		New expansion site		Maya				
	N	%	N	%	N	%	N	%	N	%	
>100 m	23	67	10	51.9	11	52.3	13	44.82	57	44.1	35.933***
100 - 200 m	4	12.1	0	0.0	6	28.6	0	0.0	10	9.1	
200 - 500 m	0	0	2	7.4	3	14.3	2	6.9	7	6.4	
500 meter above	7	20.5	15	55.5	2	9.5	14	48.2	38	31.1	
Total	34	100.0	27	100.0	21	100.0	29	100.0	111	100	

*** Significant at less than 1% probability level: m is the distance in meter, km is the distance in kilometre.

From the above Table 4.16, it can be inferred that most households i.e. 57 (44.1%) are getting their water from the primary source at less than 100 meters walking distance which is within the Intermediate. Access according to WHO accessibility standard, 2004. While 10 (9.1%) HHs get water at a distance range of 100 up to 200 meters and 7 (6.4%) HHs gets in between 200 and 500-meter distances which are together within Basic access range but 38 (31.1%) HHs travel over 500 meters to get their water. According to WHO accessibility standard, 2004 they have no access to clean drinking or tap water. All these together shows that the distance traveled to collect water from the primary sources is reasonable except during interruptions that force women and children to collect water from far distances spending their time, energy and paying additional costs.

4.2.6 Water collection time

On WHO (2004) water accessibility indicator, it is mentioned that time consumed to fetch water from sources is one factor in showing accessibility. Based on the survey on the study area, at times, when there is no water interruption, over 44.1% of the sample households' travel for less than 5 minutes which is an Intermediate access, about 16 % of them take 5-30 minutes to fetch water from their primary source for a single trip that is a Basic access. But the remaining sample households around 31.1% take more than 30 minutes which is under no access category based on Access standards of WHO (2004). These reported water collection times varied considerably with the primary source type that the households use. Households with standpipe and vendor source types cover the longest time per tripe whereas households with private house and yard connection sources travel the shortest time. It is very important to recognize that all of these reported times are only average times used by the respondents to collect from their nearest primary source. But in time of interruption that is another story. According to the discussion made with the sample respondents, some of them spend over an hour to collect water.

Table 4.16: Average time used by households for water collection

Time travel to a water source	Frequency
<5 minute	44.1
5-30 minute	15.5
>30 minute	29.1

Especially if we consider only public tap users, only 9.5 % of them travel less than 5 minutes, 61.9 % travel 5-30 minutes and 28.6 % of them take more than 30 minutes for single tripe. Therefor from all sample households of all primary source types, public (stand) pipe users are the most that travel long distances and consume much time

4.2.7 Water Tariff

Water tariff is the appropriate price for using water services from municipal or commercial water providers. The major objectives of water tariff are financial and cost recovery, efficient allocation of resources, water conservation and water provision for low-income groups. The affordability of water has a significant influence on the use of water and selection of water sources. Households with the lowest levels of access to safe water supply frequently pay more for their water than households connected to a piped water system. The high cost of water may force households to use small quantities of water and alternative sources of poor quality that represent a greater risk too (Public Health Protection, 2000).

From the total sampled household, 64.0% responding yes definitely it is important to pay for water utilization if there isaccess to water at need time and place whereas 1.8% no definitely important to pay for water utilization. Therefore, this implies that most of the sampled communities believed to pay for their utilization of water pipe if they got regularly. Community perception toward water utilization payment across PAs in relation to water resource utilization also indicated that there was a statistically significant difference at less than 5% probability between the four PAs.

Table 4.17**:** Sampled household perception toward water payment (N=111)

Import to pay for water utilization	Zone of the Town										X^2
	Walenbo		Jawaro		New expansion site		Maya		Total		
	N	%	N	%	N	%	N	%	N	%	
Yes, definitely	22	64.7	17	63.0	11	52.4	21	72.4	71	64.0	23.318**
Yes, perhaps	10	29.4	4	14.8	2	9.5	4	13.8	20	18.0	
Not really	1	2.9	3	11.1	1	4.8	2	6.9	7	6.3	
No, definitely	1	2.9	1	3.7	0	0.0	0	0.0	2	1.8	
Don't know	0	0.0	2	7.4	7	33.3	2	6.9	11	9.9	
Total	34	100.0	27	100.0	21	100.0	29	100.0	111	100.0	

** Significant at less than 5% probability level

Cost of water pipe utilization was found to have different average cost across the communities. The cost of water pipe utilization of the sampled household was found to be within the range of 0 to 900 Birrs. While the average cost of water pipe utilization per month was 137.93 Birr with a standard deviation of 135.16 Birr. In this study area, there are a big difference in water pipe expenses between PAs. This is may be due to the access of water pipe in across the PAs. Therefore, this told us that there is a gap in water pipe installation or access to water across the area.

Table 4.18: Cost of water per month (N=111)

Zone of the Town	Cost of water per month in Birr			
	Mean	Std. Deviation	Maximum	Minimum
Walenbo	81.91	79.206	350	20
Jawaro	168.22	139.332	500	20
New expansion site	206.00	135.313	450	0
Maya	128.45	158.661	900	25
Total	137.93	135.161	900	0

The above table could be explained this graph

However, the fairness of the price set for private connection to the poor community on one hand and on the basis of cost recovery, on the other hand, is questionable. According to the result, from table 4.11 the total sampled 60.0% of the respondent was not really about the fairness of the payment on water pipe utilization whereas 0.9% of the sampled household responds that yes definitely the cost of water pipe was fair in payment. This implies that most of the respondents believed that there is no fair payment in relation to water utilization. Community perception toward payment fairness across PAs in relation to water resource utilization also indicated that there was a statistically significant difference at less than 1% probability between the four PAs.

Table 4.19**:** sampled household perception toward water payment (N=111)

Fairness of payment	Zone of the Town								Total		X^2
	Walenbo		Jawaro		New expansion site		Maya				
	N	%	N	%	N	%	N	%	N	%	
Yes, Definitely	1	2.9	0	0.0	0	0.0	0	0.0	1	0.9	52.360***
Yes, Perhaps	5	14.7	0	0.0	0	0.0	0	0.0	5	4.5	
Not Really	19	55.9	11	40.7	10	47.6	26	92.9	66	60.0	
No, Definitely	3	8.8	15	55.6	11	52.4	0	0.0	29	26.4	
Don't Know	6	17.6	1	3.7	0	.0	2	7.1	9	8.2	
Total	34	100.0	27	100.0	21	100.0	28	100.0	110	100.0	

*** Significant at less than 1% probability level

The operational tariff for Awaday water supply Office is blocking rising progressive tariff with the lowest band consumption tariff of ETB 5/M3 and the highest in the band at ETB 9/M3. Public tap users pay using flat charge tariff system and it is ETB 5/M3.

Table 4.20. Awady water supply Current and Proposed Water Tariff

Consumption Band (m3)	Current Tariff (Birr/m3)	Proposed Tariff (Birr/m3)
0.1-5.0	5.00	6.00
6.0 -10	6.25	7.25
10.0 -15	7	7.5
15.0 -20	7.25	8.25
20 above	8	9
Public taps	5.00	5.00

Source: Awady Town Water Supply Service Office

As can be observed from the prices given above in the table 4.14 for private pipe connection users, the one who consumes more pays less price and vice- versa, i.e. after a certain limit of consumption, the tariff remains the same, 8 m3. This pricing approach subsidizes the high-income level community and increases the burden on the poor people, particularly public standpipe users because they are paying using flat rate charging system.

Table 4.21: Is the current tariff reasonable?

Category	Frequency	Valid Percent
Yes	60	54.5
No	50	45.5
Total	110	100.0

It is shown in table 4.15, the sample households were interviewed if they are paying for water and their idea on the price, then 96.7 % are paying and 3.3 % are not. And out of the total sample households, 71 (64 %) answered the current tariff is high whereas the rest 40 (36%) of them responded it is not high. It was also found that households pay on average ETB 45 / m3 for vendors, which is about 8 times the unit cost set by AWSS for public taps. Households spend on average ETB 0.37per capita per day on water currently according to AWSS report (2017), the office's annual expenditure (2,640,060 ETB) exceeds its revenue (1,809,000 ETB) and it is not able to cover its coasts. Therefore it is not easy to lower the tariff below the current amount and even it has risen as shown in table 4.14 above in the proposed new tariff.

4.2.8 Community store water for home utilization

Of the total sampled households, 76.4% of the sampled households were used store water for home utilization while the left 23.6% have no used. But this condition varies across PAs. Utilization of store water in Maya was higher whereas lower in new expansion site with the comparison of other studied areas. In general, the communities have an experience of store water utilization even if the stored water is not sufficient for daily usage. The statistical analysis showed there is a significant difference across PAs in relation to storing water utilization for daily needs

Table 4.22**:** Number of respondents store water for home utilization

Per cent (%) of respondent store water	Zone of the Town								Total		X^2
	Walenbo		Jawaro		New expansion site		Maya				
	N	%	N	%	N	%	N	%	N	%	
Yes	30	88.2	16	61.5	10	47.6	28	96.6	84	76.4	21.982^{***}
No	4	11.8	10	38.5	11	52.4	1	3.4	26	23.6	
Total	34	100.0	26	100.0	21	100.0	29	100.0	110	100.0	

*** Significant at less than 1% probability level

Access to water and sufficiency for daily needs

The problem of water shortage for dinking, washing and house can be alleviated through proper management and utilization of available pipe water, well and/or rainfall harvested. Communities in different area practice various method in solving their own problem. As a result, of the total sampled household, 95.5.0% household has no suitable stored water sufficient for daily usage whereas only 4.5% have this water. Independently among PAs of the stored water sufficiency for daily usage was that no have 97.1% Walenbo, 84.6% Jawaro, 100% new expansion site and 100% Maya. This implies that in almost all PAs of the study areas indicated that there is a critical problem with regard to access to store water for daily needs. The statistical analysis showed there is a significant difference across PAs in relation to storing water utilization for daily needs.

Table 4.23**:** The stored water sufficiency for daily needs in the communities

The stored water sufficient for daily needs	Zone of the Town										
	Walenbo		Jawaro		New expansion site		Maya		Total		X^2
	N	%	N	%	N	%	N	%	N	%	
Yes	1	2.9	4	15.4	0	0.0	0	0	5	4.5	9.623^{**}
No	33	97.1	22	84.6	21	100	29	100	105	95.5	
Total	34	100	26	100.0	21	100	29	100.0	110	100.0	

** Significant at less than 5% probability level

4.3 WEAP Model Results for Water demand assessment.

4.3.1 Water Demand Results in the Current Account Year 2016

The Current Accounts represent the basic definition of the water system as it currently exists. It is also assumed to be the starting or base year for all scenarios where we feed the currently available data. Hence, it is important to look at the nature of the demand in the current account year as it is the base for all scenarios and future demands. The annual water demands for the selected demand sites for the current account year 2016 are shown in figure 4.9 below.

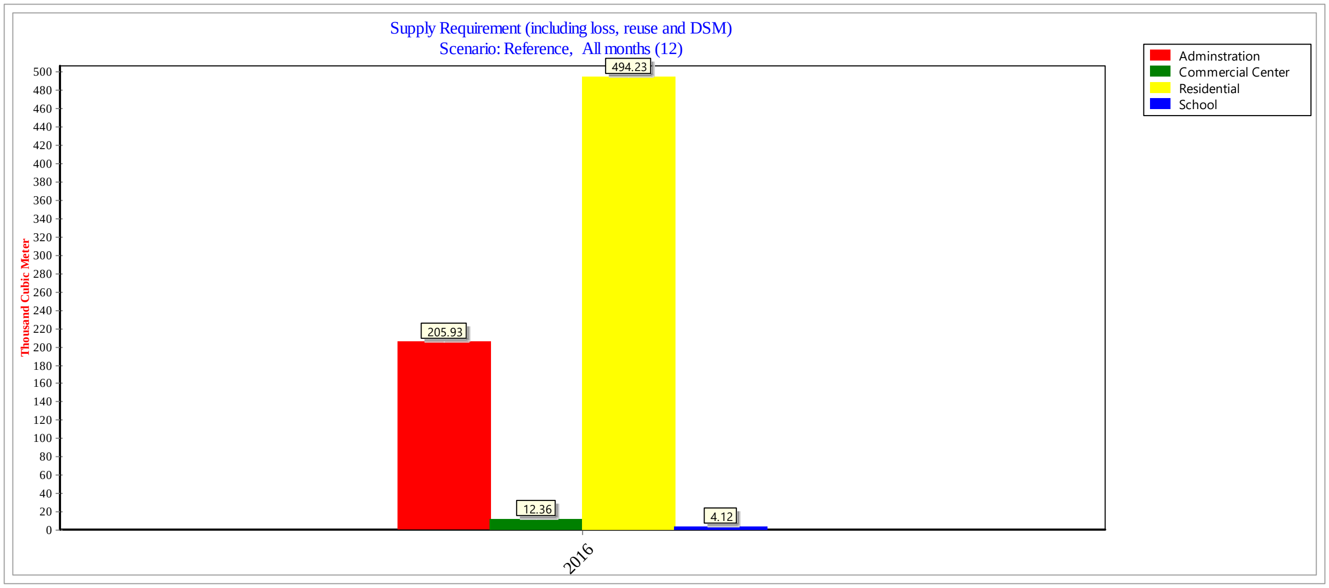

Figure 4.4: Annual water demand in current accounts year (2016)

The result shows that most of the total annual current water demand is consumed by Residential 417003 (95%) CM demand sites as compared to the commercial, 7413(1.7%), institution and School 15586(3.5%) so the total annual current water demand is 440,022.

4.3.2 Unmet Water Demand in the Current Year 2016

The unmet demand result showed that all most all water supply demand sites are fully supplied

Which has got 38% unmet demand? Demand site fell in water stress in the base year.

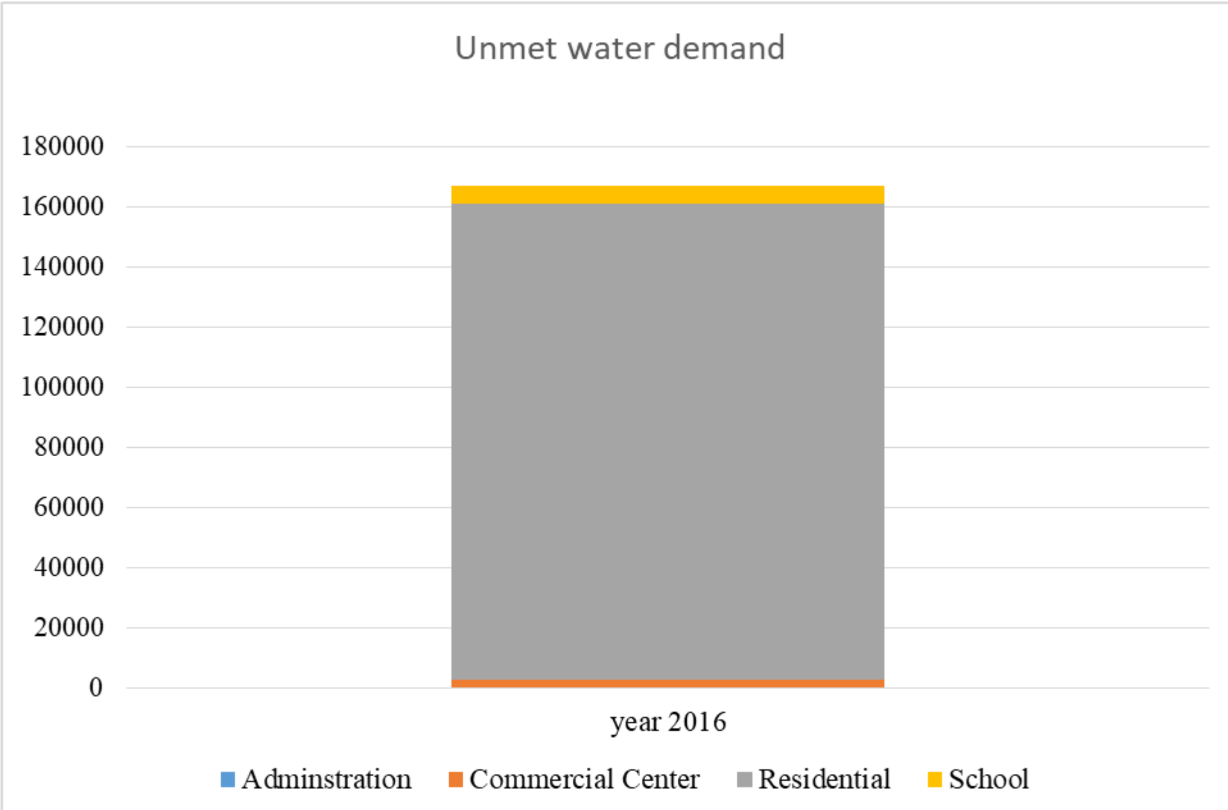

Figure 4.3: Annual unmet water demand in the current account year (2016)

The unmet water demand (demand minus water availability) increases over time the total unmet current water demand is 167277 CM. annual current water availability or supply (demand minus unmet demand) which has got 272744CM. This implies the overall coverage of supply is 62%.

4.3.3 Annual Water Demand Results of All Demand Sites (2016-2036)

After analyzing the demand in the current account year 2016, the population was projected to the future year 2036 and the demand was analyzed how it will look like in the near future. Using the current annual growth rate of 3.5% has been applied to human. Administration demand site accounts the least share of the total water supply demand .0004% in the current account year 2016 and .0034% in the year 2036. While Residential demand site accounts the largest share from the total water supply demand, that's 94.7% in the current account year 2016 and 96% in the year 2036. The water supply demand for all the water supply demand sites clearly grows from 440022 cubic meters in the current account year 2016 to 16376256 million cubic meters in the year 2036. . This is clearly due to population growth.

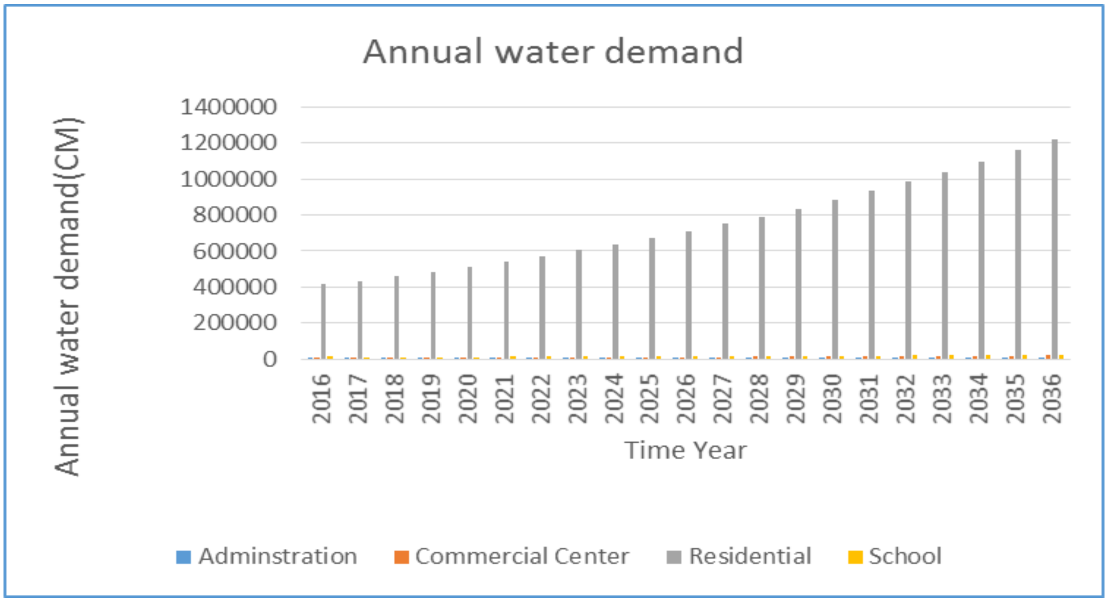

Figure 4.6: Annual Water demand for all demand sites (2016-2036)

WEAP estimates the water demand and the unmet water demand for every demand site alone taking in consideration the amount of supplied water to demand site, then adds the water demand or the unmet water demand for all demand site together at the end of every year.

4.4 Developed and Estimated Scenario

4.4.1 Reference Scenario

Reference scenario was developed from the current account year 2016 with future projections without intervention up to the year 2036. In this case, all variables remained constant.

Table 4.24: Reference Scenario

Reference Scenario											
		Water demand MillinCM					Unmet water demand MillinCM				
	Assumption	2017	2021	2026	2031	2036	2017	2021	2026	2031	2036
1	With no water supply development using 50l/cd current town use rate	0.45	0.56	0.74	0.97	1.27	0.18	0.3	0.5	0.77	1.13
2	With no water supply development using 100 l/cd	0.46	0.59	0.82	1.12	1.54	0.19	0.34	0.59	0.96	1.48

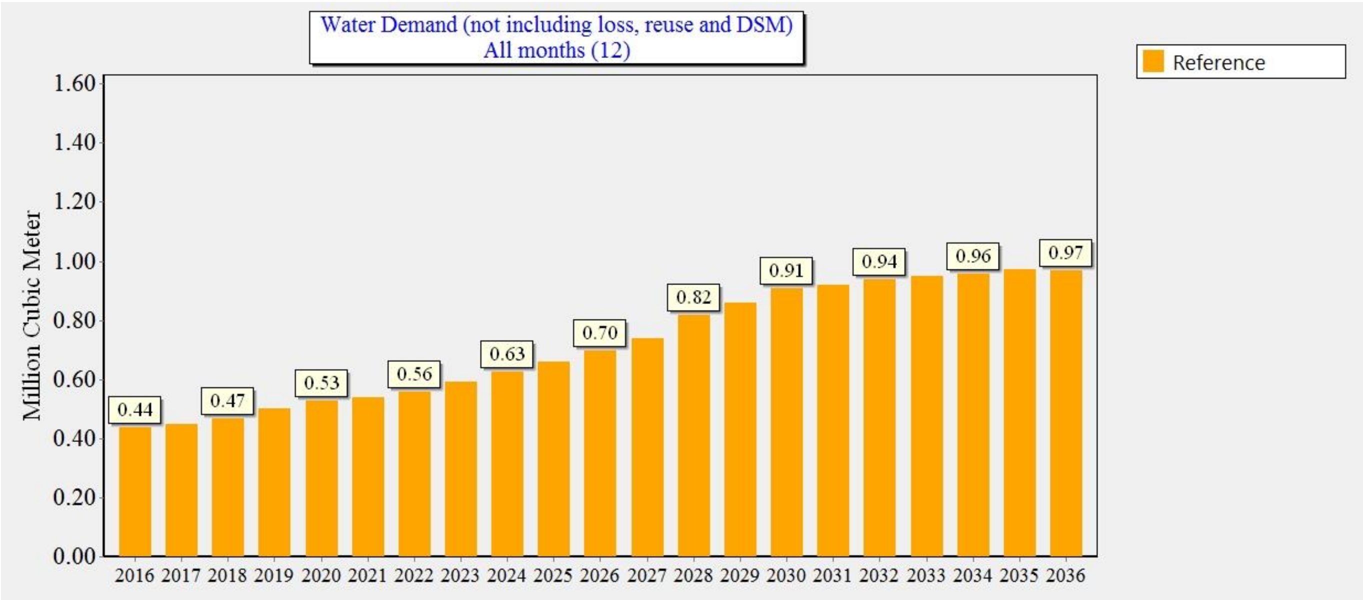

Figure 4.7: Annual water demand for the reference scenario (2016-2036MCM)

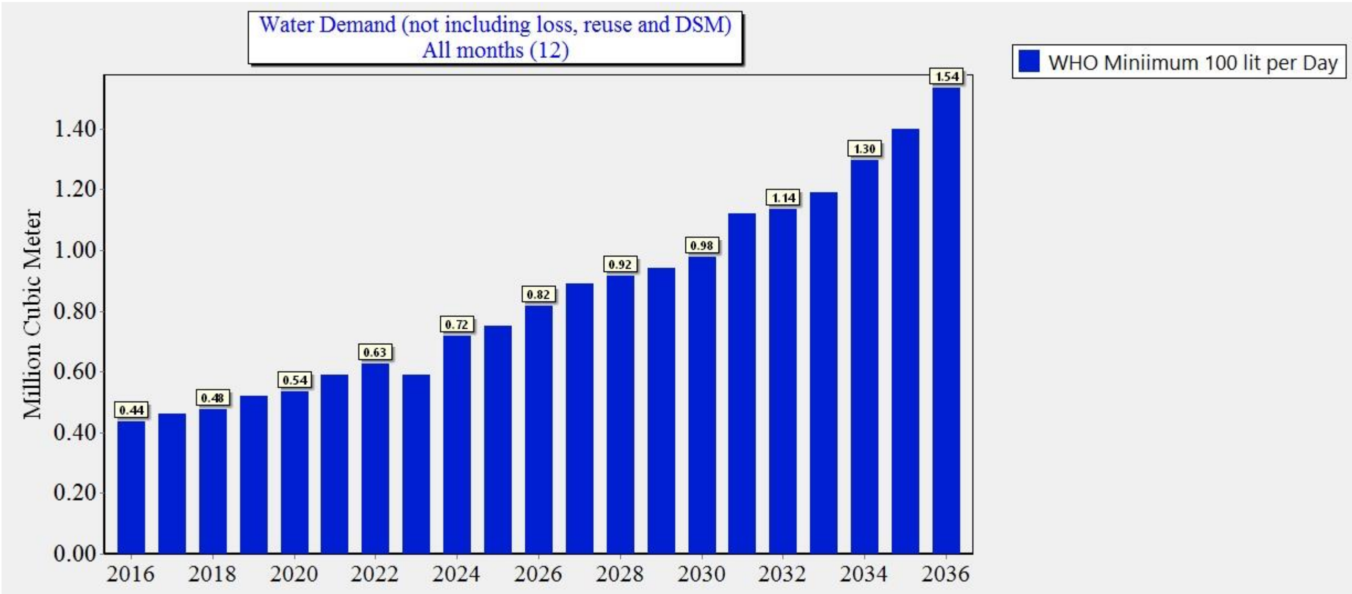

Figure 4.8: Projected water demand for using 100 l/c-d scenario

Figure 4.9: Projected unmet water demand for using 100 l/c-d scenario

WEAP provides the results (Table 2 in Appendix A, which shows the estimated water demand for the residential uses in-demand site). If these different demands are represented in a conceptual model it may be necessary to further subdivide the requirements. For example, it may be important to distinguish domestic demand that is largely influenced by tourism and residential domestic demand to take into account different underlying driving forces and demand patterns. (Dominik Wisser, 2004).

The reference scenario WEAP results indicate the following:

The total water demand will increase from 0.45 mcm in 2017 to .97 cm by the end of 2036 when using the current average use rate of 50 l/c-d. This increase is due to population growth only. However, if the use rate reaches the minimum standard of WHO which is 100 l/c-d, then the amount of water demand will increase by 10149.48 cm to be 490122.2 cm in 2017 and by 274779.7 mcm to be 1.54 mcm in 2036. The amount of unmet water demand will increase by .04 mcm to be .34 mcm in 2017, while for the year 2036 it will increase .35 mcm to be 8.26 mcm. The water supply demand is found to be increasing as the population increases in the reference scenario. Figure 4.12. Assures the usual trend.

4.4.2 High Population Growth Scenario

But what will happen if the population growth rate is set to a higher growth rate than the reference scenario population growth rate? In this case, the population growth rate was raised to 4.2% to simulate the water supply demand in the future.

Table 4.25: Population growth increase scenario

Population growth increase													
No.	by 4.2% growth	Water demand MillinCM						Unmet water demand MillinCM					
		2016	2020	2025	2030	2035	2036	2016	2020	2025	2030	2035	2036
1	With no water supply development using 100 l/cd	0.47	0.6	0.87	1.24	1.61	1.7	0.18	0.34	0.66	1.11	1.57	1.67

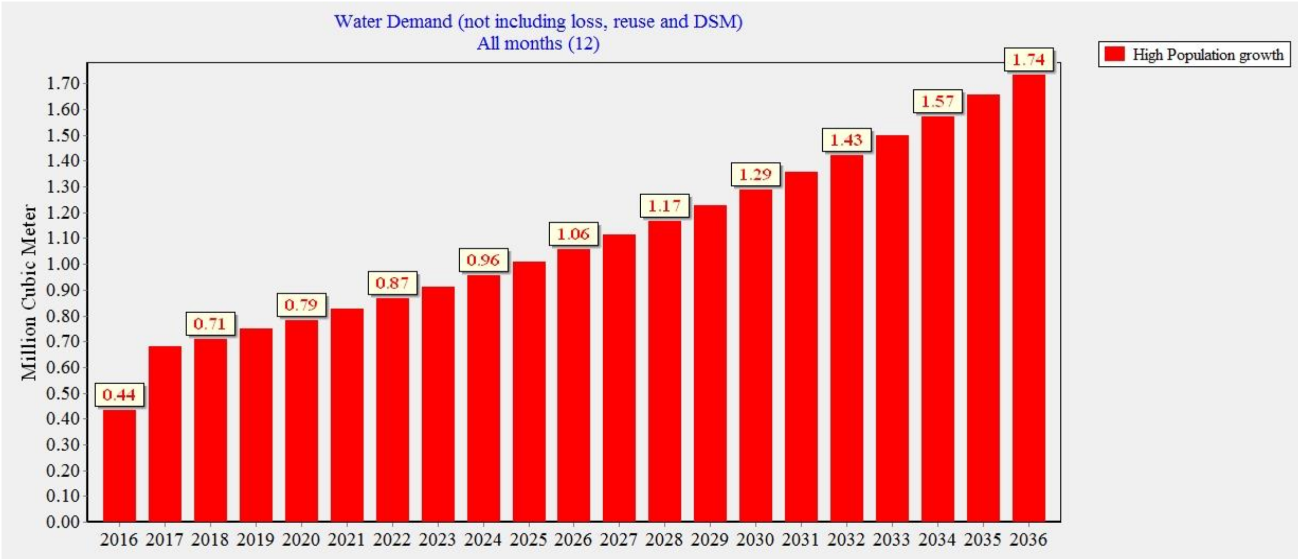

Figure 4.10: Annual water demand for high population growth scenario

As illustrated in Figure 5.14, the water supply demand increased to a higher level of increment than the reference scenario water supply demand showed. After population census performed in 2007, the growth rate of Awaday town shows an increased average of 3.5% growth rate used for reference scenario. Based on the 3.5 to 4.2%. This increase is due to the assumption of improving the city conditions (the highest socio-economic development of commercial centre) which encourages the immigration of the people to Awaday town. In addition, the placement of people from villages to the city is another cause of the increase in population growth.

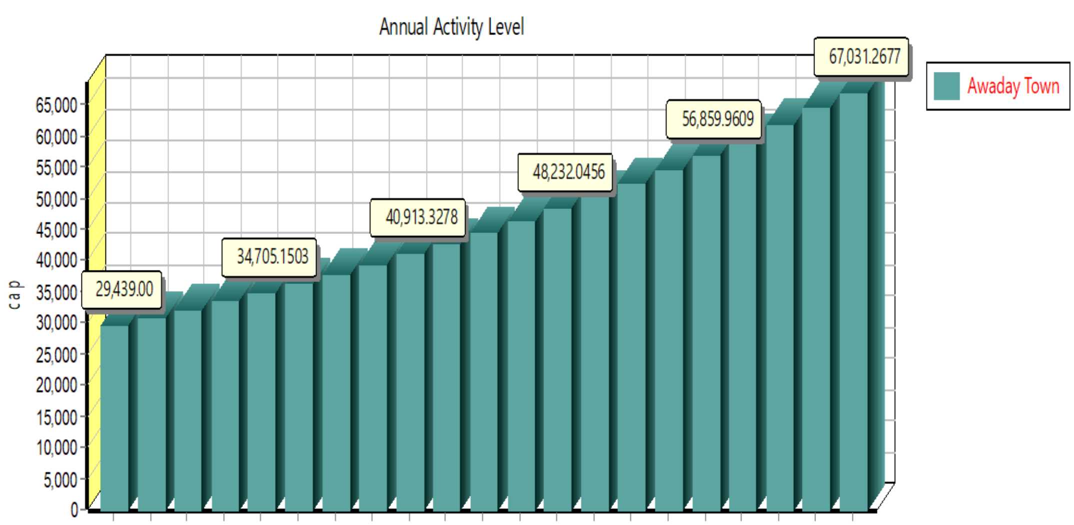

Figure 4.11: Population growth with 4.2% of the annual growth rate of Awaday Town

However, in this scenario because of urbanization the water requirements per person per year have been giving consideration on the urbanization rate. According to Basnyat (2007) based on the Ministry of National Planning (1988) and UNDP (2005) indicated that there is a clear trend of urbanization. The increase in population that turned from rural to urban between 1988 and 2005 is 15%, corresponding to an annual increase of 0.88 %. Therefore, his finding indicated that the average per capita water demands are raising too, just based on a change in lifestyle and water supplies.

Annual domestic water demand with an annual growth rate of 4.2% was used in this scenario was assumed that to be constant in all scenarios. The total human population number in 2036 will be estimated to be 67031 if 4.2% annual growth rate is applied while annual water use rates of domestic water demand per person, including industrial, commercial and institutional which was linked to the population were assumed to increase 1% due to urbanization, industrial and economic developments of the Awaday town 25.118 m^3person per year.

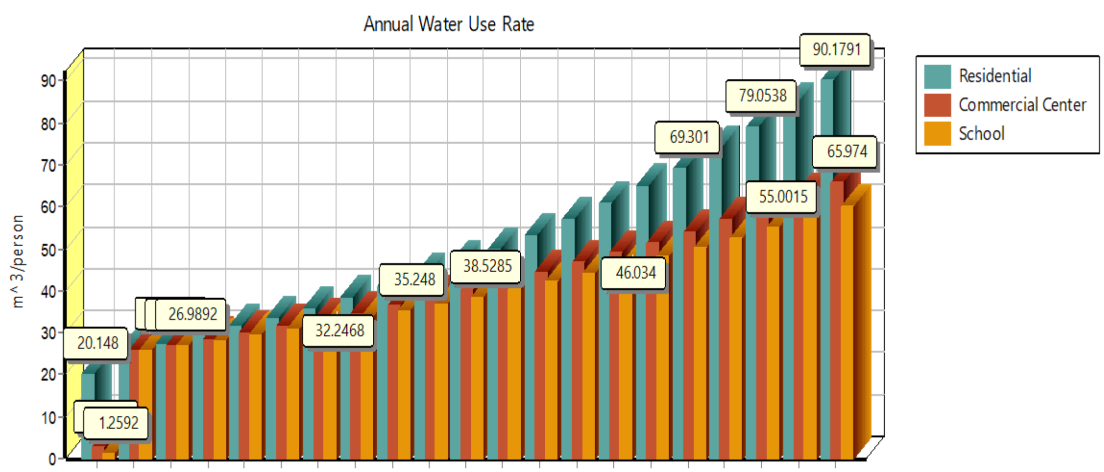

Figure 4.12: Annual water use rate for Awaday town

4.4.3 Climate change scenario

Climate change which is the change in the magnitude of a single climate parameter such as temperature. The assumption that there will be a decline in the yield of the water resources can be attributed to the potential impact of climate variability which may lead to a decline the well yield and groundwater recharge below the average values In this scenario the effect of climate change on water resources and the yield, and how this change will affect water supply and the unmet water demand were considered.

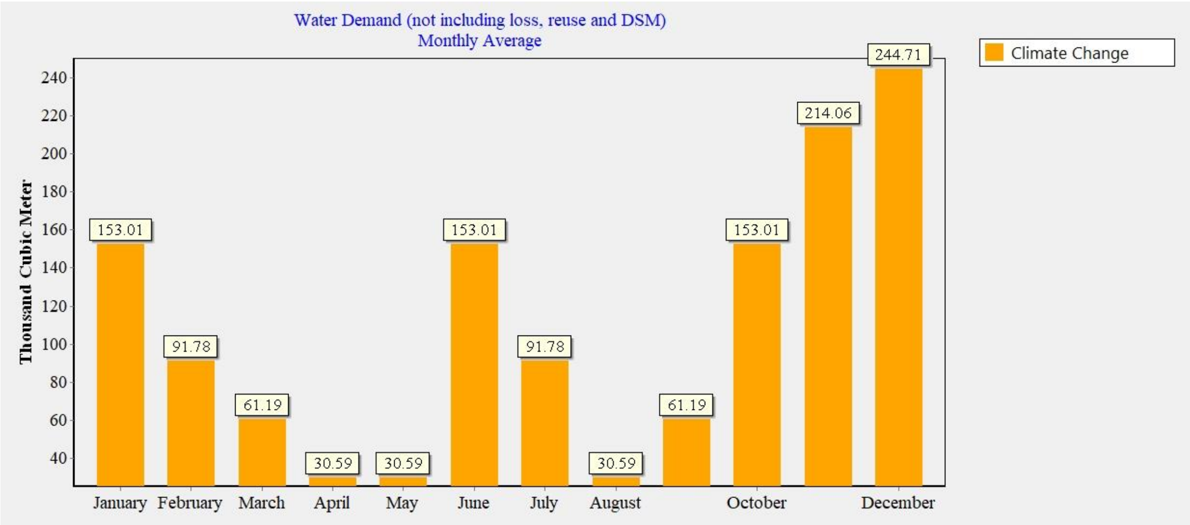

Figure 4.13: Average Monthly water demand due to Climate change

With a changing climate and increase of population, water demand may become more temporal and spatial aspect (Beatrice, 2008). So the yield of the well decline with only change temperature see the blow the fig 4.19according to climate variation from season to season, very low water consumption in winter months, but rises during summer months due to the increase in water use in bathing and cleaning, .Also, there is a variation in water consumption from one area in the city to another, which reflects the socioeconomic conditions.

Table 4.26: Climate change scenario.

Climate change scenario											
		Water demand MillinCM					Unmet water demand MillinCM				
		2017	2021	2026	2031	2036	2017	2021	2026	2031	2036
1	With no water supply development using 100 l/cd	0.46	0.55	0.69	0.86	1.07	0.25	0.29	0.37	0.71	1.01

Therefore, there are fluctuations in Well yield from month to month, season to season, and year to year. This variability relies largely on the groundwater recharge which in turn depends on the total rainfall and level of urbanization.

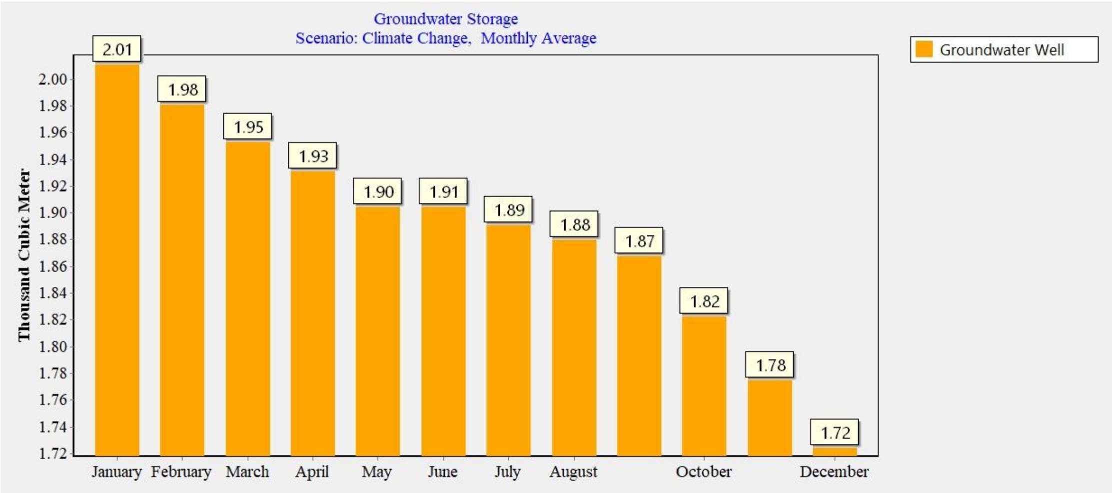

Figure 4.14: the ground water decline due to climate change.

4.4.4 Using WHO scenario

Table 4.27: Using WHO Scenarios

Using WHO Scenarios											
		Water demand MillinCM					Unmet water demand MillinCM				
		2017	2021	2026	2031	2036	2017	2021	2026	2031	2036
1	With no water supply development using 150l/cd	0.48	0.62	0.89	1.28	1.85	0.19	0.36	0.68	1.15	1.86

This is illustrated in (Figures 4.20 and 4.21), the per capita water availability will decrease to become approximately 28.9 l/c-d l/c-d at the end of the year 2036 if the available water remains the same and no new water resources will be developed (see figure 23).This decrease is due to the increase in water demand that accompanies population increase with the same water available. For the increase in population growth rate by 0.4%, the water demand increases by an amount of .04 mcm in the year 2017, and by an amount of 1.14 mcm in the year 2036.

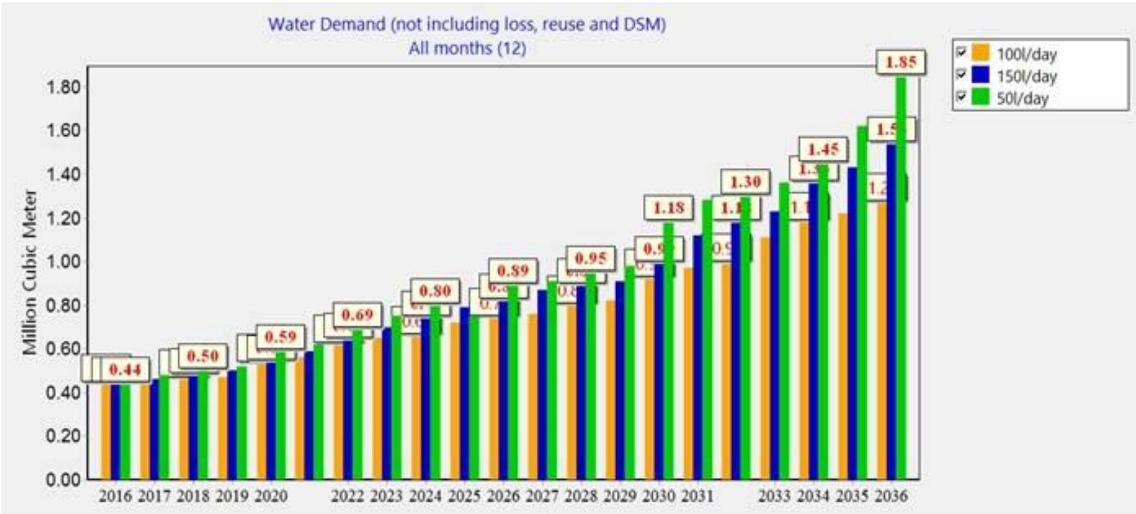

Figure 4.15: Water demand for 50l/day , 100l/day and 150l/day use rate .

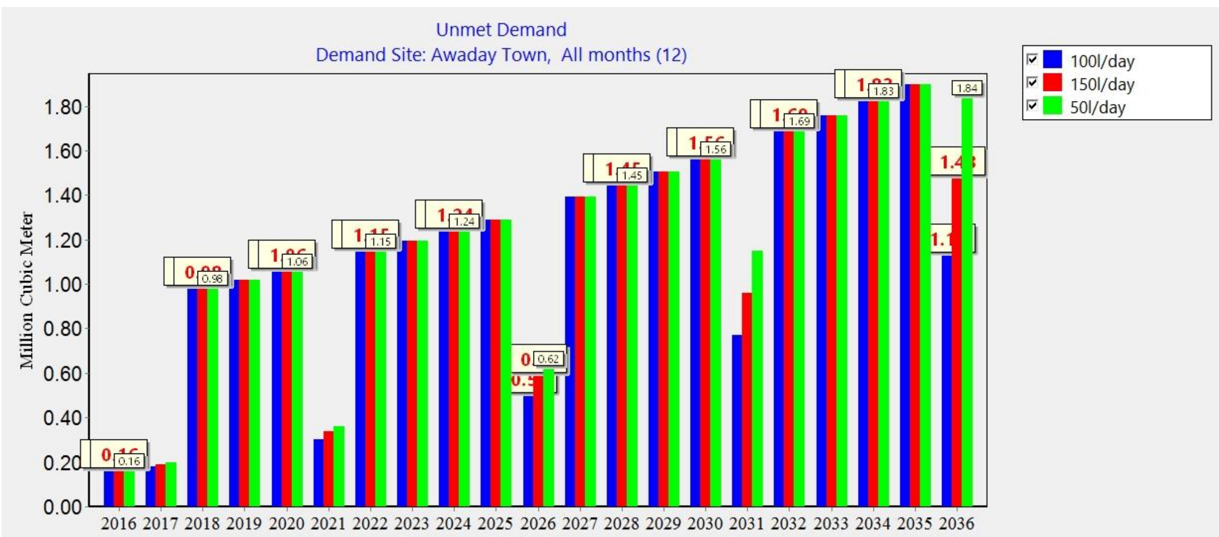

Figure 4.16: the unmet water demand 50l/day , 100l/day and 150l/day use rate

Using 150 l/c daily use rate scenario and when comparing the water demand for the different daily use rates in the year 2017 (see Figure 4.20) we got the following estimates 50 l/c-d are .45 mcm, 100 l/c-d are .46 mcm and 150 l/c-d are .48 mcm. The water demand when using 150 l/c-d has increased by an amount of .03 mcm when using 50 l/c-d and .02 mcm when using 100 l/c-d. Also the unmet water demand increased by an amount of .04 mcm when using 50 l/c-d, and by an amount .35 mcm when using 100 l/c-d (Figure 4.17)

5. Conclusion and Recommendation

5.1 Conclusion

Access to water is a major problematic condition in general in Ethiopia and East Hararghe zone specifically. Therefore, the main target of this study was investigating the existing of the water supply system and demands to the specific study area. The study was conducted at Haramaya district of Awaday administration town. The major livelihood of the communities was classified under farming, trading and self-employed working activities. More of the tenancy arrangement was self-owned. In the administration area, more than half of the respondent households were accessed to the Awaday water supply system.

However, the result indicated that access to the water supply is an irregular way. The problem is very serious in old resettled PA of Maya as compare to new resettled site. More than half of the respondent households were believed that there is no fair payment for the water pipe. However, most of the respondents were showed positive or willingness to pay more for water utilization. This is only agreed if there is a regular water pipe access on time and amount of need. So that most of the respondent households were not satisfied by the service provided in town.

Therefore, this implies that it is a weak water service provision by the government in the study area in general. The major water sources in the area; pipe, well, rainwater and other water sources. Among other than pipe water sources, well water source was a big share for household contribution. This implies that well water is a common water source in the area. The distance of water source was another challenge for the study area. From the scheduled distance, most of the respondent households were shared the highest distance among them for their water utilization. Some communities had developed an experience of store water utilization even if the stored water is not sufficient for daily usage. Therefore, in almost all PAs of the study area indicated that there is a critical problem with regard to access to store water for supply services in the daily needs.

The existing sources of potable water for Awaday has been underground water which reaches the customers through meter connection and public water points. However, since the source is only from underground water which is characterized by decreasing water table, especially during peak dry season, the amount of production is not adequate even for those who have access to it. The amount of production is also further reduced by less well working hour, a limited number of boreholes and loss by leakage.

Moreover, the state of water supply in the town in terms of coverage both in spatial and population, reliability, accessibility, and sustainability is not at the required standard. The rate of meter connection is low and the distribution system is inefficient. The major constraints of distribution system identified are the low density of pipelines network, a limited number of public water points and their unfair distribution, low capacity of reservoirs and inadequate pressure in the pipe. As a result, water consumption is affected in the town due to these physical factors in addition to socio-economic factors such as population growth, household income, and size that affected their water consumption. The water tariff set in the town is also not fair and did not cover the cost of the service to fulfil the principles of cost recovery. This is because of the fact that the price is not charged based on the volume of water consumption. After a certain limit of consumption, the customers pay a low price for a higher volume of water consumption. Such price charging subsidized the rich and favoured water vendors. The majority of the victims of the problem are the poor as they cannot afford the connection charges. Thus, it is observed that the water supply in the town is concentrated on traditional systems of service coverage, service pricing and mandated institutional arrangements for service delivery rather than identifying self-selection of the service type, consumers' willingness to pay, consumption-based service charging and emerging partnerships with NGO, CBOs and private sector.

Because of this poor functioning of the existing water supply service, most of the households in the town are willing to pay a higher price for improved water supply service if the government provides it. This prevalence of willingness to pay implies two things: there is further demand and the existing water supply service is not convenient for the customers so that they need better service at a higher price. Thus, AWSS office could have been generated sizable revenue if it could provide a better water supply than the existing one.

Therefore, the problems of water supply in Awaday town are multidimensional in terms of both efficiency and equity. Among the problems identified inadequate water supply, inequitable and inefficient distribution system, low coverage, unfair price, and the resultant limited consumption are the major ones. These problems imposed different challenges on inhabitants such as lose of time, energy and money; exposure to waterborne and related diseases which penalizes the poor medical cost and paya high price for water vendors. The result of the WEAP model shows that water supply demand is extremely increasing in the future due to the fast growing population. The water supply demand in the current account year 2016 is 440022 cubic meters while this demand grows to 16376256 million cubic meters in the year 2036; which corresponds to 26.8% increment. The unmet water demand (demand minus water availability) increases over time the total unmet current water demand is 167277 CM. annual current water availability or supply (demand minus unmet demand) which has got 272744CM. This implies the overall coverage of supply is 62%.

In water demand analysis, 62% of the supply requirement is met while only 38% is the unmet demand in the study area based on the demand sites considered in the current account year. The results show that the unmet water demand will continue to increase over the coming years. This is mainly due to the increase in population with limited water resources. Therefore, securing additional water supplies becomes an essential issue to meet the increase in water demand. The per capita water availability will decrease to reach approximately 28.9 l/c-d by the end of the year 2036 if the available water remains the same and no new water resources are developed this due to climate change. The development of additional groundwater wells for water supply is an influential option especially for the period from 2017 to 2036. Improving the water-related infrastructure of the city to decrease water losses is crucial in mitigating the water shortage problem

5.2 Recommendations

The result of the study indicates that the current water supply provision, demand, and accessibility are low standards in the town. Therefore, AWSSA should increase the distribution line to bring the system near to the residents in order to facilitate the people to get pipeline at close to their surroundings.

The municipality should support the establishment and expansion of water services by accessing the capacity of the AWSSA and the East Hararghe water, mines and energy office should provide the necessary supports (financial, materials and technical) to the activity to serve the people and alleviate the present and long term water shortages in the town. So, the municipality has to design strategies for a coordinated and organized intervention between different stakeholders such as the government, NGOs, community-based organizations, charity and religious organizations, and sanitation and hygiene problems and their consequences.

CBOs and Community participation is very low in the study area. So, these stakeholders should be encouraged in all parts like resource contribution; decision making and support implementation management. Therefore, this AWSSA and municipality should encourage and conduct a different investigation on urban infrastructures to identify the problems and improve plan which supports to solve the problems. The HWSSSE has to design strategies to bring together and involve different stakeholders such as the government, NGOs, community-based organizations and community at large to reduce of the poor water provision. The help of mechanism for water supply facilitate some budget/fund getting means and inviting different concerned bodies, businessman, community at large, NGOs and other stakeholders and in the town to improve the services.

Since this is the first time to use WEAP at the Town level, additional work should follow in this regard by other researchers in order to address all the outstanding issues including carrying out economic analysis. To better improve the outcome of this work, stakeholder involvement should be considered when executing similar work. It is highly recommended that Awaday town has a better and well-arranged database that summarizes and contains all the information regarding water use rates for the different sectors in the city. The city of Awaday should continue working on public awareness campaigns, though people are consuming an average amount of waterway less than the WHO standards. This is just to urge people to adapt to water availability.

6. REFERENCES

Alebele Bayrau (2002). Affordability and Willingness to Pay for Improved Water Supply in Urban Areas. A Case Study of Nazareth Town, Ethiopia.

Alfarra. (2004). Modelling Water Resource Management in Lake Naivasha, . The Netherlands, Amani (International Institute For Geo-Information Science and Earth Observation Enschede),.

Arranz, R. (2006). "Future water demands and resources in the Olifants catchment, South Africa: a scenario analysis approach using the WEA P model

Assaf (2008). "Generic Simulation Models for Facilitating Stakeholder Involvement in Water Resources Planning and Management: A Comparison, Evaluation, and Identification of Future Needs in Environmental Modelling, Software, and Decision Support."

Assefa Delesho (2006). Urban Water Supply, the Case of Assosa Town. Addis Ababa,Ethiopia

Assaf, H. M. and Saadeh ((2006).). Development of Integrated Decision Support System for Water Quality Control in Upper Litani Basin, American University of Beirut, Lebanon

Awaday(2016).awaday administration annual report.

AWSSA(2016).Awaday Water Supply Suwaraghe Aouthority Annual Report.

Basnyat, D. B. (2007). Water Resources of Somalia. Technical Report No W-11, FAOSWALIM,Nairobi, Kenya.

Beatrice, B. Y. (2008). Risk Assessment of a Water Supply System under Climate Variability.A Stochastic Approach. Civil Engineering. Ontario, Canada., Waterloo.

Bernd and Jone (1963). "Urban Water Supply Conditions & Needs In Seventy Five Developing Countries, Sanitary Engineer, Division of Environmental Health, WHO, Geneva & Consulting Engineer Savannah, Ga. The USA."

Bihok Kassa (2006). Household Water Supply and Factors Affecting Consumption Level: The Case of Mekelle Town. Addis Ababa, Ethiopia.

Bithas, K. and C. Stoforos (2006). "Estimating Urban Residential Water Demand Determinants and Forecasting Water Demand for Athens Metropolitan Area. ." South-Eastern Europe Journal of Economics 1 (2006) 47-59

Brighid, A. a. (2009). "Mapping For Water Supply and Sanitation (WSS) In Ethiopia, British Geological Survey.."

Brocklehurst 2000 and K. Vairavamoorthy2007 "Local ManaLocal Management Models for Water Supply and Sanitation for the Urban Poor Draft Workshop Report unpublished."

Chala Deyessa (2011). An Assessment of Urban Water Supply and Sanitation. The Case of Ambo Town. Addis Ababa, Ethiopia.

Charlotte C., Daene, et al. (2006). WEAP Hydrology Model Applied: . Texas, Center of Research in Water Resources.

Christine, J. a. (2002:81). "Small Community Water Supplies Technology,

People 86 Partnership, IRC International Water 86 Sanitation Center."

Dominik Wisser (2004). Water Management Methodologies for Water Deficient Regions in

Southern Europ.

Durga (2004:1). Multi-criteria spatial decision analysis for forecasting urban water requirements: a case study of Dehradun city, India.

Dzurik (1996). "water resources development planning."

FDRE (the Federal Democratic Republic of Ethiopia. (2011). . *Ethiopia's vision for a climate resilient green economy*. Green economy strategy.

Flint (2004). "The sustainable development of water resources, UCOWR. Journal of Contemporary Water Research and Education, 127: 41-54.."

Francis, L. (2010). "Determination of domestic water consumption pattern in Accra. Ghana, Accra.."

Froukh, Jones, et al. (1996). *Forecasting Urban Water Demand. F. U. W. Demand.* , American Water Works Association in Denver, USA.

Gelamo (2014). to assess the challenges of domestic water supply. The Case of Gimbichu town.Addis Ababa,Ethiopia.

Getachew Begashaw. (2002). Integrated water and land management research and capacity building priorities for Ethiopia, Proceedings of MoWR/EARO/IWMI/ILRI international workshop held at ILRI,. Addis Ababa, Ethiopia.

Gleik (1996). "the changing water paradigm: a look at twenty-first-century water resources development.."

Global Water Partnership (2000). Global Water Partnership Technical Advisory Committee, Background Paper no.4.

Harry, E. H. (2008). Water Supply Systems and Evaluation Methods. .US fire administration

Horgan and J (2003). *Modelling Water Consumption and Impact of Watering Restrictions*. Unpublished, University of Western Australia.

IRC (2003). "Community Water Supply Management, International Water 86 Sanitation Center, By Amsalu Negussie, Uganda."

Khatri and Vairavamoorthy (2007). "Challenges For Urban Water Supply 86 Sanitation In The Developing Countries, Delft, The Netherlands."

Vairavamoorthy, K. K. a., Seckler., et al. (1998,2007). Challenges For Urban Water Supply86 Sanitation In The Developing Countries. Delft, The Netherlands.

Khatri, Vairavamoorthy, et al. (2009). "Water Demand Forecasting for the City of the Future against the Uncertainties and the Global Change Pressures."

Korkeakoski (2006). A guide to sanitation and hygiene for those working in developing countries.Global dry toilet club. Finland.

Lévit., H., Sally, et al. (2003). Water Demand Management Scenarios in a Water-Stressed Basin in South Africa. South Africa.

Lifuo (2005). "Urban water provision in Maseru (Lesotho),A Geographical analysis.."

Mekonnen Abdisa., a. and R. Uttama Reddy. (2014). "ASSESSMENT OF POTABLE WATER SUPPLY IN AWAYDAY TOWN IN." journal vol.19 No.1.

Mengesha., M. (2008). Ecological sanitation and manure treatment as tools to improve water Hygiene University of Kuopio Department of Environmental Science, Finland.

Mouni, Z. M. (2011). "Application of Water Evaluation and Planning (WEAP): A Model to Assess Future Water Demands in the Niger River (In Niger Republic."

Nyarko B, O. N. and, et al. (2006). Optimizing social inclusion in urban water supply in Ghana.

Peter Ashton, sang, et al. (2003). "Handbook for the Assessment of Catchment Water Demand and Use."

Pieter van der Zaag , et al. (2003). Basic of water resources.

Rao (2002). Safe Drinking Water; the need, the problem, solutions, and an action plan. Report of the Third World Academy of Sciences, Italy.

Sechi and Sulis (2010). "Intercomparison of Generic Simulation Models for Water Resource Systems.."

Sieber, J., et al. (2005). WEAP a demand, priority, and preference driven water planning model: Part 1, model characteristics, Water International, 30(4), 487-500

Simonovic (1996). "Decision Support Systems for Sustainable Management of Water Resources2. Case studies." Water International 21No4( ).

UN (2006). "Coping with Water Scarcity-A strategic Issue and Priority for System-Wide Action, UN Thematic Initiatives, New York."

UNDP (2005). the millennium development goals report 2005, New York, USA

UNESCO (1998). world water resources a new appraisal and assessment for the 21st century.

UNICEF;, W. a., A. a. Brighid, et al. (2008, 2009). A snapshot of Drinking Water and Sanitation Target, A Regional Perspective Based on New Data From The WHO/UNICEF Joint Monitoring Programme For Water Supply 85 Sanitation.

Vairavamoorthy, K. K. a., Seckler., et al. (1998 , 2007). Challenges For Urban Water Supply 86 Sanitation In The Developing Countries. Delft, The Netherlands.

Wallace, T. B. (2001). "A Procedure for the Preliminary Assessment of Water Supply Availability."

WHO(2010a): Strategies For The Safe Management of Drinking Water For Human Consumption, World Health Organization, Executive Board, 127th Session, Provisional Agenda Item5.4.

WHO (2006b). Water Sanitation and Health (WSH) water, sanitation and hygiene links to health, Facts, and figures. , Geneva, Switzerland.

WHOandUNICEF(2008): A snapshot of Drinking Water and SanitationTarget, A Regional Perspective Based on New Data from the WHO/UNICEF Joint Monitoring Programmed for Water Supply 85Sanitation.

WSM (2010). "Water Service Management Core Group." E: \water service management.html.

WUP (2003). Better Water and Sanitation for the urban poor. Good practice document from sub-Saharan Africa, Water Utility Partnership for Capacity Building in Africa

Zegeye Zagie (2010): Cause of Water Supply Shortage, the Case of Arbaminch Town, M.A. Thesis, AAU, CDS.

7. APPENDIX A

WEAP applications generally include several steps:

- **Study definition**: The time frame, spatial boundaries, and system components are established.
- **Current accounts**: Actual water demand, pollution loads, and available resources and supplies for the system.
- **Scenarios and options**: A set of alternative assumptions about future impacts of policies, costs, and climate (on water demand and supply, hydrology, and pollution) can be explored.
- **Evaluation**: The scenarios are evaluated with regard to water sufficiency, costs, and benefits

Table 1 **Average monthly well data for town demands**

month	pumping well
Jan-16	842.4
Feb-16	561.6
Mar-16	561.6
Apr-16	561.6
May-16	561.6
Jun-16	351
Jul-16	351
Aug-16	351

Sep-16	351
Oct-16	842.4
Nov-16	842.4
Dec-16	842.4

Table 2: The estimated water demand for the residential uses in-demand sites

year	Water demand (m3)
2016	417003.558
2017	435937.8776
2018	460264.7369
2019	485949.1202
2020	513066.7819
2021	541697.7041
2022	571926.3319
2023	603841.823
2024	637538.3101
2025	673115.1792
2026	710677.3621
2027	750335.6463

2028	792207.0016
2029	836414.925
2030	883089.8052
2031	932369.3072
2032	984398.7778
2033	1039331.675
2034	1097330.02
2035	1158564.876
2036	1223216.851

Table A-3: Annual Sectorial Water Demands for Domestic Different scenario

year	Reference scenario		High population scenario	climate change scenario	using WHO scenario
2016	440022.1544		440022.1544	440022.1544	440022.1544
2017	454758.224		471391.6844	459957.881	459807.0486
2018	479972.6911		509962.3961	480796.8687	494729.3809
2019	506587.0151		551281.5446	502580.0452	532309.425
2020	534678.9926		595531.2894	525350.1925	572749.7654
2021	564330.7469		642905.3351	549152.0317	616268.4481
2022	595628.9693		693609.6414	574032.3099	663100.162

2023	628665.1729		747863.1758	600039.8927	713497.5103
2024	663535.9612		805898.7112	627225.86	767732.3791
2025	700343.3114		867963.6717	655643.6061	826097.4113
2026	739194.8735		934321.0289	685348.945	888907.592
2027	780204.2859		1005250.252	716400.2199	956501.9567
2028	823491.5091		1081048.315	748858.4175	1029245.428
2029	869183.1771		1162030.764	782787.2882	1107530.797
2030	917412.9692		1248532.848	818253.4713	1191780.848
2031	968322.0023		1313980.845	855326.6257	1282450.657
2032	1022059.244		1382859.622	894079.5666	1380030.056
2033	1078781.952		1455349.019	934588.4093	1485046.291
2034	1138656.133		1531638.306	976932.7178	1598066.882
2035	1201857.03		1611926.671	1021195.662	1719702.703
2036	1268569.638		1696423.747	1067464.179	1850611.293

Table –A-4Unmet demand different scenario

Table -A -4 unmet demand different scenario

year	refarance	High Population growth	clamate scenario	WHO Maximum 150 lit per Cd
2016	166659.6	167277.3	167277.3	167277.3
2017	181721.9	203126.4	251102.8	190307.1
2018	205714.8	245697.9	210575.6	228917
2019	230547.6	291368.7	234656.1	270387.2
2020	255412.4	339083.5	258614.3	313907.9
2021	283852.7	393400.5	286095.8	363195
2022	312389.1	452402	313557.4	416911.6
2023	342313.9	515484.2	278803.3	475524.9
2024	372428.4	582360.9	307396.9	537415.3
2025	407871.6	657539.4	340212.7	607624.3
2026	444022.5	736586.7	373037.7	682481.2
2027	481876.2	821196.1	407360.2	763071.3
2028	520378.9	910334.5	586122.4	848586.1
2029	563134	1008015.6	627490.1	943050.4
2030	607729.8	1112096.3	669780.8	1043474.8
2031	654380.3	1193596.9	713946.8	1154263.3
2032	702138.4	1278556.1	759240.3	1275037.4
2033	754521.9	1370411.7	849161.8	1407458.9
2034	808156	1465708.6	902113.5	1548686.7
2035	864313.2	1566110.3	957446.4	1700762.9
2036	921993.4	1670555.2	1014414.9	1863341.3

Questions

JIMMA UNIVERSITY

JIMMA INSTITUTE OF TECHNOLOGYSCHOOL OF GRADUATE STUDIES

Hydraulic and Water Resources Engineering Hydraulic Engineering Msc Program

Assessing Existing Water Demand and Supply Patterns and Rate of Consumption source of Water Supply in Awaday Town

This questionnaire is in support of a study for the award of MS **Hydraulic Engineering**. The result is purely academic and will be treated with utmost confidentiality.

Number---Date---------------

I. Questions answered by sample Households.

SECTION A: PERSONAL DATA

1. Community:

a. Walenbo [ ] b. Jawaro [ ]

c. New expansion site [ ] d. Maya [ ]

2. Sex:

a. Male [ ] b. Female [ ]

3. Age (in years):
4. Marital Status:

a. Single [ ] b. Married [ ] Consensual Union [ ]

d. Separated [ ] e. Divorced [ ] f. Widowed [ ]

5. Religion

a. Christian[ ]b. Muslim [ ] c. Traditional [ ] d. Other [ ] ....

6. What is your highest educational attainment?

a. None [ ] b. Non-Formal Edu. [ ]c. Primary[ ] d. Middle/JSS [ ]

e. Secondary [ ] f. Tertiary [ ] g. Other (specify) [ ]

7. What is your main occupation?

a. Farming/Fishing [ ]b. Trading [ ] c. Civil/Public Servant[ ]

d. Artisan [ ]e. Self employed [ ] f. Other [ ]

8. Are you engaged in any other income earning activity?

a. Yes [ ] b. No [ ]

9. If yes, what is it? ---------------

10. How much on average do you earn in a month?

a. <Br 200[ ] b. Br 200 - 500[ ] c. Br 500 – 1000 [ ]

d. Br 1000 - 1500 [ ] e. >Br 1500[ ] f. Other

11. What house type do you live in?

a. Compound [ ] b. Detached [ ]

c. Semi-Detached [ ] d. Apartment [ ] e. Other [ ]

12. Tenancy Arrangement

a. Landlord/landlady [ ] b. Rent [ ] c. Caretaker [ ] d. Free Co-habitation [ ] e. State owned [ ] f. Self owned

13. Household Size:

14. Which type of toilet facility do you have in your house?

a. Water closet [ ]b. Pit latrine [ ] c. Bucket[ ]

d. Public toilet [ ] e. Other

B. POTABLE WATER DEMAND AND SUPPLY CHARACTERISTIC B1: SUPPLY

15 Are you connected to Awaday water supply system (AWSS) distribution network?

a. Yes [ ] b. No [ ]

16. Do you have a water meter?

a. Yes [ ]   b. No [ ]

17. If yes, do you receive your bills regularly?

a. Yes [ ]   b. No [ ]

18. How much do you pay for pipe tolerated water in a month?

19. How many times in a week do you receive water supply

a. Everyday [ ]   b. 5 -6 times [ ]   c. 3 – 4 times [ ]

d. 1 -2 times [ ]   e. irregular [ ] f. none [ ]

20. What will you say about the quality of the water that you get from AWSSA?

a. Good [ ]   b. Salty [ ]   c. Coloured [ ]   d. Bad odour [ ]

e. Has some particles inside [ ]   f. Other

21. Do you boil your water from AWSSA before use? If

a. Yes [ ] why------------------------------------

b. No [ ] why ------------------------------------

22. Which of the following categories of water do you drink?

a. Pipe-water [ ]   b. Boiled water [ ]   c. Sachet water [ ]

d. Bottled water [ ]   e. Other

23. Do you think it is important to pay for water?

a. Yes, definitely [ ]   b. Yes, perhaps   [ ]   c. Not really [ ]

d. No, definitely [ ]   e. Don‘t Know   [ ]

B2: DEMAND

24. What is the estimated total quantity of pipe-borne water used by your household per day? *(20 litres =)*

a. Less than 20 litres [ ] b. 20-50 litres [ ] c. Over 50 but less than 70 litres [ ]

d. Between 70-100litres [ ] e. 100-150 litres [ ]f. More than 150 litres [ ]

25. Are you satisfied with the level of water service provided by AWSS in your community? a. Yes,

a. definitely [ ] b. Yes, perhaps[ ] c. Neutral [ ]

d. No, not really [ ] e. No, definitely [ ]f. Don‘t Know [ ]

26. If not, what problems are you experiencing with the service?

a. Leaking pipes [ ] b. Days without water [ ] c. Poor water quality [ ]

d. No water supply [ ] e. Illegal connection [ ] f. Other

27. Do you have any of these in your home?

a. Lawn [ ] b. Garden [ ] c. Trees[ ]

28. If yes, which of them do you water?

a. Lawn [ ] b. Garden [ ] c. Trees [ ] d. None [ ]

30. Do you take measures to reduce water use in the above activities? a. Yes [ ]b. No [ ]

C.WATER MANAGING MECHANISMS

29. Apart from Pipe borne water supply what other source(s) of domestic water supply do you rely on?

a. Rainwater [ ] b. Neighbor [ ] c. Vendor Services [ ]

d. Tanker Services [ ] d. Borehole [ ] e Well. [ ] f. Dam/River/Lake/Pond[ ]

g. Other

30. Do you share this other water source with other people?

a. Yes [ ] b. No [ ]

31. What is the distance of this water source from where you live?

a. Less than 50 metres [ ] b. 50-100 metres [ ] c. 101 - 200 metres [ ]

32.How much does it cost compared to pipe borne water?

33. How often do you access water from these source(s)?

a. Every day [ ] b. At least once a week [ ] c. At least once a month [ ]

d. Occasionally [ ] e.other ....

39. Do you store water in your home?

a. Yes [ ] b. No [ ]

40.If yes, what kind of storage equipments do you use in your home? Please explain

42.How often do you clean your storage containers? ....

43.Is your stored water enough to meet your daily needs? Y/N

Are there seasonal differences (rainy or dry) in water availability to your community?

a. Yes [ ] b. No [ ] c. Don't know [ ]

II. Questions answered by Officials.

Personal information

Age ____sex ________your responsibility or position in the organization _____ years of experience in the office ______________

II. Questions answered by Awaday Town Water Supply and Sewerage Service Authority

1. How about accessibility, adequacy and affordability of water to the urban dwellers?

2. How do you measure household's water service accessibility adequacy and affordability?

3. What is/are the source/s of water to urban dwellers in the Awaday Town? is /are it they

enough to meet the current and future water demand of the town?

4. What strategy is set by your office to provide improved water and facilities to the urban dwellers?

5. What are the prerequisites an individual fulfilling to have private connections?

6. Do you think that these prerequisites limit the individuals to have private connection?

7. If your answer for Q7 is yes, what do you think the solutions?

8. What are the challenges in providing improved water services to the urban dwellers?

9. What measures should be taken to overcome the problems?

10. Is there any water related problems on the life of the urban dwellers and the environment?

11. If your answer for Q11 is yes, what are they and what should be done to solve the problems?

12. Is there water shortage/interruption in your town?

13. If your answer for Q13 is yes, how often and how long? What do you think the causes of interruption and what solution do you have on the time?

14. Have you ever encountered any claim related to water and sanitation from urban dwellers?

15. Is there any other institution (NGO, civil society organization, community organization etc) and local community, which participate in water and sewerage provision activities in Awaday Town?

16. If your answer for Q16 is yes, what are their participations?

In general, how do you rate the overall water and sanitation facilities in Awaday

III.FGD for Members of the water board

1. Do you think there is institutional capacity problem in the water supply service office?

2. Did the water service, town administration or municipality invest on town water expansion?

3. How does the board facilitate in capacitating (human and material) the water service

3. Is the water service profitable?

4. If not what is the reason behind?

5. Is there coordination among stakeholders of the water supply

6. What are the major causes of water supply shortage problem in the town?

7. What socio economic impact do you see due to the water supply shortage?

8. What solution do you recommend for the water supply shortage?