MEKELLE UNIVERSITY

Graduate Studies Program
College of Social Science and Languages
Department of Geography and Environmental Studies

GIS Based Assessment of Rural Potable Water Access: In Ahferom Woreda, Tigray, Ethiopia

By

Gebrewahd Brhane

A Thesis submitted in partial fulfillment of the requirements of Master of Science in Geography and Environmental Studies: Specialization in GIS and Remote Sensing

Main Supervisor: Tesfayohannes Hailu (PhD)

Co-Supervisor: Ato Solomon Hishe (M.Sc.)

Mekelle University
July, 2014

DECLARATION

This is to certify that, the thesis entitled as **GIS Based Assessment of Rural Potable Water Access in Ahferom Woreda** submitted in partial fulfillment of the requirements for the award of masters degree in Geography and Environmental Studies: **Specialization in GIS and Remote Sensing** to the School of Graduate Studies, Mekelle University, through the Department of Geography and Environmental Studies, is done by **Mr. Gebrewahd Birhane Gebreyesus, Id. No CSSL/PS060/04.** It is his legitimate work carried out by himself under our supervision. The work has not been submitted earlier for the award of any degree or diploma to the best of our knowledge and faith.

Name of the student: Gebrewahd Birhane Gebreyesus,

Signature: _____ Date: _____

Main Supervisor: Tesfayohannes Hailu (Dr)

Signature: _____ Date: _____

Co-Supervisor: Solomon Hishe (M.Sc.)

Signature: _____ Date: _____

Mekelle University
Department of Geography and Environmental Studies
GIS and Remote Sensing Postgraduate Program

GIS Based Assessment of Rural Potable Water Access: In Ahferom Woreda, Tigray, Ethiopia

By:
Gebrewahd Brhane

Approved by Board of Examiners

	Signature	Date
1. H/mariam Meaza(Chairman)	_____	_____
2. Dr. Senbete Toma (External Examiner)	_____	_____
3. Biadglign Demisse (Internal Examiner)	_____	_____
4. Dr. Tesfayohannes Hailu (Main-Advisor)	_____	_____
5. Solomon Hishe (Co-Advisor)	_____	_____

ACKNOWLEDMENTS

First and for most, I would like to praise the almighty God for his overall bounteousness. Next I would like to present my thanks to my main supervisor Dr. Tesfayohannes Hailu and co-supervisor Ato Solomon Hishe for their family hood treatments, close supervisions, guidance and constructive comments in all activities from data gathering to accomplishment of my thesis unless, this thesis would not have been possible to complete.

A Heartfelt thanks also goes to my family, friends (Miftah Ebrahim, Wel-day Bruk, Abraham Taffere…) and others who have contributed on the success of my work.

My warmest gratitude goes to staff members of Ahferom Woreda Water Resource Management Office in giving reliable and relevant data.

I would also like to present my thanks to Ato Tesfu (REST coordinator) and who gave me valuable vision for my works.

Lastly but not least, I would like to present my thanks to Ato G/meskel Aregawi (IT Teacher) for his continuous technical support and his motivation and to Ato Haile Belay(School principal).

Gebrewahd Brhane

TABLE OF CONTENTS

Contents **Page**

Tables **Page**

Figures **Page**

ACRONYMS

ADB	African Development Bank
ADF	African Development Fund
AWED	Ahferom Woreda Education Department
AWHO	Ahferom Woreda Health Office
AWWRMO	Ahferom Woreda Water Resource Management Office
BoFED	Bureau of Finance and Economic Development
BoWR	Bureau of Water Resource
DWA	Department of Water Affairs
EWRMP	Ethiopian Water Resource Management Policy
FAO	Food and Agriculture Organization
FEDAW	Finance and Economic Development of Ahferom woreda
FEDB	Finance and Economic Development Bureau
FWSPs	Functional Water Supply Points
GPS	Geographic Positioning System
JMP	Joint Monitoring Program
MDGs	Millennium Development Goals
MoWR	Ministry of Water Resource
NFWSPs	Non-functional Water Supply Points
NGO	Non-Governmental Organization
O&M	Operation and Maintenance
REST	Relief Society of Tigray
RSU	Reform Support Unit
RWS	Rural Water Supply
RWS	Rural Water Supply
RWSS	Rural Water Supply and Sanitation
RWSS	Rural Water Supply and Sanitation
SPSS	Statistical Package for Social Science
UN	United Nations
UNDP	United Nations Development Program
UNICEF	United Nations Children's Emergency Fund

WaSH	Water Supply Sanitation and Hygiene
WHO	World Health Organization
W.S/W.P	Water Schemes/Water Points
WaSHE	Water, Sanitation and Hygiene Education

Abstract

Access to a safe and affordable water supply of drinking is universally recognized as a basic human need for preset generation and precondition for the development and care of the next. But, many Tigray rural communities are suffering from lack of safe drinking water supply facilities specifically in Ahferom woreda. So, in order to realize the severity of shortage of safe water in the rural community and to find timely solutions it is important to take an assessment on the existing accessibility situation of the woreda. To do that, detail accessibility assessment has been taken in the issues of: Type of water technologies introduced to the woreda, growth trend of water schemes, spatial coverage of water schemes and ratio to the beneficiaries, accessibility coverage of safe water in relation to regional standard and the determinant factors for the non-functionality of water schemes were detail analyzed. To do that spatial and non-spatial data were collected from primary and secondary and analyzed using buffer, descriptive statistical tables and graphs and by visualizing the results in the map. As a result, the study identified 520 water schemes spatially distributed in the study area. Of the total, 396(76.2%) and 124(23.8%) were functional and non-functional water schemes respectively. The basic reasons for non-functionality of water schemes were: lack of ownership in the beneficiaries, weakness in maintenance and operation system, lack of spare part accesses and quality, poor financial capacity of the community to repair the breakdown water schemes and for different activities, Lack of training to the water committee and poor management system were accepted by the respondents as key problems to the non-functionality of water schemes in their district. And also the study found that, three types of potable water technologies: Hand dug well, Shallow well and protected springs were introduced to the study area. Hand dug well covered majority of the woreda, 62 percent followed by shallow well 26 percent and protected spring 11.9 percent. In Ahferom woreda the spatial coverage of water schemes and the ratio to beneficiaries in 2013 was, one water scheme to 3.25 square kilometers area and 2.36 water schemes to 1000 beneficiaries. The actual average potable water per capita (L/d) of the beneficiaries in the rural area was 7.6 l/d. Therefore, in contrast to the regional standard (15 L/d) the consumption level of the Woreda is below the regional standard. Also the distributions of water schemes have not equity to the existing population and to the given area. The accessibility coverage as a standard within 1.5km radius of travel distance and 15 l/day also analyzed and the result was found below the regional coverage which is only 39%(65,463) population were within 1.5km radius and 15 L/day access. The growth rate of water schemes was also analyzed and the result showed an increment from time to time but not in similar ranges throughout the four of the five years plan of the woreda. But, a steady increment has been observed in the first five year (1996-2000) with 91.4 percent and second five years (2001-2005) with 13.1 percent. In general the average growth rate of water schemes throughout the twenty years was 23.7 percent

UNIT- ONE

INTRODUCTION

1.1 Background of the Study

Water is life in general and potable water in particular is essential for life, health and human dignity. Access to water is a fundamental need and constitutes one of the most important human rights. But most rural areas in the developing world and in hilly and mountainous regions suffer from acute shortage of water both in quantity and quality (WHO, 2012).

The question to the accessibility of safe drinking water and sanitation is a global concern. However, comparatively with the developing and developed countries, developing countries like Ethiopia, have suffered from lack of access to safe drinking water from improved sources and to adequate sanitation services (WHO, 2006). As a result, people are still dependent on unprotected water sources such as rivers, streams, springs and hand dug wells. Since these sources are open, they are highly susceptible to flood and birds, animals and human contamination. Demand for clean water increases continually in line with world population growth. People in many areas of the world lack fresh, drinkable water essential to their survival. According to the world health organization and United Nations International Children's Emergency Fund, in 2010, only 63% of the world's population used improved sanitation facilities, with sub-Saharan Africa and southern Asia having only 30%and 41% respectively. It is common that people who are most vulnerable to water-borne diseases are those who use polluted drinking water sources. The report from UNICEF (2010), shows that in the world 884 million people use unimproved drinking water sources in 2010, and in 2015 it estimates about 672 million people will still use unimproved drinking water sources. The WHO (2000) revealed that seventy five percent of all the diseases in developing countries arise from polluted drinking water. The lack of access to water also limits sanitation and hygiene practices in many households because of the priority given for drinking and cooking purposes.

An improved drinking water source is defined as a type of drinking water facility or water delivery point that by the nature of its design protects the drinking water source from external contamination, particularly which can be piped into dwelling, plot or yard, public tape/stand pipe, tube well/borehole, protected dug well, rain water collection and protected springs (Van Norden 2007) as cited by Sutton, 2008). 3 Unimproved sources include unprotected dug well,

unprotected springs, tanker truck, surface water (river, dam, lake, pond, stream, and irrigation canal), and bottled water (Van Norden 2007 by Sutton, 2008).

In Africa, millions of women and children travel long distance daily to fetch water. On average a member of the house hold (commonly women and their children) often go for almost half an hour to reach the water source, fetch water and return. Children's education and gender equality are jeopardized (WHO and UNICEF, 2006).

According to an ADF (2005) report, the Millennium Development Goals (MDG) objective of Ethiopia is to increase the improved water sources coverage from 2004 levels of 25% water supply and 8% sanitation to 62% water supply and 54% sanitation by 2015.

So as to succeed these and others objectives, governmental and non-governmental organizations made efforts to construct improved sources to provide access to safe and potable drinking water.

Despite of these efforts, improved water sources are often located far from user households, and due to the undulating nature of the country's topography, water sources often occur at inconvenient locations, forcing people to travel long distances over continuous short and long steep slopes. This resulted in more waiting times, inadequate supply, lack of income and lack of quality being the characteristics of many improved schemes (Admasu et al., 2002). In relation to this, even after they get rest from their social obligations, such as collecting fire wood, fetching clean water and preparation of food, they can not involve in socio-economic and Educational activities because, they are too tired of those home tasks. Consequently, they leave school and finally are exposed to early marriage; bringing children in their childhood age and other related problems.

The WHO (2000) reports that polluted drinking water causes about 1.8 million people die from diarrhea diseases annually worldwide. Ethiopia is a country in which the water supply and

Sanitation infrastructure endeavors are still low. Seventy five percent of Ethiopians do not have immediate access to clean water. Throughout the country, women walk long distance to reach to the potable water sources, which are often stagnant, unclean and contains deadly diseases. In this also, the researcher strongly supports that, the problem is serious in Ethiopia especially in Ahferom woreda, Tigray. That is why; he intended to make a study on assessment of potable water access in the woreda. Because of long distance and queue to fetch water they would be vulnerable to school dropout and low participation of other social and political activities of their country. on the basis of the ideas mentioned earlier, one can obviously deduce the unavailability of nearby purified water make the women liable to be far away from partaking various community-focused opportunities. And this incident leads them towards backward style survival

which in turn brings about economic downfall to their family and the whole country. It should also be understood that the utility of unclean water by the family results in the outbreak of water-borne diseases. For this reason the main objective for conducting this research is to identify the factors hindering peoples from having access to nearby clean water and to provide a permanent solutions.

1.2. Statement of the Problem

Nearly 250 million cases are reported every year, with more than 3 million deaths annually; about 10,000 a day. More ever, diarrhea disease affects children most severely, killing more than 2 million young children a year in the developing world. Many more are left underweight stunted mentally and physically, vulnerable to other deadly disease (Hans van Damme, 2001).

Similarly, there is a very significant report from Water Partner International (2006) which vividly indicates the number of people who lack access to improved water supply could increase to 2.3 billion by 2025. Furthermore, Global Water Supply and Sanitation Assessment (2000) report also indicates that majority of the world's population without access to improved water supply or sanitation services lives in Africa and Asia: less than 50% of all Asians have access to improved sanitation and less than 40% Africans have improved water supply(WHO & UNICEF,2000). And this shows that developing countries in the continents of Africa and Asia are highly inflicted by the inadequate and un-sanitized supply of water.

In Africa around 300 million people do not have access to safe drinking water and 313 million have no access to sanitation. That means; Africa has the lowest total water supply coverage of all the continents in the World (ADF, 2005). About 84 percent of population of Ethiopia lives in rural areas. This happens due to the nature of settlement and policy of the government (Alem T., 2013). Regarding to this the researcher strongly believe that, if this much member of the country lives in rural area solving their problems and providing good accesses like road, education, clean drinking water… is the key means to achieve the policies and strategies of the government.

The issue of clean and safe water accessibility and level of sanitation in Ethiopia is not unique with the problems that other member of third world countries face. At the national level, the total coverage for clean water in 2000 was 24%, which means from the total population around 15.2 million people have access to drinking water. Comparatively in the rural and urban settlers from the total beneficiaries only 6,698,000 or 23% have the opportunity to clean water. This means 87% of the rural population has no access to potable water (WHO, 2000). In addition to this, WASH (2005) report indicates that the consequence of this poor water supply coverage in the

country is severe. This exposes the people to the infant mortality rate of 180 per 1000, very low economic productivity and low female enrolment ratio in school, lower participation of females in political activities etc. This is more serious in the rural population that has virtually no sanitation facilities, while in the country as a whole only 8% of the population has access to sanitation (Desalegn, 1999). Similarly, ADF (2005) reports that potable water access in Tigray region was low, which was only 25%. More again, in the year 2003/4, rural water coverage of Ahferom Woreda was not more than 10% (AWWRM).

These all the problems in global, national and local level requires a quick solution. So the present target of the Ethiopia's Millennium Development Goal is to alleviate poverty through improving the strategy of effective utilization of water supply sources. In order to achieve the goal, a priority area is being provided access to clean water; sanitation and hygiene are the significant elements for poverty alleviation (Water Aid, 2009). Provision of water is a critical factor to the improvement of the quality of life of people because having access to sufficient quantities of clean and safe water enhances the health and productive lives of people in rural areas. This is important both in social and community development (GRZ 1994: 3; Bernstein & Gray 1997: 7).

The basic reason for this study, as it is indicated in the above about problems of rural potable water and its consequences, is to dig out the fact that to what extent the peoples of Ahferom Woreda have the access of pure and sanitized water in their nearby surroundings without exerting much effort and energy to look for it. And thereby to deliver the basically permanent solutions and recommendations in case some unexpected negative outcomes have been recognized.

In addition to the reason of this study, as the level of investment in rural areas for the provision of clean water is increasing from time to time, governmental and non-governmental organizations need to have an assessment to evaluate the level of progress and the satisfaction of the beneficiaries. That is to mean, concerned bodies are anticipated to assess whether the society is obtaining based on the standards/ 15litter per person per day within 1.5 kilometer average travel distance to fetch water, and the level of progress of each year and the five year plan of the nation and the Woreda specifically . This would be useful to gather sufficient information before investing large capital for construction of rural water supply works in general since the question of water is a question of life.

1.3 Objectives of the Study

1.3.1 General Objective

The overall objective of the study is to assess the accessibility status of potable water in the rural areas of Ahferom Woreda by using GIS environment.

1.3.2 Specific Objectives

1. Assess the distribution and spatial coverage of safe water supply in the rural village communities,
2. Estimate generating capacity of the water schemes and calculate safe water per capita of individuals in each Kushet and Tabia and compare with the regional standards,
3. Analyze the accessibility coverage of potable water in the study area,
4. Examine the growth trend of drinking water supply and the roles of governmental and NGOs in the expansion of safe water facilities to the society,
5. Identify the major factors which influence the functionality of potable water sources in the study area.

1.4 Research Questions

To achieve the intended objectives of the study, the author has employed the following research questions:

1. Is the distribution and spatial coverage of safe water supply equitable for the rural communities of Ahferom Woreda?
2. What is the status of accessibility coverage of drinking water at Ahferom woreda?
3. What are the generating capacity of each water scheme and the actual potable water per capita of the inhabitants (l/day)?

5. How is the growth trend of potable water schemes and the role of governmental and non- governmental organizations in the expansion of safe water sources?
6. What are the major problems that can influence the sustainability of water schemes?

1.5 Significance of the Study

Water is life and is the pre-requisite for the use of all other resources. Because of this, the researcher is encouraged to study on the issue of potable water accessibility in the place where he lives. Therefore, this research is significantly important to generate more information about the ongoing condition of drinking water accessibility in rural areas of Ahferom Woreda Moreover, conducting this research could by far be significant in that the research findings would enlighten the policy makers, local leaders, governmental and non-governmental organizations and water supply experts to think critically and design policies so as to provide clean and safe water based on the needed standards and to solve water related problems in the Woreda.

In addition, it gives a good direction to the other individuals who need to study in this topic in the same area so as to improve limitations. Similarly, making a research on this topic will be quite useful since no detailed local investigation was made about the topic. More again, the reason for conducting such a research gives an advantage for researchers to create strong awareness and need for local investigation. It would also be helpful to make the decision makers so diligent about the problem under study. Furthermore, it is obvious that a number of relevant studies have been conducted for years. So this research could be significant in filling the gaps among the existing studies.

1.6 Scope of the Study

The study focused on accessibility assessment of rural potable water in Ahferom Woreda. It covers 27 rural lower administrative units called tabias. That is, to assess the distributional equity and coverage of water schemes, accessibility level of the beneficiaries to potable water and the key problems of the water schemes. The study did not assess the sanitation, health and water quality status. The assessment covers from 1994-2013 but, In this case urban areas are not included.

1.7 Limitations of the Study

The first major limitation is budget. The researcher can say that the study is conducted without

regular research budget since he is a self-sponsor. Due to this known reason the researcher forced to work hard on cost effective methods. The other barrier and headache of this study was the availability of literatures related to the study and potable water accessibility analysis at national level, which affect the quality and quantity of the information embodied in the study. Another barrier in doing this thesis was distance barrier from advisors location and lack of internet service access in the study area.

1.8 Structure of the Report

The structural organization of the report has five units:

- **Unit one (introduction)** contains, background of the study, statement of the problem, objectives, delimitation, significance and limitations of the study.
- **Unit two (literature review)** embraces the existing drinking water schemes carried out by the state government and central government from the available literature. It has also got relevant quotes scholarly definitions, explanations and research outcomes made by some distinguished individuals.
- **Unit three (materials and methods)** deals with the research design, data collection and their source as well as the means of analysis.
- **Unit four** deals with results and discussions and consists of information about the findings of the primary/ field visit observations and GPS data, and secondary data analysis. It also includes findings of village level and habitat level data analysis. It further describes the available GIS data and feature data analysis.
- **Unit five** comprises of conclusion and recommendations of the study. It deals with a short summary of the findings of the researcher and gives constructive ideas as solutions for problems identified to concerned bodies.

1.9 Definitions of Terminologies

- **Non-functional:** in this paper means that those water supply schemes stopped providing service due to some disrepair problem. However, functional refers to the water supply schemes providing service to water users.
- **Potable Water**: is water which is fit for consumption by humans and it is also called drinking water or safe water, in a reference to its intended use. On the other hand, drinking water or potable water is the water safe enough to be consumed by humans or used with low risk of immediate or long term harm.

- **Water Schemes/Water Points:** type of protected water sources constructed by governments or non- governmental organizations for the purpose of potable water provision to the rural communities. It may be constructed by machines or human power depending on the ground water potential. In other words we call it Water Points/W.Ps/
- **Rural Water Supply:** (RWS) refers to provision of clean and safe water to rural Communities through construction of boreholes, protected wells and springs.

UNIT – TWO

REVIEW OF RELATED LITERATURE

2.1 Introduction

This unit reviews some of the important works from different literatures about the use and application areas of GIS for potable water accessibility analysis. In doing so, several sources like, books, journals, official reports and web site have been explored. in general this unit reviews concepts of potable water accessibility, the situation of potable water accessibility in developing countries, Causes for Rural Potable Water Inaccessibility, potable water inaccessibility and its influence on children's and women, organizational structure of safe water delivery in Ethiopia, Ethiopian rural drinking water polices and strategies a and application of GIS technologies.

2.2 Meaning and Importance of Potable Water

Numerous definitions of potable water/drinking water with similar concept have been given by different scholars and organizations. Drinking water or potable water is water safe enough to be consumed by humans or used with low risk of immediate or long term harm (WHO, 2001). Potable water is defined as having acceptable quality in terms of its physical, chemical, bacteriological parameters so that it can be safely used for drinking and cooking (WHO, 2004). Drinking water is a water delivered to the users that can be used safely for drinking, cooking, and washing(WRRI, 2008). Improved water is a source which is preserved from external contamination, in particular from contamination with fecal matter (WHO and UNICEF, 2008).

The JMP of WHO and UNICEF (2006) have been differentiated "Improved" and "Unimproved" drinking-water sources as presented below:

- Improved drinking water sources:- piped household water connection, public standpipe, Borhole, protected dug well, protected spring, rain water collection.
- Unimproved drinking sources:- unprotected dug well, unprotected spring, surface water(river, dam, lake, pond, stream, canal, irrigation channel), vender provided water(cart with small tank), tanker truck water, bottled water

Water is essential for life. We are also aware of its necessity, for drinking, for producing food, for washing. Water is the essence for maintaining our health and dignity that means People's lives and livelihoods depend on water.

Water is also required for domestic and non- domestic use in schools, colleges, institutions, Offices, markets etc. The integral role of water in international development has been recognized over the last two decades; with several international agreements specifying targets on water supply and sanitation dating back to the United Nations Children's fund (UNICEF) 1980) International water supply and Sanitation Decade (IWSSD), which established the target of universal coverage of safe water supply and sanitation by 1990.

In relation to this, the researcher also described that an access to potable water is a fundamental need and constitutes one of the most important human rights. Without having enough clean water in a community; direct and indirect impacts could appear in the society like that of society in the study area. Direct problems relates to the exposure to water borne diseases and the expenditures to get rid of them. Indirect problems are decreasing productivity because of sickness of the productive forces, conflicts caused by water scarcity, political instability and overburdening of public hospitals to treat the patients of water borne disease. Therefore, it is important to work jointly for the accessibility of potable water for all. Additionally, Access to water is a prerequisite for health and livelihood, which is why the MDG target is formulated in terms of sustainable access to affordable drinking water supply. The availability of improved and quality water supply and sanitation infrastructures are widely recognized as an essential component of human rights, social and economic development (ADF, 2005).

Water is essential element in human livelihoods because of its necessity to life; food security and economic activities, etc. It is indispensable for crop production, industry, domestic processing, aquaculture, livestock, recreation, navigation and transport, and electricity supply. Safe water and sanitation also shape health through potable water supply, safe food preparation, hygiene, better nutrition, and entertainment. (Misgna, 2006).

Water is a prime natural resource and a basic human need. Without having the access to potable water every human's activity is meaningless and the right to use other resource will be violated (Pratiksha et al, 2012*).* Access to water is a fundamental need and constitutes one of the most important human rights. People's lives and livelihoods depend on water. Demand for clean water increases continually in line with world population growth (WSSCC 1990).

Access to drinking water is a pre-condition or a base for health and livelihood that is why the Millennium Development goals target is formulated in terms of sustainable access to affordable drinking water supply. The availability of protected and quality water supply and sanitation infrastructures are widely recognized as an essential component of human rights, social and economic development (ADF, 2005).

2.2 Definitions of Accessibility

It considered that accessibility is a notion that has obtained on a variety of meaning, including Accessibility can be seen as the amount of effort for a person to reach a destination or the number of activities which can be reached from a certain location (Geurs and Ritsema Van Eck, 2001).The term also has social implications—the distance between a person and services that she/he seeks for is not only geographical, but also may arise out of various individual and social conditions (Shyam, 2007). Moreover, Access is defined as "participation" in each of the areas under analysis. Participation means that an individual has had the opportunity to experience an education or training opportunity (Manuel & Andrew, 2005). Accessibility is an attribute of people (and goods) rather than transport modes or service provision, and describes integrated systems from a user viewpoint (Derek, Peter, and Sarah, 2005).

2.3 Potable Water Inaccessibility and Gender Inequality

Water collection is a major part of the work of women in rural areas of the global south (Ben Crow, 2001). African and Asian women spend more time in collecting water. In Senegal, women spend 17.5 hours per week collecting water. In Mozambique, they spend 15.3 hours per week collecting water in the dry season. In the Baroda region of India, women spend 7 hours per week collecting water. Observations from Nepal confirm the important role of female children in the collection of water, with girls of 10 and over devoting almost 5 hours per week to the task (United Nations, 2000). In Bangladesh, women and girls have been found to walk between 2 and 5 hours each day to fetch water (Shamim and Salahuddin 1994). Regarding to this the researcher strongly supports that, this paragraph shows the severity of clean water inaccessibility and exposure of women to miss their precious time in fetching water from very long distant area with very huge weight of load. Therefore, they lose their opportunity in the social, economic and political aspects.

Some regions, particularly sub-Saharan Africa, are lagging behind. Many rural dwellers and the poor often miss out on improvements to drinking water and sanitation. And the burden of poor

water supply falls most heavily on girls and women. Reducing these disparities must be a priority (WHO and UNICEF 2012).

The problems related to safe and clean water is locked in the heart of the poverty. Even though the issue of water is observed as a general problem for both the urban and the rural population, women bear the greatest burden because of their social gender roles including collecting water for their households (Rose, 2009). As a result, over burdening of children and women for water provision at the households, women and children suffer from disease, have limited participation in education, and both income generating activities and engagement in cultural and political issues are often compromised. Provision of safer and more accessible water could also have an influence on school enrolment and attendance especially for young girls. It is widely believed that greater schooling of girl children leads to late marriage, greater birth spacing. The girls themselves and the next generation of children will have lower mortality and morbidity rates and hence savings in public sector provision of health care and welfare support (Thornton, 2003).

Women have a decisive role to fetch water by carrying a clay pot, a water container or jar form long distances. In the rural parts of Ethiopia, the water points are remote especially during the dry season of the monsoon from the individual households and the difficulty of the topography to travel with heavy loads make females move up and down by carrying water (Admassu et.al, 2002). About twenty one hours are being lost per week for fetching water by rural women and girls who have no access to safe drinking water sources around their houses (UNICEF, 1999). Sometimes women prefer fetching water from unprotected spring, river and other sources in order to decrease their time and energy they spend to fetch water and this opportunity let them get water free from payment without worrying about the quality of water and its consequences (Admassu et.al, 2002). If there is less time spent for fetching water, girls can have a chance to learn in school and get time to study in house (UNICEF, 1999).

In Africa almost 40 billion hours are lost every year for fetching water from distant sources. And reports indicate that in this continent an additional benefit of the community is that many costs of the project are minimized or eliminated (UNICEF, 1999). As the community provides volunteer or low-cost labor during construction or contributes locally available materials, the sense of ownership increases and this involvement in the planning stage of the project may provide the local knowledge necessary to avoid using unsafe water sources (UNICEF, 1999). If the operation and maintenance program of water project is designed by the community, the project will function much better than when the program is designed by outsiders and the consequence will reduce the repairing cost (UNICEF, 1999; USAID, 2009).

Gleick (2006) mentioned that the human body's basic water requirements depend on climate, workload and environmental factors. The amount of water needed for other purposes, including cooking or hygiene, is more variable and depends on cultural habits, socio-economic factors and types of water supply. On the other hand, if women fetch water from distant sources, they lose one third of their nutritional intake which is about 600 calories because they walk a long distances to fetch water. So, improved water sources near to the households decreases the amount of calorie that are burnt and increase the nutritional status of most women and children (UNICEF, 1999). Regarding to this, in addition to the violation of women's right to schooling, participation in socio-economic and other social activities lose their health and energy and become liable to abduction while fetching water. Consequently, they can be exposed to sexually transmitted diseases like AIDS, unwanted pregnancy etc.

2.4 Drinking Water Shortage and Its Influence in Health and Economic Aspects

No wealth and health can exist without understanding the role of safe water. One of the key elements to success in all countries and societies in the world, past and present, is the proper handling of water specially the potable water because water is an essential factor in socio-economic development and poverty reduction. Therefore, it is time to share experiences and join forces towards the delivery of the common goal of "clean water for all." (Tanja et al, 2011).

When human beings do not have access to potable water; they do not only suffer physically and emotionally but also socio-economically (UNDP 2006).

In developing countries, it is estimated that over 80% of disease is caused by contaminated drinking water and as a consequence, over 30% of work productivity is lost. Meaning, water is largely the cause of most disease and a considerable amount of work potential is compromised because of this (www.safewater.org).

The effect of a safe drinking water intervention is not only to reduce the water borne diseases, but also to improve the access of drinking water in terms of time and energy utilized in collection and treatment. In many locations, people have to travel considerable distances to collect water for drinking and domestic water usage. Most interventions in rural areas could serve both purposes. Time released for other activities through time savings in terms of accessing and treating water has been found to be substantial (G. Hutton, 2006), (Z.S. Wang, 1989). The poor and marginalized people living in rural and pre-urban settlements are most in need for improved and safe drinking water, appropriate forms of sanitation and access to water for other domestic purposes (Crow, 2001). Lack of access to potable water, sanitation and hygiene leads tremendous

human and economic costs and rein forces gender and other societal inequalities, especially for women and girls. Chronic diarrheal diseases debilitate victims and, coupled with malnutrition, induce a negative spiral into poverty. The productive activities of poor rural people, such as schooling and farming, are severely restricted by ill health from water- and excreta-related disease, as well as by the time and energy spent fetching water (Joint Monitoring Program for Water and Sanitation, 2006).

In line to this, several studies have been carried out to analyze people's perception and attitude about the drinking water source quality and accessibility. Creating good community awareness about water quality issues and the associated problems like sanitation and hygiene services is important to alleviate health effects but it remains below the expected rate of coverage. According to certain studies undertaken before some ideas mentioned below:

on the bases of Haysom (2006) and Harvey(2007), by the year 2015 the national water supply and sanitation program under its millennium development goal planned to increase the coverage of water supply and sanitation by 64% and 54% respectively. It has been said that the chances of achieving the Millennium Development Goal of halving the proportion of people without access to safe water by 2015 will be seriously lowered unless levels of sustainability can be greatly improved.

When human beings do not have access to potable water supply, they suffer a lot in the overall their health condition, socio-economic and environmental existence. The main health problems, especially in developing countries like Ethiopia, are results of poor access of potable water; poor hygiene and sanitation practices. This leads to economic dependency and finally it hampers all rounded development of the country. In these cases, supplying safe drinking water is of critical importance (Misgna, 2006).

In addition to the above basic idea of the basic resource for human beings life, the researcher also believes that water is the base for our survival in this world. Meaning every human activity relates with water especially the drinkable water. When there is a problem of potable water and unprotected access in one society, firstly the people will get endangered by the common type of water born diseases (cholera, diarrhea). Because of this, they will be out of work and they expose to an expected expenditure for medication. Secondly, they waste time in fetching water from long distance area. So it affects the socio-economic environmental existence of the society.

2.5 The Causes for Rural Potable Water Inaccessibility

In developing countries national and regional governments, and non-governmental organizations as well as other concerned bodies invest large capital every year for the implementation of rural water supply projects and for the success of millennium development goals. However, construction of water projects does not help if they fail serving after a short time (Gebrehiwot, 2006). ADF (2005) report shows that about 33% of rural water supply projects in Ethiopia are non-functional due to lack of funds for operation and maintenance, inadequate community mobilization and commitment, less community participation in decision making as well as lack of spare parts.

2.6 MDG and Various Scholars' Point of View on Potable Water Accessibility

Different intellectuals, agents and the UN sub organizations have been delivering different perspectives on to what extent water can be consumed per person per day. The perspectives are stated below:

Muthusi et.al. (2007) has just explained the consumption rate of potable water per person per day in this way: The human body's basic water requirement depends on climate, work load and environmental factor. If the work load is high and the season is dry the family use large amount of water per day, whereas the family size increases the amount of water consumed by one person per day decreases relative to the one that small number of family sizes.

However, Gleick (2006) defined the minimum requirement for human body and found that it is between 3 and 10 liters per day. The amount of water needed for other purposes, including cooking or hygiene, is more variable and depends on cultural habits, socio economic factors and types of water supply in terms of quantity, quality and availability.

Gleick (2006) has also stated that the international acceptable standards for water requirements for basic needs, commonly referred to as basic water requirement (BWR). BWR is defined as water requirement in terms of quantity and quality for the four basic needs of drinking water, human hygiene, sanitation service and modest household needs.

This standard is defined by WHO guide line as 20 liters per capita per day (Admassu et. al, 2002). And The UNDP (2008) says the minimum absolute daily water need per person per day is 50 liters (13.2 gallons) which include: 5 liters for drinking, 20 liters for sanitation and hygiene, 15 liters for bathing and 10 liters for preparing food. However because of scarcity of drinking water, millions of people try to exist on 10 liters (2.6 gallons) a day.

In 2000, the United Nations adopted eight Millennium Development Goals (MDGs) to address the main problems facing developing countries. The goals – which include achieving universal

primary education, reducing child mortality, eradicating extreme poverty and hunger and combating AIDS, malaria and other diseases– must be met by 2015. To achieve these goals, availability of drinking water in the society plays a pivotal role.(Algemene Rekenkamer, 2008). That is without having the access to clean water the other goals will be difficult to their achievements. It is obvious that, without good health everything is difficult for its accomplishment and health also absolutely dependant on water. Therefore, achievement of Millennium Development Goals is dependent on accessibility of drinking water.

The Millennium Development Goals and UNs drinking water target in 2015.

To achieve the MDGs many governmental and non-governmental organizations fund huge amount of money to the world citizens especially to the developing countries. Some of them reached their ultimate goals and the others in their way. UN sponsored to the developing countries in 2005 approximately €1.4 billion to meet the MDGs goals which is "clean water for 50 million people until 2015 and other MDGs". The WHO and UNICEF established the following normative guidelines for the drinking water target (WHO/UNICEF, 2000):

- Sources must be 'improved' (that is no unprotected sources or bottled water).
- Sources must supply at least 20 liters of water per person per day.
- Sources must be located within one kilometer of users' homes. and
- Maximum time taken to collect round trip of 30 minutes.

Progress towards the United Nations Millennium Development Goal for water and sanitation is particularly poor in sub-Saharan Africa (WHO and UNICEF (2006).

2.7 Accessibility of Fresh Water

Fresh water is a natural resource with high significance to the overall development contributing its lion share to all sectors including agriculture and for domestic supplies (Mike H., 2007). The management and protection of regional, national and international fresh water sources have reached a crucial period (Gleick, p.etal, 2001). Its proper management is the most challenge of all natural resource (SCBD, 2010). By its very nature and multiple uses, water is a complex subject. Although water is a global issue, finding the problems and their solutions often highly localized (SCBD, 2010).

As different scholars or writers indicates that, fresh water is scarce in nature and unevenly distributed in the world. From the world water the 97% of the total is salty water which is undrinkable and less than 3% is fresh water (SCBD, 2010). From the 3% over 2.5% is frozen,

and blocked up in the surrounding of the two poles and are not available to human consumption. To answer how many percent of world water is used for human consumption is? It is 0.5 percent (WBCSD, 2005).

Access to fresh water is increasingly crucial national and international issues. In many parts of the world consumption interest exceeds its supply (Mike, 2007). This has been stressed more due to withdrawal of available sources for irrigation, for industry, and for domestic uses 82%, 10%, 8% respectively (WBCSD, 2005).

2.8 Potable Water Supply Facilities in Ethiopia

According MoFED (2008), Ethiopia is characterized by limited access to potable water services particularly in the rural dwellers. In 1990, for example, only 19 percent of the country's population had access to a safe drinking water supply and after seven years this figure had grew to 52 percent.

Table 2.1 Rural and urban areas of Ethiopia's population accessible to potable water

	1996	**1998**	**2000**	**2004**	**2006**	**2007**
Rural	10	14	17	25	41.2	46.4
Urban	72	84	92	92	78.8	82
Total	19	24	28	36	47.3	52.2

Source: MoFED, 2008

The JMP (2012), updated reported that the percentage of population using improved water source was 44 percent of which 97percent urban and 34percent of rural.

According to situational analysis of the GTP the recent drinking water supply coverage as of 2010 was 68.5 percent which are 91.5 percent and 65.5 percent water coverage within 0.5km and 1.5km radius in urban and rural areas respectively(MoFED,2012). Even though there has been shown significant growth in the recent years, but, there are still close to 30 million Ethiopians who lack access to safe and reliable sources of sources of drinking water (UNICEF, 2012). The difference between the government and the JMP figure can be due to different definitions of improved water sources.

Table 2.2 Estimated trend of drinking water coverage in percent

	1990	**1995**	**2000**	**2005**	**2010**
Rural	5	10	19	27	34
Urban	79	82	87	92	97
Total	14	20	29	37	44

UNICEF, 2012

Even though the accessibility coverage of potable water supply facilities has gradually increased at the national level, the rate is very low. in adequate quality of drinking water is the major causes of health problem especially in rural areas of Ethiopia(MoFED, 2008).

In recognition of water problems in the country, especially in rural areas, the government has increased resource allocation to provide clean water for its in habitants. As a result, the proportion of government budget that went to water and sanitation infrastructure development grew from 2.8percent to 4.5percent between 2000/01 and 2005 (MoFED) and access to improved water supply increased from about 19 percent to 52.5 percent between 1999 and 2007 (MoFED, 2008). However, access still varies strongly across geographic regions in the country, and the problem is more observed in rural than in urban areas.

2.9 Ethiopian Rural Drinking Water Polices and Strategies

Ethiopia is one of the member countries that adopted the millennium development declaration with its main objective of poverty reduction (UNDP, 2008). Out of which one disseminates safe and clear water to every corner of the country. Here the government is exhausting much effort in calling for investors and other non governmental agencies to undertake water projects in quality and quantity manners. According to an ADF (2005) report, the Millennium Development Goals (MDG) objective of Ethiopia is to increase the improved water sources coverage from 2004 levels of 25% water supply and 8% sanitation to 62% water supply and 54% sanitation by 2015.

on the other hand , based on the WASH and UAP stated program on accessibility of water, Ahferom woreda has been exerting double effort so that every rural sites could have the distance range for fetching water to be1.5km and the consumption rate of water to be 15litre per person per day. And this water strategy will fully be implemented in 2007e.c.

The Ministry of Water resources is the body in Ethiopia to formulate polices and strategies; prepares plans and guidelines, as well as for the allocation and utilization of water resources in the country. Regional administrations are responsible for the implementation of polices and strategies within their authority (MoWR, 1999). According the Ethiopian MoWR (2001): the objectives of national water resource management policy is to enhance and promote all national

efforts towards the efficient, equitable, and optimum utilization of the available water resource of Ethiopia for significant socio-economic development as sustainable basis.

The following are some of the water management strategic objectives stated by the government to contribute for the achievement of the overall goals (MoWR, 2001):

- Development of water resources of the country for economic and social benefits of the people, on equitable and sustainable basis.
- Allocation and apportionment of water resources based on comprehensive and integrated plan and optimum allocation principles that incorporate efficiency of use, equity of access and sustainability of resources.
- Conserving, protecting and enhancing water resources and the overall the aquatic environment on sustainable basis.
- Extending water supply sanitation coverage to large segment of the society, thus achieving improved environmental conditions.
- Promoting the principles of integrated water resources management in order to translate the national water resource management policy in to action and then to secure basis for the provision of sustainable, efficient, reliable, affordable and users-acceptable WSS services to the Ethiopian people the water resource strategy was developed focusing in the improving the performance of this sector by providing access to clean and adequate water supply and sanitation facilities (MoWR, 2001).

UNIT – THREE

METHODOLOGY & DESCRIPTION OF THE STUDY AREA

3.1. Description of the Study Area

3.1.1 Geographic Location of the Study Area

Ahferom Woreda, is situated between 14 °06'30" and 14 38' 30" north latitude and 38° 56' 30" and 39° 18'00" east covering an area of 133,979 hectare. It is bounded by Eretria in the north, Werieleke in south, Ganta'Afeshum in the east and Adwa Woreda in the western. Ahferom Woreda is divided into 33 Tabias and 125 Kushets for administrative purposes. The rural part of Ahferom Woreda has 27 tabias, 105 kushets.

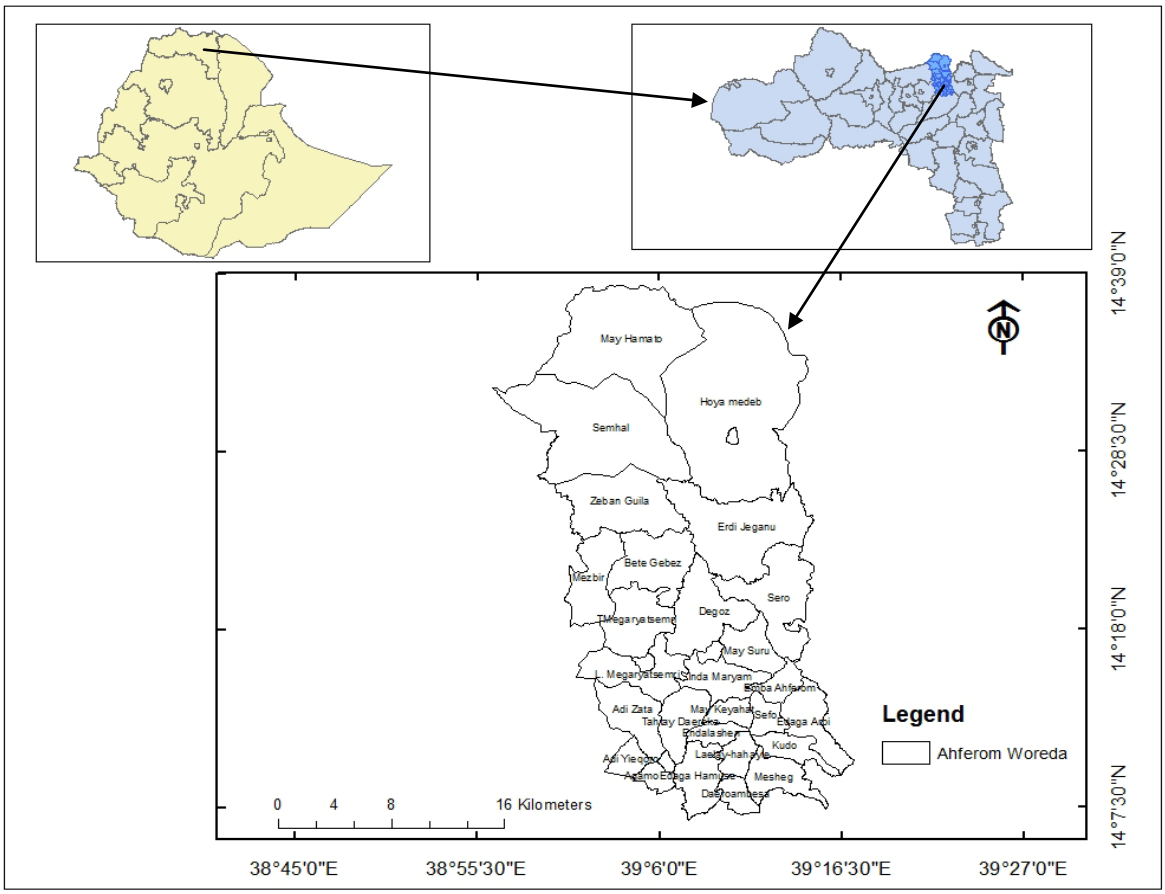


Fig.3.1 Location Map of the Study Area

3.1.2 Topographic Characteristics of Ahferom Woreda

The State of Tigray is one of the nine member states of Ethiopia which is found in the northern part of the country. Geographically, it is located between 12 ° 15' -14° 49' north latitudes and 36°

27'- 40^{o} 00' east longitudes (Peter et al, 2000). Tigray Region is bounded by Eritrea in the north, Afar Region in the east, Amhara Region in south, and Sudan in the west.

The Region covers an area of 80,000 sq. km and has a total population of 4.43 million (Tigray Region BoFED, 2005). Altitude of the Region ranges from 500 to 3935 meters above sea level. Agro-ecologically, the Region is 11% Dega (high land), 40.5% woynadega (temperate) and 48% kola (low land) respectively (Tigray region BOFED, 2005).

3.1.3 Climate & vegetation cover of Ahferom Woreda

There are three agro-climatic zones in the Woreda. These are "kola" (60,875 hectares), woinadega (59,719 hectares), degua (13,385 hectares). When we state the areas in percentiles; "Kola" zone comprises about 45.5% of the Woreda followed by "Woina dega" with 44.5% and "Dega" with 10% respectively.

Rainfall has one seasonal occurrence in a year. During the summer season, it ranges from 540 to 650mm. The highest rainfall under normal condition is recorded during the July month. The Woreda has moderate type of temperature that usually extends between 22^{o}c to 27^{o}c. Moreover, about 10.4% of the area of Ahferom Woreda is covered by natural vegetation and is among the few areas to have such large tree cover area in the south and sparsely in the other (Ahferom Woreda Public relation Office, 2004/5).

3.1.4 Population of the Study Area

Ahferom Woreda has a total population of 167,123. Of the total population, 52% is found in the age range of 15-64 (the productive age group), while 44.4% (less than15) and 5.6% (greater than 64) represent the young and old age groups of the population (FEDAW, 2013).

3.1.5 Population Density

Population density is a ratio of total population number to the total area of a place. It is the ratio of population size and area of a given place. Therefore, the ratio of the population size of Ahferom Woreda to its total area in 2013 was 129.7. This makes the Woreda to be one of the densely populated areas in Tigray. According to CSA (2008) the average national population density was about 82.95 populations per square kilometer. The population density of Ahferom Woreda is above the national average.

Population density of each Tabia shows the proportion of population to the land area of the particular Tabia. As presented in appendix I and Figure 3.2, the population density of Ahferom Woreda extends from 34 in Hoya-medeb to 606 in Daero-Anbesa. Daero-Anbesa, Sefo, Adi-yiekoro and Emba-Ahferom have highest population density which accounts 606, 417, 412 and

398 populations per square kilometer area respectively. Hoya-Medeb, May-Hamato, Semhal and Sero; however, have the lowest population density with 34, 44, 48, and 61 population per square kilometer respectively.

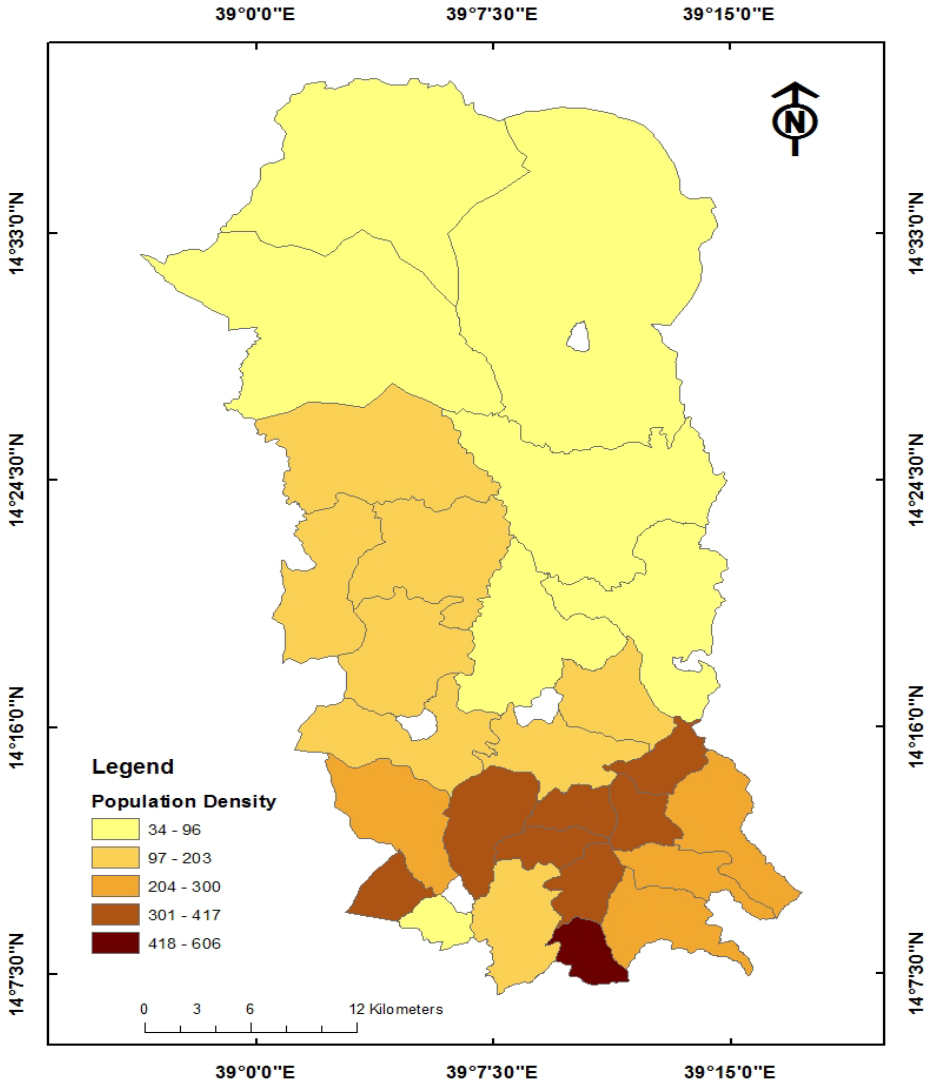


Fig.3.2: Population density map of Ahferom Woreda in 2013

3.2 Research Methodology

3.2.1 Data Sources

As far as the nature of the data required, they are collected from a number of different sources. The data required for the study are of two types: **spatial** and **non-spatial** data collected from primary and secondary sources. The spatial data (absolute location of water points and kushets) are collected from AWWRO (2002). The shape file of the study area used to produce various

types of maps of the study was clipped from Tigray Regional State Map (2013). On the other hand, non-spatial data such as total population of each Tabia, kushet and the data showing the characteristics of water schemes (generating capacity, functional and non-functional, when and by whom were constructed, and the types of water scheme technologies used) from the Woreda Water Resources Office. The basic regional standards of drinking water usage (15 liters per person per day with in 1.5km radius) of the rural dwellers were gathered from TRWRB (2002).

3.3 Methods and Materials:

i. **Arc GIS** software **(**version 10) developed by Environmental System Research Institute (ESRI) is employed as a tool for all activities from preparing data base for all information needed up to the final steps of visualizing results of the research. This application has a capability of integrating different data like population distribution data, and average travel distance data to generate an output about drinking water service distribution and accessibility by using Buffer technology.

ii. **Indices**:

$$\text{PWA index} = \frac{\text{Total amount of water generated by water schemes per day in a given area}}{\text{Total population of a given area}}$$

Where, PWA = Potable Water Accessibility

iii. **SPSS** statistical data editor(Pearson X^2)

SPSS = Statistical Package for Social Sciences

IV. GPS and digital camera

V. Questionnaire to the focus group

Sampling techniques: using stratified sampling techniques 4 from woreda water resource office and 10 technicians 14 water committee (AWWRMO, 2013)

3.4 Methods of Data Analysis

To make a proper investigation on the research problem identified and achieve its intended objectives, the following methods were applied. Data were gathered from the required data sources to build the data base required for the study and assess the spatial distribution and accessibility of water schemes in the study area by using buffering system to identify the accessible and inaccessible areas. It has been attempted to compute the per capita income of the beneficiaries by using the above indices, and compare with regional standards and also to make comparisons between tabias that generally fall in the categories of highly accessible, moderately

accessible and less accessible. Water supply growth trend in the study area is analyzed by grouping into four categories based on the five year plans of the Woreda.

- Descriptive statistical tables, charts and graphs.
- Quantitative and qualitative descriptions

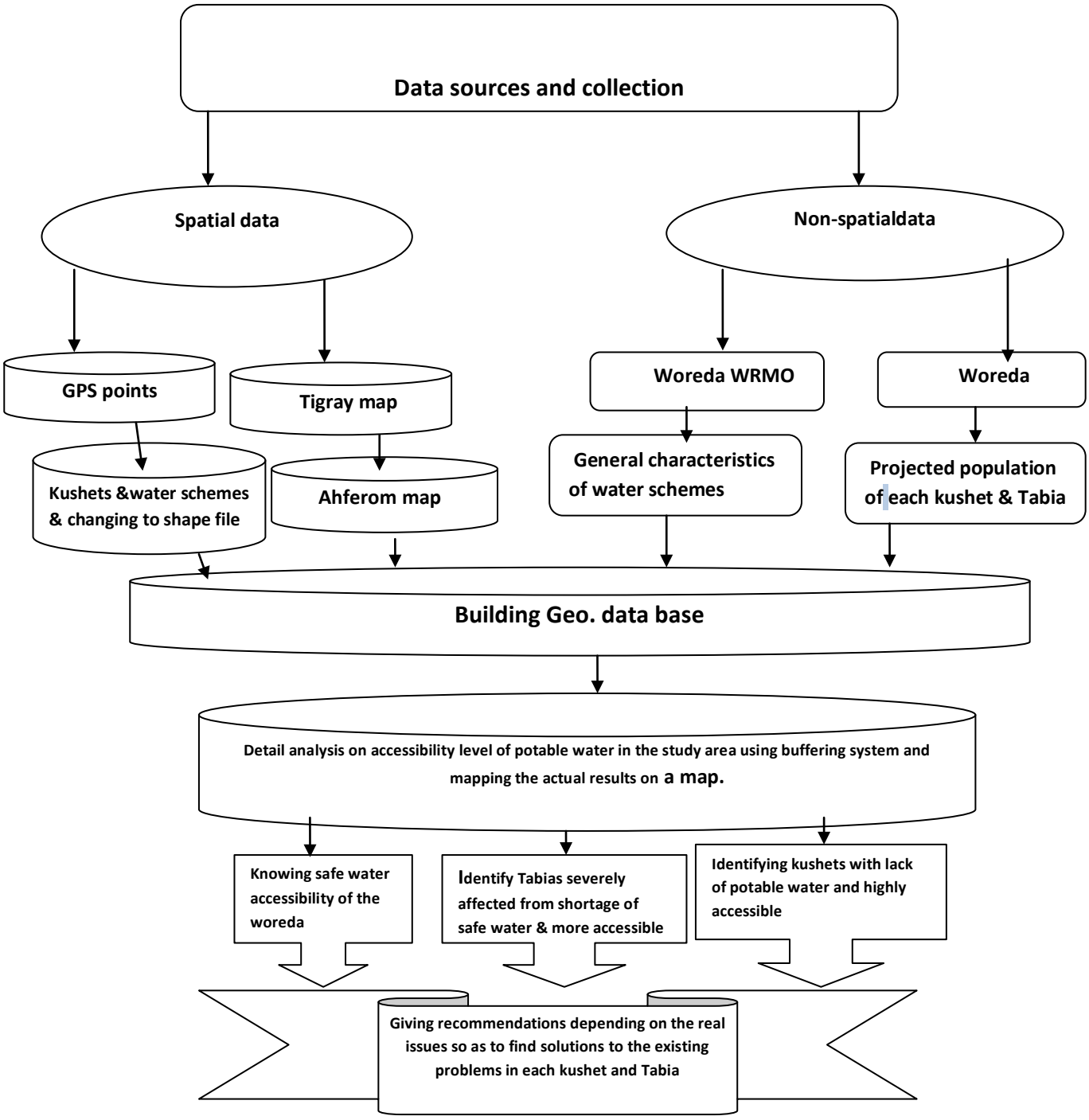


Fig.3.3: Flow chart of the activities

UNIT-FOUR

4. Data Analysis and Discussions

This chapter investigates potable water accessibility situations of Ahferom Woreda. In view of the major objectives of the study, the author has given much emphasis on exploring and analysis of four important factors. These four targeted factors include the distribution and spatial coverage of potable water sources, the rural communities actual clean water accessibility coverage in relation to the regional standard (an average distance travel from nearby safe water source of 1.5 km and 15 liters per person per day) or safe water per capita of the rural people in the study area versus the regional standards, the growth trend of potable water schemes from 1994 – 2013, and the crucial factors influencing the functionality and sustainability of the potable water schemes in the study area.

4.1 Types of Potable Water Technologies

Till the past few decades, clean water technologies were not introduced to Ethiopia. The Ethiopian people were using rivers, lakes and dams as their sources of drinking water (FWRMO, 2003). But, after 1988, potable water sources had begun to be operational in Ethiopia. After certain period of time, particularly from the 1994 onwards, potable water supply was introduced in Ahferom Woreda (AWRMO report, 2001). Therefore, the type of clean water Technologies which were introduced to the rural areas up to 2013 were Hand Dug Well, Spring Development, and Shallow Well.

Table 4.1: Type of Clean Water Technologies until 2013

No	Types of Clean Water Technologies	Conditions (status) of water schemes					
		Functional		Non-functional		Total	
		No	%	No	%	No	%
1	Hand Dug Well	257	79.6	66	20.4	323	100
2	Spring Development	31	50	31	50	62	100
3	Shallow Well	108	80	27	20	135	100
	Total	396	76.2	124	23.8	520	100

Source: AWWRMO, 2005

As clearly shown in table 4.1 above and figure 4.1below, there were 520 water schemes in the study area. Of the total number of the water schemes, 396 (76.2%) were functional while 124(23.8%) were non-functional respectively. The proportions of the three types of water technologies in rural communities of Ahferom Woreda are as follows. Hand Dug Well (the most dominant one) accounts 323 (79.6%) functional and 66 or 20.4% non-functional. The second important is Shallow Well and has 135 (80%) functional and 27 (20%) non-functional. The third water technology in the rural community is referred to as Spring Development and has a higher rate of non-functional water schemes which accounts 31(50%) functional and 31(50%) non-functional ones. In relation to this research, in Ofla Woreda, Gebrehiwot (2011) had analyzed about sustainability of safe water sources. He found that, about 40% of the water technologies were non-functional. He also pointed out that the reasons for un-sustainability of water schemes were over-utilization (over population, poor quality pumping machines, lack of technicians) un-skilled man power and irresponsibility of the beneficiaries to the clean water source are the main reasons to the non-functionality of potable water source. Similarly, about 34 percent of water points in Ethiopia are non-functional due to lack of funds for operation and maintenance, inadequate community mobilization and filling of irresponsibility as well as lack of spare parts to repair broken water points (African Development Fund report, 2005). Even though, the purpose of all water schemes is to provide safe water to the community, they have differences in depth when they are constructed. The deepest of the others is 35-56 m and is constructed in areas of

less water potential and more populous districts. Hand Dug Well (8-12m) is shallower in depth while Spring Development has no depth (AWWRO, 2003). According to the researcher's observation, Hand Dug Wells are shallow wells and look one and the same.

Samples of non-functional water schemes in study area

Fig4.1: Non- functional HDW type in May-hamato
Source: Author's own picture, 2014

Fig 4.2: Non- functional SHW in Hoya-medeb
Source: Author's own picture, 2014

The above figures (Fig 4.1 and Fig 4.2) indicate that there are critical problems that may range from errors done during the studies before the construction of the water schemes (on the

potential underground water) to the mismanagement of their operation and failure to maintain the broken ones.

The following map (Fig 4.3) (in the left) is expected to provide more clear information about the distribution of the existing number of functional and non-functional potable water schemes in the study area. On top of this, the second map (Fig 4.3) (in the right side) expresses the types of the available water schemes in 2013 in Ahferom Wereda.

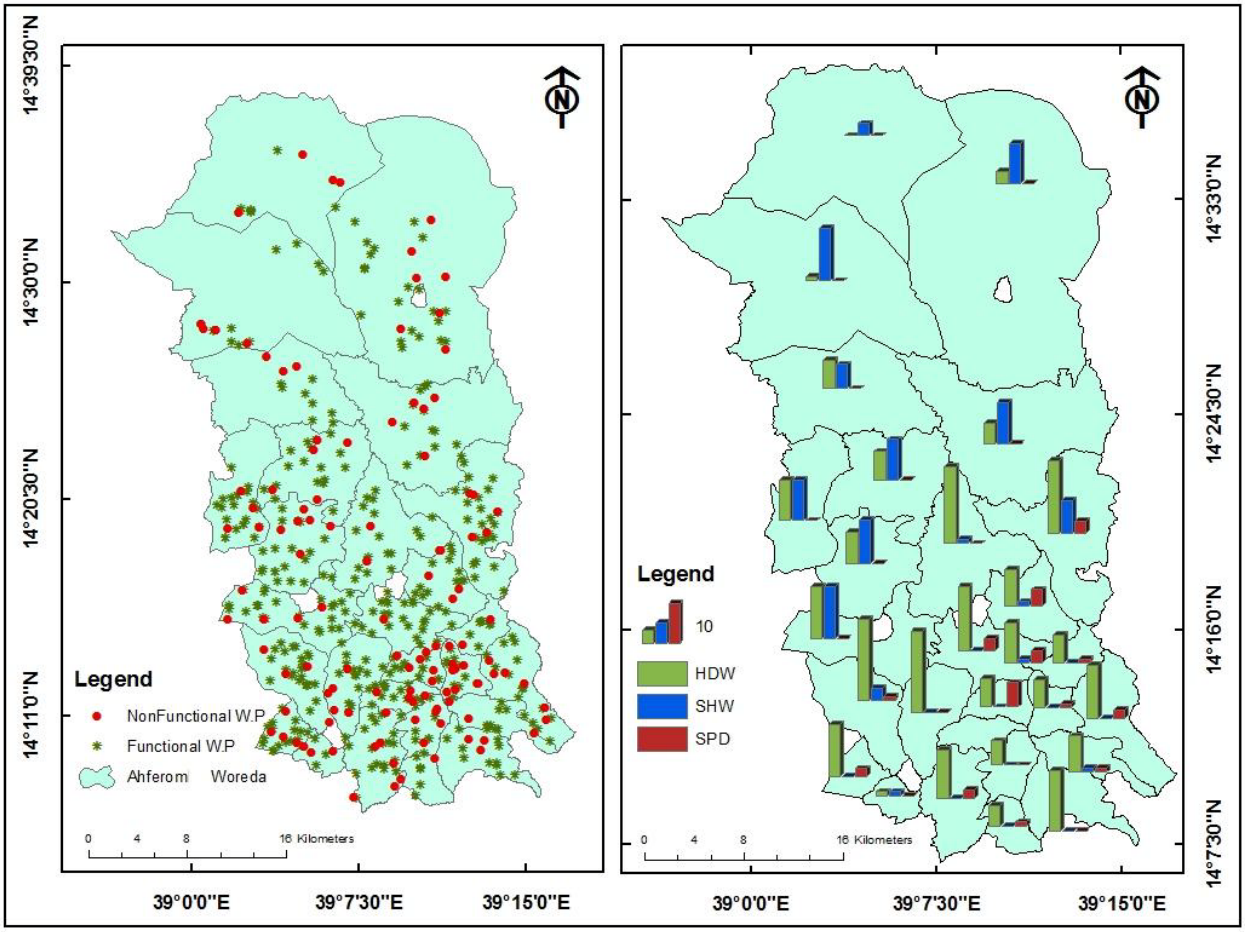


Fig 4.3: Distribution of Functional & Non-functional W.S (left) and Types of W.S (right)

4.2 Roles of the Government and NGO's in Expansion of Water Schemes

Construction of water schemes and expansion of safe water supply is the responsibility of every organization and every member of the society (WHO, 2010). In Ahferom Woreda, governmental and non-governmental institutions are the two main sources of finance for the development of clean water supply facilities to the rural communities. However, comparing the governmental and non-governmental institutions about 94 percent of the rural potable water sources of the

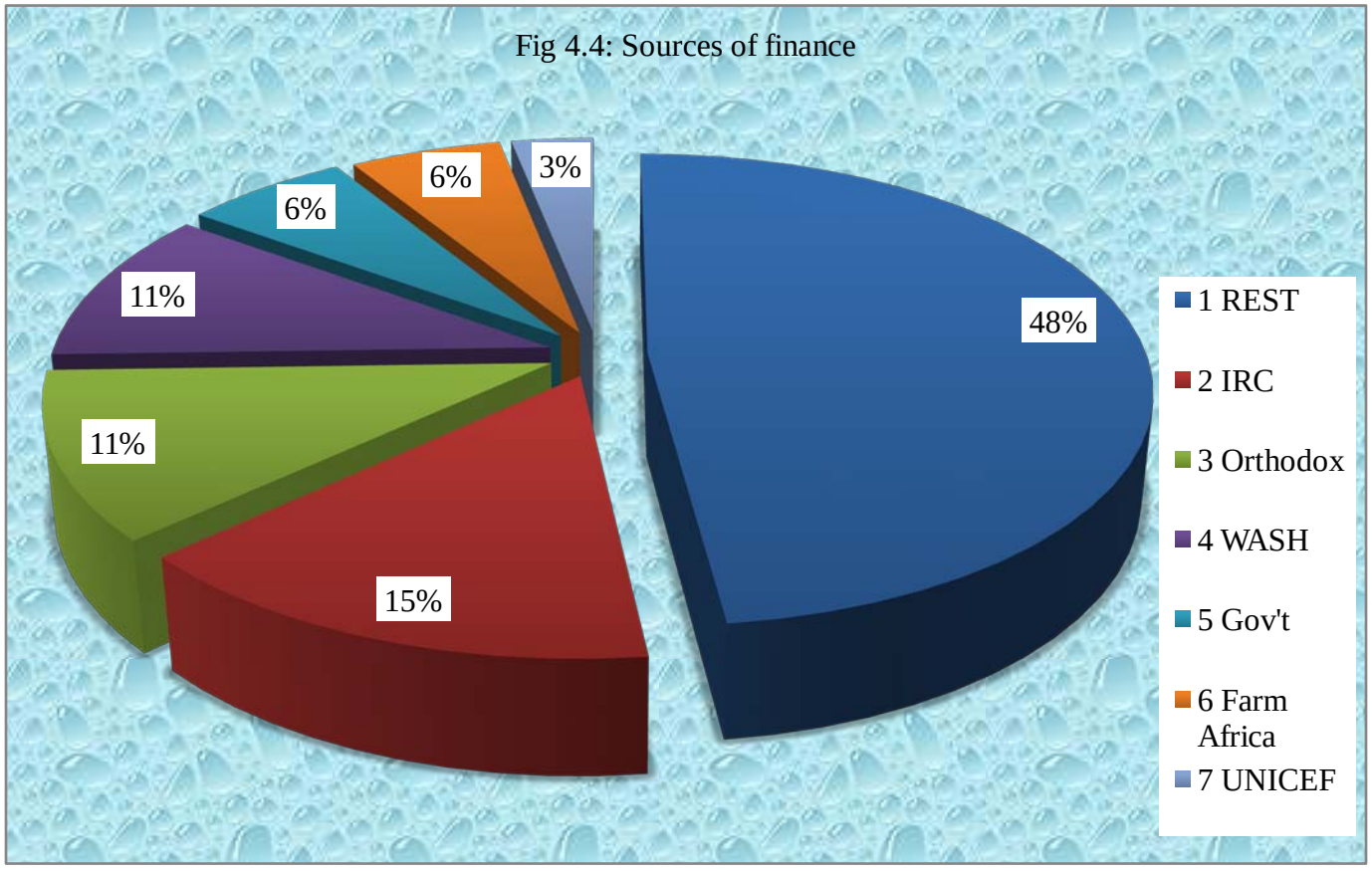
study area were constructed by non- governmental organizations. Supportive data are provided by table 4.2 and fig 4.4 as follows.

Table 4.2: Sources of finance for the construction of water schemes in the twenty year

S/no	Organizations	HDW		SHW		SPD		Total Cost	%
		No	Cost	No	Cost	No	Cost		
1	REST	200	10,000,000	53	7,950,000	45	2,250,000	20,200,000	48.5
2	Orthodox	47	2,350,000	12	1,800,000	13	650,000	4,800,000	11.4
3	WASH	33	1,650,000	18	2,700,000	1	50,000	4,400,000	10.4
4	Farm Africa	28	1,400,000	6	900,000	2	100,000	2,400,000	5.7
5	IRC	2	100,000	25	3,750,000	0	0	6,250,000	14.8
6	Gov't	12	600,000	13	1,950,000	0	0	2,550,000	6.1
7	UNICEF	2	100,000	8	1,200,000	0	0	1,300,000	3.1
	Total	324	16,400,000	135	20,250,000	61	3,050,000	42,100,000	100

Source: AWWRMO, 2014

Fig 4.4: Sources of finance



Source: AWWRMO, 2014

As clearly shown in the above table 4.2, and fig 4.5, nearly half of the Rural Water Schemes were constructed by REST (48.5%) followed by IRC (14.8%). Comparing by their cost covering share of each institution, construction costs were covered by REST 20.2 million (48.5%), IRC 6.25 million (14.8%), Orthodox 4.8 million (11.4%), WASH 4.4 million (10.4%), Government 2.6 million (6.1%), Farm-Africa 2.4 million (5.7%), and UNICEF 1.3 million (3.1%) respectively. Of all the institutions REST and IRC covers 63.3 percent and the remaining 36.7 percent was covered by other organizations.

4.3 Water Schemes' Distribution and Coverage in Ahferom Woreda

In Ahferom Woreda there are 396 functional water schemes. These are unevenly distributed throughout the 27 tabias to provide water supply service to the total rural population of 167,123.

4.3.1 Tabia level Distribution of Water Schemes

Distribution refers to the situation whether the water schemes are evenly or unevenly distributed over the study area. This section further evaluates the number of clean water sources available in the study area. The evaluation includes the spatial distribution of water schemes and the distribution to the existing population of Ahferom Woreda. The result of the study reveals that the distribution of water schemes is not fair and uneven in study area. Some tabias have large number of water schemes while others have lower.

Generally, those people who live in areas having highest number of water schemes have better service while the others have not. Misgina (2006) raised discussed related issues in his thesis and suggested that with fair distribution of water sources having enough quantity and quality, the following advantages could be achieved: total travel distance can be reduced, water born diseases can be reduced, waiting time can be reduced, children's get time to go to school and study and personal hygiene of family members could also be improved.

As it is shown in Appendix I and Fig 4.5 of "A", some tabias such as Sero, Laelay-megaria tsemri, Adi-zata and Mezbr are highly accessible to numbers of water schemes accounting 29, 28, 24, and 21 water schemes respectively. On the other side, May-hamato, Agamo, Laelay Hahayle and Daero-Anbesa have lower numbers of clean water sources accounting 3, 2, 6 and 6 water schemes respectively. The other tabias in the study area are in between the two extremes. From this, it is clear that those people who live in the tabias with higher number of water schemes have better clean water accessibility than those living in the lower number of water schemes and are free from the challenges of safe water. Generally, water schemes (potable water

sources) distribution in the tabias of the Woreda is uneven (unfair). The following tabia level water schemes' distribution map of Ahferom Woreda (Fig 4.6 of "A") provides clear information about the uneven distribution of the water schemes in the study area.

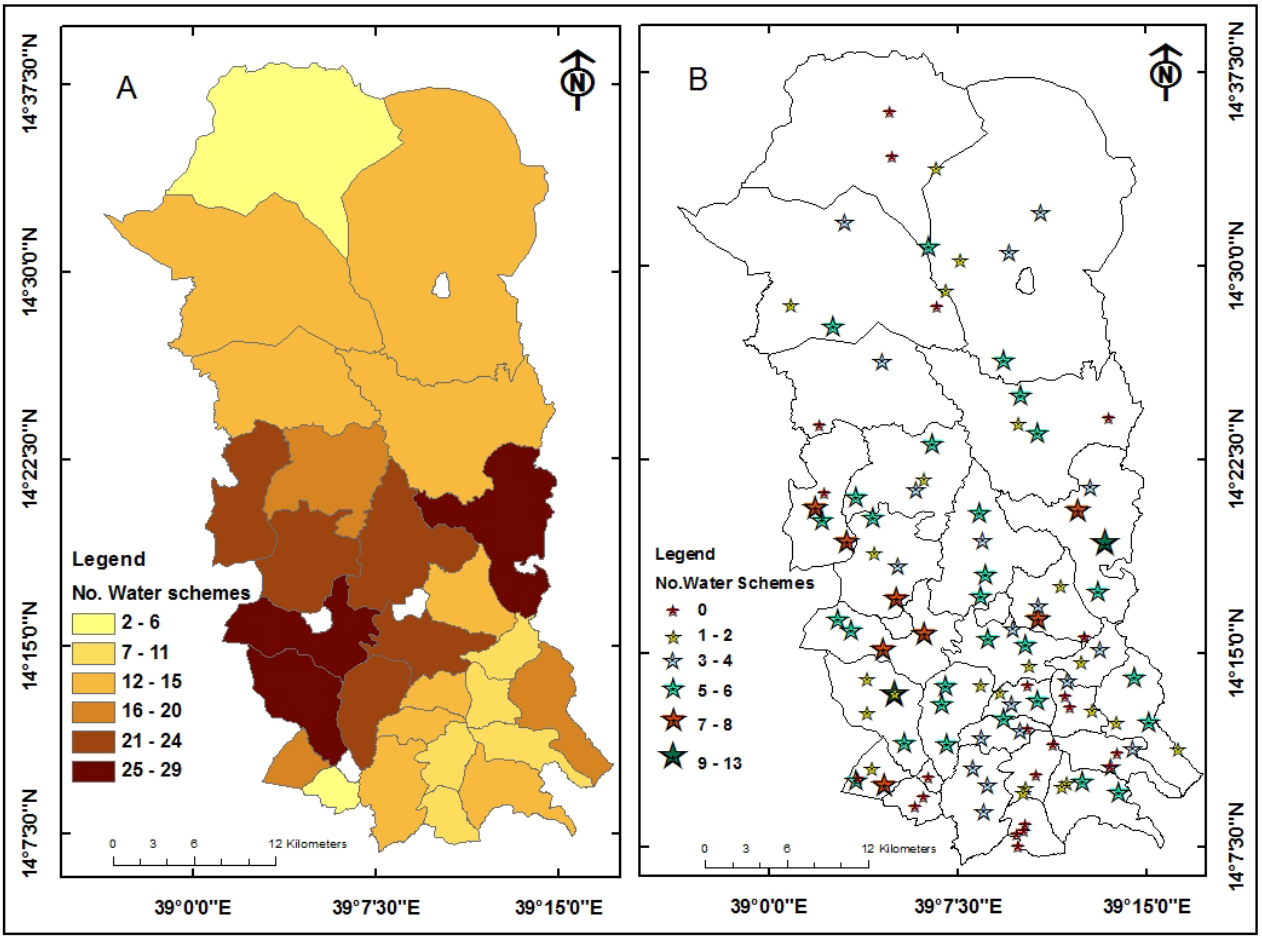


Figure 4.5: Tabia (A) and Kushet (B) level water schemes distribution map of Ahferom, 2013

N.B = Kushets

4.3.2 Kushet level Distribution of Water Schemes

As it is mentioned in tabia level distribution above, the kushet level distributions of water schemes also have similar trends. In other words, clean water sources are not equally and fairly accessible to the dwellers of the rural communities.

As shown in Appendix II and Fig 4.5 of "B" above the distributions of water schemes are not fairly shared among the rural society. In this regard, results show critical problems in kushets with zero clean water sources. These kushets are Alagsa, Blay-tisha, Sye, Mashal, Kole, and Amus. Kushets with higher number of water schemes include May-Liham (13 water schemes),

Edagakedam (12 water schemes), Munguda, Limat and May-weyni (9 water schemes each) and Liham, Adikers, Endagergis, May-shewit, Erasur (with 7 water schemes each). To the contrary, kushets with low water schemes (potable water sources) are Adi-keleto, Hbret, Kelli , May-arbaa', Adi- mereta, Adi-wula ,Hnflo, Adi-wuray, Laeaya-gamo, Tahtayagmo, Azmera , Adi-tserae and tsetse have one water scheme (source) each.

Generally, comparing the two distribution extremes in tabias and kushets; the highly accessible tabias and kushets could have healthy family and faster socio-economic progress than the less accessible ones. In other words, the highly accessible ones can protect their self-hygiene and save time and energy for other socio-economic activities rather than wasting time in fetching water from distant areas**.**

4.3.3 Density and Spatial Coverage of Water Schemes

Spatial coverage refers to the ratio of water schemes to square kilometer area of a given place and to total population. To assess the spatial coverage of water points or water schemes, the researcher has computed the number of water schemes to the given area and the number of water schemes to the total population. The computed result of the ratio of water schemes to area coverage of the woreda is 0.307 water schemes per square kilometer area or 307 water schemes per 1000 square kilometer area. On the other hand, the ratio water schemes to the existing total population of the Woreda is 0.0024 water schemes to each person or 2.4 water schemes (sources) to 1000 beneficiaries. In this cases, the average travel distance of beneficiaries to fetch water from the nearby clean water source is 1.02km. In general the ratio of water schemes to the beneficiaries was below the regional standard. This means large numbers of people are forced to use from single water scheme.

4.3.3.1 Density of Water schemes in the Study Area

Due to the disproportional distribution of water schemes in the tabias and kushets, the ratio of clean water sources per-square kilometer area is low. In Ahferom woreda, water schemes' coverage per square km in 2013 was 0.307. Within 3.25 square km, there was one water scheme. Since the area coverage of each Tabia and the total number of water schemes in each Tabia are different, the value of water scheme coverage to the total area is different. Therefore, Tabia level areal coverage of water schemes of Ahferom Woreda ranges from 0.022 (22 per 1000 square km in May-Hamato) to 1.469 in Adi-yiekoro.

As it is shown in fig 4.6 and appendix I, comparing tabias with maximum water schemes coverage per square km area are: Adi-yiekoro, Endalashen, May-keyahat and Tahtay Daereka are among the tabias of Ahferom Woreda with values 1.469, 1.237, and 1.083 respectively. To the opposite, May-Hamato, Hoya medeb, Semhal and Erdi-jeganu are among the tabias with lower water schemes per square km area coverage with the values, 0.022 (22 water schemes per 1000 square km), 0.055 (55 per 1000 square km), 0.097 (97 per 1000 square km) and 0.157 (157 per 1000 square km) respectively. The other tabias range in between the two extremes.

From these statistical results of tabia level water schemes per area coverage, we can understand that there is no fair distribution and equity of accessibility of water schemes (water sources) among the whole tabias of the Woreda as well as among the beneficiaries (rural communities).

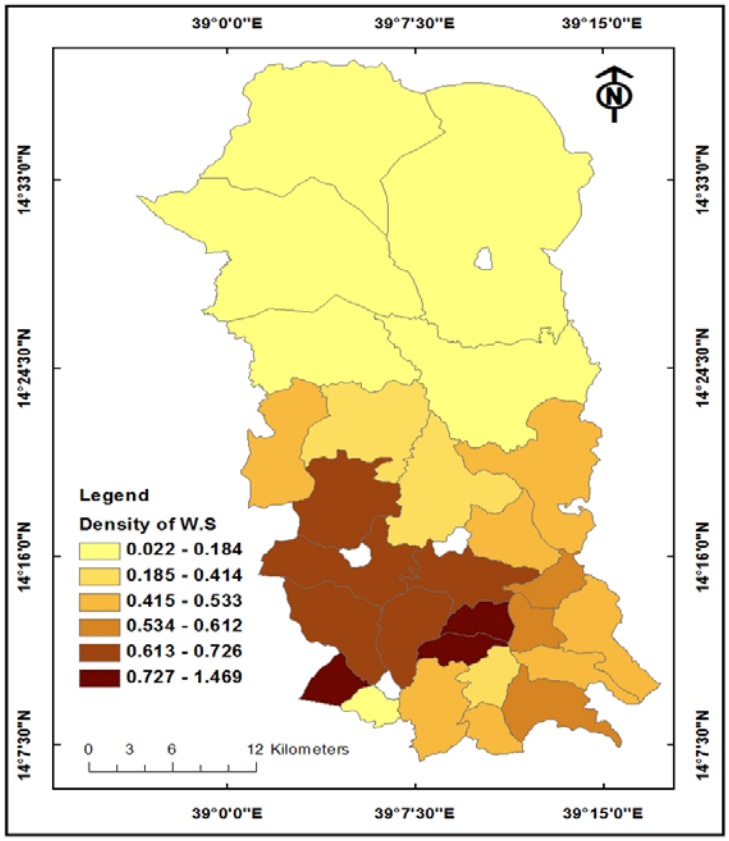


Figure 4.6: Tabia level water schemes density map of Ahferom Woreda, 2013

4.3.3.2 Density of Water Schemes per Beneficiary

To assess the ratio of water schemes to beneficiaries; two parameters have been employed: one is dividing the number of water schemes to the beneficiaries and the second is applying the

regional standard of water schemes to beneficiaries. According to the Regional Plan (1998) of potable water usage of rural area HDW, SPD and SHW, the types of water schemes are designed to serve 250, 300 and 400 beneficiaries respectively. As it is shown in appendix I and Table 4.3; Ahferom Woreda water schemes coverage per beneficiaries is computed to be 0.00236 (2.36 per 1000 beneficiaries) in 2013. In other words, the ratio of beneficiaries per water scheme is 422 people to one water scheme. Comparing to the stated regional policy, irrespective of generating capacity, on average one water scheme is expected to serve for 316 beneficiaries (TRWRMB, 1999). Therefore, comparatively Ahferom Woreda is below the expected ratio of water scheme to the beneficiaries and the existing water schemes are serving more than their capacity. Therefore, water schemes coverage estimated by area and population parameters is low. The highest and the lowest water schemes coverage to the beneficiaries are found in Sero and May-hamato, with 7.75 water schemes per 1000 beneficiaries and 0.5 water scheme per 1000 beneficiaries respectively. The other technique employed to assess the ratio of water schemes to beneficiaries is comparing the existing ratio of water schemes to the beneficiaries against the regional standards.

Table 4.3: Ratio of water schemes to beneficiaries

S.No	Name of Tabia	Total population	Functional .W.S	Non-functional	Type of water schemes and the ratio to beneficiaries									Total Stand.Bene	Excess pop
					HDW			SPD			SHW				
					Number	Sta.Ben_ratio	Beneficiaries	Number	Sta.Ben_ratio	Beneficiaries	Number	Sta.Ben_ratio	Beneficiaries		
1	May_Hamato	5981	3	3	0	250	0	0	300	0	3	400	1200	1200	4781
2	Hoyamedeb	8063	13	7	3	250	750	0	300	0	10	400	4000	4750	3313
3	Semhal	6885	14	1	1	250	250	0	300	0	13	400	5200	5450	1435
4	Zbanguila	9089	13	8	7	250	1750	0	300	0	6	400	2400	4150	4939
5	Erdijeganu	8704	15	5	5	250	1250	0	300	0	10	400	4000	5250	3454
6	Betegebez	6935	17	5	7	250	1750	0	300	0	10	400	4000	5750	1185
7	Mezbir	6724	20	4	10	250	2500	0	300	0	10	400	4000	6500	224
8	T.m. tsemri	6312	19	5	8	250	2000	0	300	0	11	400	4400	6400	88
9	L.m.tsemri	8171	28	6	13	250	3250	2	300	600	13	400	5200	3850	4321
10	Degos	5108	20	5	19	250	4750	0	300	0	1	400	400	5150	42
11	Sero	3741	29	5	18	250	4500	3	300	900	8	400	3200	8600	*4859
12	Mysru	5333	14	5	9	250	2250	4	300	1200	1	400	400	3850	1483
13	Endamariam	4582	19	3	16	250	4000	3	300	900	0	400	0	4900	318
14	Adi-zata	9319	24	3	20	250	5000	1	300	300	3	400	1200	6500	2819
15	Endalashen	4005	14	5	10	250	2500	3	300	900	1	400	400	3800	205
16	Mykeyahat	4029	13	5	7	250	1750	6	300	1800	0	400	0	3550	479
17	Sefo	5374	8	10	7	250	1750	1	300	300	0	400	0	2050	3324
18	Embaahferom	5388	8	2	7	250	1750	1	300	300	0	400	0	2050	3338
19	Edaga arbi	7940	16	6	13	250	3250	2	300	600	1	400	400	4250	3690
20	Kudo	5348	10	3	9	250	2250	1	300	300	0	400	0	2550	2798
21	Mishig	7716	15	3	15	250	3750	0	300	0	0	400	0	3750	3966
22	Laelay-hahayle	5120	6	6	6	250	1500	0	300	0	0	400	0	1500	3620
23	Daero-anbesa	7051	6	5	5	250	1250	1	300	300	0	400	0	1550	5501
24	Edagahamus	5497	14	3	12	250	3000	2	300	600	0	400	0	3600	1897
25	Agamo	587	2	2	1	250	250	0	300	0	1	400	400	650	*63
26	Tahtaydaeraka	5359	20	5	20	250	5000	0	300	0	0	400	0	5000	359
27	Adiyiekoro	4762	15	4	13	250	3250	2	300	600	0	400	0	3850	912
	Total	167123	396	124	257	250	64250	31	300	9300	108	400	43200	116750	50373

Source: AWWRMO, 2014

The ratio of water schemes to beneficiaries presented in table 4.2 above reveals that of the total population (167,123), about 116,750 people are accessible while 50,373 people remained inaccessible to potable water sources respectively. In this case, water scheme to beneficiary ratio

is not uniform throughout the tabias of the study area. In Ahferom Woreda, except Agamo and Sero which have sufficient clean water sources, all tabias have clean water access just below the regional standard. This indicates that the water schemes are serving more than their capacity. The existing water schemes in tabia May hamato, Daero anbesa, and Zban guila couldn't even serve half of the dwellers. While in tabia Tahtay daereka, Endamariam, Degos, and Tahtay megaria tsemri, the population to water schemes ratio is in a good status.

4.4 Potable Water per Capita (L/d)

Potable water per capita of the beneficiaries refers to the ratio of the amount of water generated by a particular water schemes per day to the number of people to be served by it. In this way, the water per capita (average consumption) of Ahferom Woreda is estimated (computed) to be 7.6 liters per person per day. According to the Regional WRMB Plan (2001), the amount of water per person per day is 15 Litters. Therefore, comparing with the Regional standard, potable water consumption of the people of Ahferom Woreda is below the regional standard. Similarly, Zemenu (2012) estimated the rural people potable water per capita in Quarit Woreda (Amhara Region) and found that average water consumption per capita is 10 litters a day. Even though the access is better than Ahferom, it is still lower comparing with the amount recommended by WRMB (15 liters per day).

4.4.1 Tabia Level Potable Water per Capita (L/d)

Because of uneven distribution and generating capacity of water schemes, the amount of water in litter per person per day varies from tabia to tabia in Ahferom Woreda. That is some tabias generate good amount of water even closer to the regional standard while the others have limited generating capacity. Hence, dwellers suffer from shortage of clean water and water born diseases.

Appendix I and Fig 4.7 of "A", indicates clean water accessibility in the tabias is not distributed in an equitable manner. In Ahferom Woreda, clean water accessibility ratio ranges from one litter per person per day in May-hamato to 11.4 liters per person per day in Adi-yiekoro and Adi-zata.

Comparatively, tabias with good or closer to the regional standard are Adi-yiekoro, Adi-zata, Tahtay-daereka, Laelay-megaria tsemri with 11.4, 11.4, 11.3 and 11.2 liters per person per day respectively. On the contrary, tabias having lower amount of water in litter per person per day are May hamato, Sefo, Kudo, Laelay-hahayle and Erdi-jeganu with 1, 3, 3, 3.5 and 3.6 liters

respectively. The levels of potable water consumption of the other tabias in Ahferom Woreda range in between the values of the above two extremes.

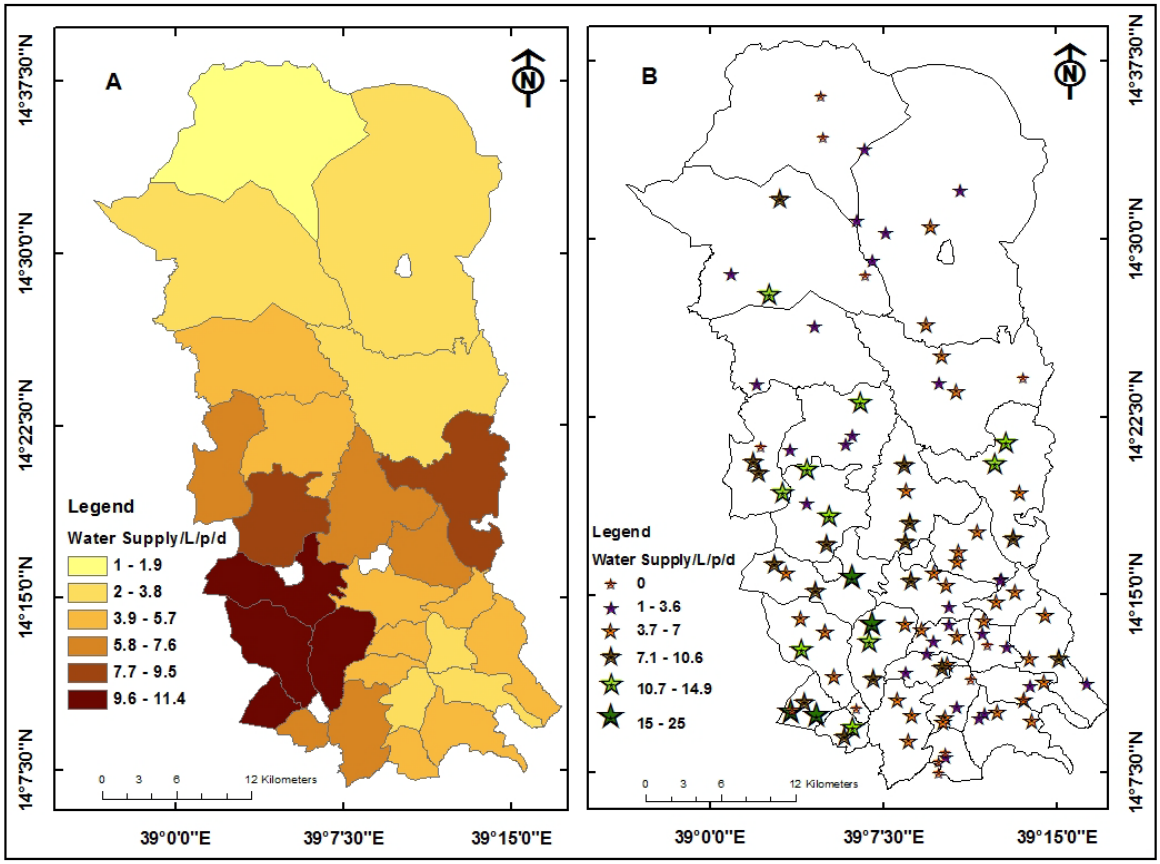


Figure 4.7: Tabia and Kushet level clean water ratio per person per day in 2013

N.B ★ = Kushet

4.4.2 Kushet level Potable Water per Capita of Beneficiaries

As it is clearly shown in Appendix II and Fig 4.7 of "B", (about ratio of clean water to the beneficiaries), the reasons discussed at the tabia level about clean water accessibility are also true at Kushet level. Clean water accessibility is influenced by the uneven distribution, generating capacity of water schemes and the number of population. Therefore, the accessibility of drinking water per day per person in litter is not equivalent (fair) in Kushets of the study area. The accessibility ratio of clean water to Kushet population ranges from zero to 25 Litters.

Kushets that are highly accessible and equal to the regional standard and above are Medebti, Genadf, Lma't, Munguda and May shewit with 25, 24, 18, 18, and 14 liters per day per person respectively. On the other side, Kushets without any clean water sources or in use from untreated water sources or with longer travel distance to collect clean water are Kelelie, Wnth, Lieto,

Amus, Kole, Sye, Debri, Blayfisha and Alagsa. These Kushets are severely affected by shortage of clean water. Kushets having minimum potable water access per day per person are Ad-keleto, Adi-senay, Adi-bula, Belesa, Endaergab, May arbaa', Smechezala and Adi- hayam with 1, 1, 1, 1.2, 1.4, 1.4, 2, 2 and 2 litters respectively.

4.5 Accessibility Coverage of Potable Water in 2013

Potable water accessibility assessment is aimed to evaluate the level of clean water access of the rural communities of Ahferom Woreda measuring through travel distance and clean water per capita of the beneficiaries. The author has also examined whether the rural dwellers are obtaining based on the regional standard or not. According to the FMWRMO (2002), clean water must be available to the beneficiaries with in 1.5 km average travel distance from home to nearby clean water sources. Clean water supply should also be 15 liters per person per day to the rural dwellers. 20 liters per person per day clean water should be available to the urban settlers within 0.5 km travel distance from home to nearby clean water sources.

Using the regional standard as a benchmark for evaluating the potential accessibility coverage, only 39% (65,463) of the total rural population of Ahferom Woreda (167,123) is accessible. The remaining 61% of the total rural population (101,660) of the Woreda is inaccessible to potable water. In other words people are using from unprotected water sources. But, using only travel distance parameter for an accessibility assessment of the total rural population, 79% (132,526) are accessible to potable water sources within 1.5km average travel distance. In general, in Ahferom Woreda, even though average travel distance to fetch water is different from one Tabia to another, the average rural population of the Woreda has access to clean water within 1.02 km distance from nearest water sources.

Table 4.4: Potable water accessibility coverage of Ahferom in 2013

Sno	Name of TABIA	Area SQ_KM	Water points	Water produ-day	Total Popula	Inaccessib popula	Accessible Popu1.5km	%inacce popula	%access popula	Lit/per day per P	Average Dista Tr	15L_With _in_1.5km	% pop 15L within 1.5km
1	May-hamato	136.4	3	4838	5981	4967	1014	83	17	1	3.8	323	5
2	Hoyamedeb	234.5	13	30758	8063	5221	2842	65	35	3.8	2.4	2051	25
3	Semhal	144.3	14	25488	6885	5296	1589	77	23	3.7	1.8	1699	25
4	Zban guila	70.37	13	41472	9089	5364	3725	59	41	4.5	1.3	2765	30
5	Erdi Jeganu	95.68	15	31968	8704	5118	3586	59	41	3.6	1.4	2131	24
6	Bete gebez	50.43	17	33696	6935	912	6023	13	87	4.8	1.0	2246	32
7	Mezbr	40.29	20	49248	6724	1886	4838	28	72	7.3	1.0	3283	49
8	T.Meg.Tsemri	41.43	19	63072	6312	157	6155	2	98	9.9	1.0	4205	67
9	L.Meg.Tsemri	40.3	28	91670	8171	1	8170	0	100	11.2	0.8	6111	75
10	Degoz	52.94	20	39658	5108	428	4680	8	92	7.8	0.9	2644	52
11	Sero	61.37	29	34560	3741	702	3039	19	81	9.2	1.0	2304	62
12	Maysuru	26.24	14	29808	5333	365	4968	7	93	5.6	1.0	1987	37
13	Endamariam	28.56	19	19,181	4582	0	4582	0	100	4.2	0.7	1279	28
14	Adi-zata	35.02	24	106963	9319	698	8621	7	93	11.4	0.7	7131	77
15	Tah. Daeraka	27.54	20	105235	9359	13	9346	0	100	11.3	0.7	7016	75
16	Endalashen	11.31	14	16,934	4005	0	4005	0	100	4.2	0.5	1129	28
17	May Keyahat	12	13	1,832	4029	0	4029	0	100	4.5	0.5	122	3
18	Sefo	12.88	8	15984	5374	282	5092	5	95	3	0.7	1066	20
19	E.Ahferom	13.54	8	20304	5388	51	5337	1	99	4.1	0.7	1354	25
20	Edaga Arbi	32.31	16	41731	7940	333	7607	4	96	5.2	0.8	2782	35
21	Kudo	17.82	9	17453	5348	373	4975	7	93	3.3	0.8	1164	22
22	Mishig	26.36	15	34042	7716	908	6808	12	88	4.4	0.8	2269	29
23	Lalay-hahayle	14.48	6	18,144	5120	0	5120	0	100	3.5	0.9	1210	24
24	Daero-anbesa	11.63	6	14515	7051	1200	5851	17	83	4.2	0.8	968	14
25	Edaga Hamus	29.97	14	34733	5497	319	5178	6	94	6.3	0.8	2316	42
26	Agamo	8.8	2	3974	587	3	584	1	99	6.7	1.2	265	45
27	Adi-yiekoro	11.57	17	54,691	4762	0	4762	0	100	11.4	0.5	3646	77
	Total	**1288.1**	**396**	**981,952**	**167123**	**34597**	**132526**	**21**	**79**	**7.58**	**1.0**	**65463**	**39**

Source: AWWRMO, 2014

4.5.1 Tabia level Potable Water Accessibility Coverage

As it is shown in table 4.4 and figure 4.8 of "A", potable water accessibility coverage of the study area varies from Tabia to Tabia. Some tabias are highly accessible while others are less accessible. Comparatively, Tabias with higher accessibility coverage are: Adi-yiekoro, Adi-zata, Tahtay-daeraka and Tahtay megaria tsemri (77, 77, 75, and 75% of their populations are accessible to clean water). These tabias have achieved the regional standards (1.5km radius and 15 litter per person per day) respectively. On the contrary, tabias with lower accessibility coverage in the study area are May-keyahat, May-hamato, Daero-anbesa, Kudo, Erdi-jeganu and

Laelay-hahayle (3, 5, 14, 22, 24, and 24% of their population are accessible). The remaining is using unprotected water sources or may travel longer distances to fetch water. In this case, if we take only a distance of 1.5km (regional travel distance) very large numbers of the people of different tabias have an access to safe water sources. As a result, Tabias: Laelay megaria tsemri, Endamariam, Tahtay-daeraka, May-keyahat, Adibereto and Adi-yiekoro are the most accessible areas which are 100% of their population are within the accessible zone of the Woreda.

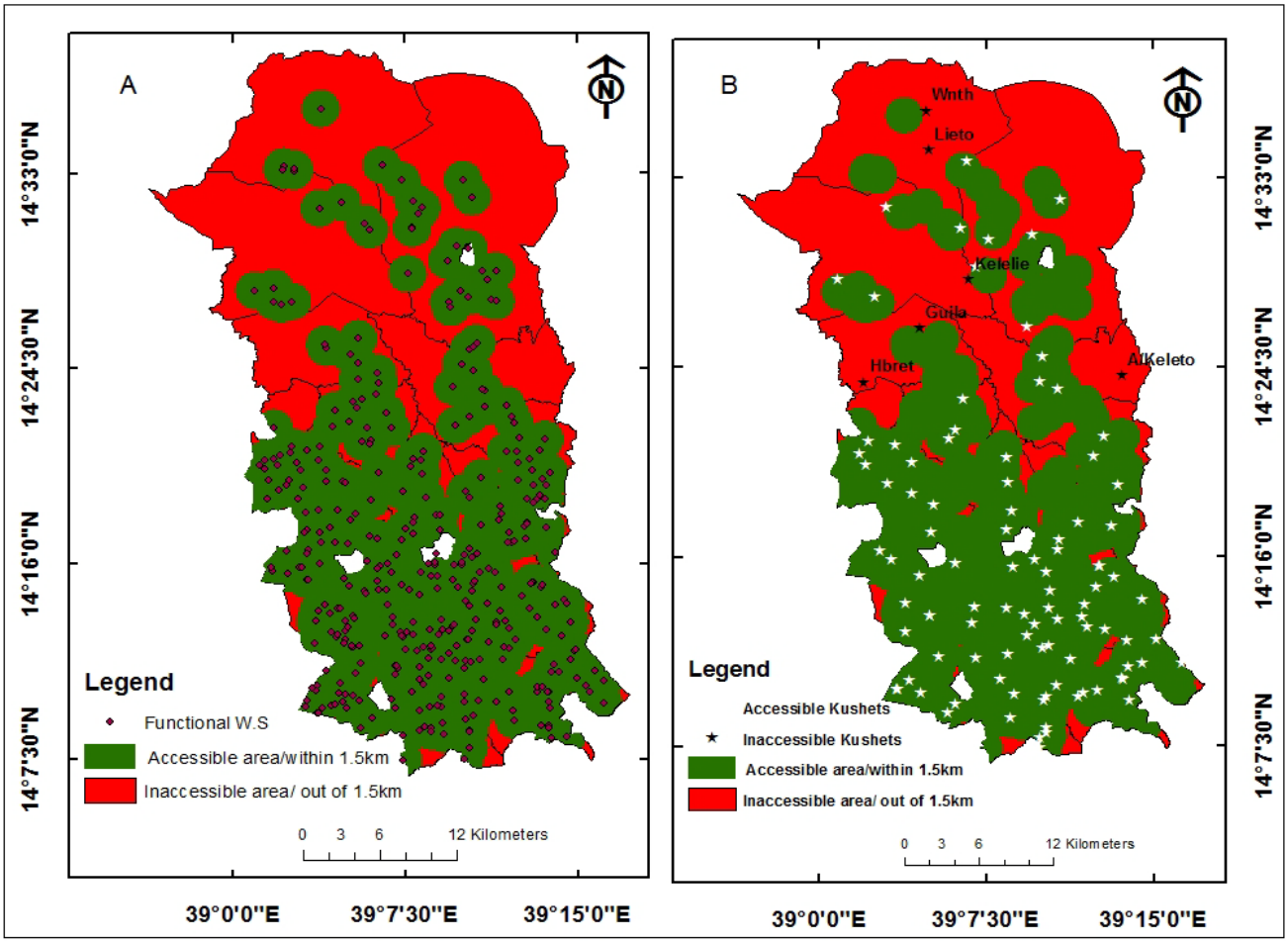


Figure 4.8: Tabia (A) and Kushet (B) level Potable water accessibility map in 1.5 km distance

N.B: ★ = kushets

4.5.2 Kushet level Potable Water Accessibility

This section examines the rural potable water access of kushets in the study area which completely found within 1.5km radius travel distance and having potable water per capita of 15 liters per person per day. The cost effective method of the application of GIS or buffering the proximity is used to identify the number of kushets that satisfy the given standards. This can

provide a good estimate of water schemes' accessibility index. This involves working with layers of water schemes' distribution map to determine how many kushets and beneficiaries are found within the specified catchments of the potable water sources. Number of kushets and beneficiaries located within 1.5 km distance to the water schemes are considered as accessible and demonstrated using Buffer in Fig 4.8 of "B" above.

Figure 4.8 of "B" indicates accessible kushets and beneficiaries to potable water or water schemes in 2013/14. Therefore, in 2013, 94.2% of kushets and 39% of the beneficiaries have access to potable water based on the regional standard (1.5km and 15 liter per person per day). This shows that the residents are accessible within shortest travel distance; but, the production capacity of the water schemes is too low (limited water generating capacity) to satisfy all the beneficiaries within the buffer zone.

As it is clearly shown in Fig. 4.8, of 'B' Kushets completely located outside of 1.5 km distance from clean water sources are Wnth, Lieto and Kelelie (in Tabia May-hamato), Guila and Hbret (in Tabia Zban-guila) and Adi-klieto (in Tabia Erdi-jeganu). From this we can understand that those people who live in these tabias are forced to travel longer distances to get safe water or may in use of unprotected water sources so as to reduce the traveling distance and time wastage as well as energy.

4.6 Growth Trend of Water Schemes in the Study Area

The main purpose of this section is to assess the growth of water schemes (potable water source development) in relation to the population growth through time. This part further examines the service provision level (capacity) of water schemes to the rural society residing in the Woreda. However, there was no data regarding the size of population since the study started 20 years before. Due to lack of data, this discussion only focuses on physical increments of water schemes in the Woreda and the construction situations of the water schemes from 1994 to 2013.

Table 4.5: Growth trend of water schemes from 1994-2013

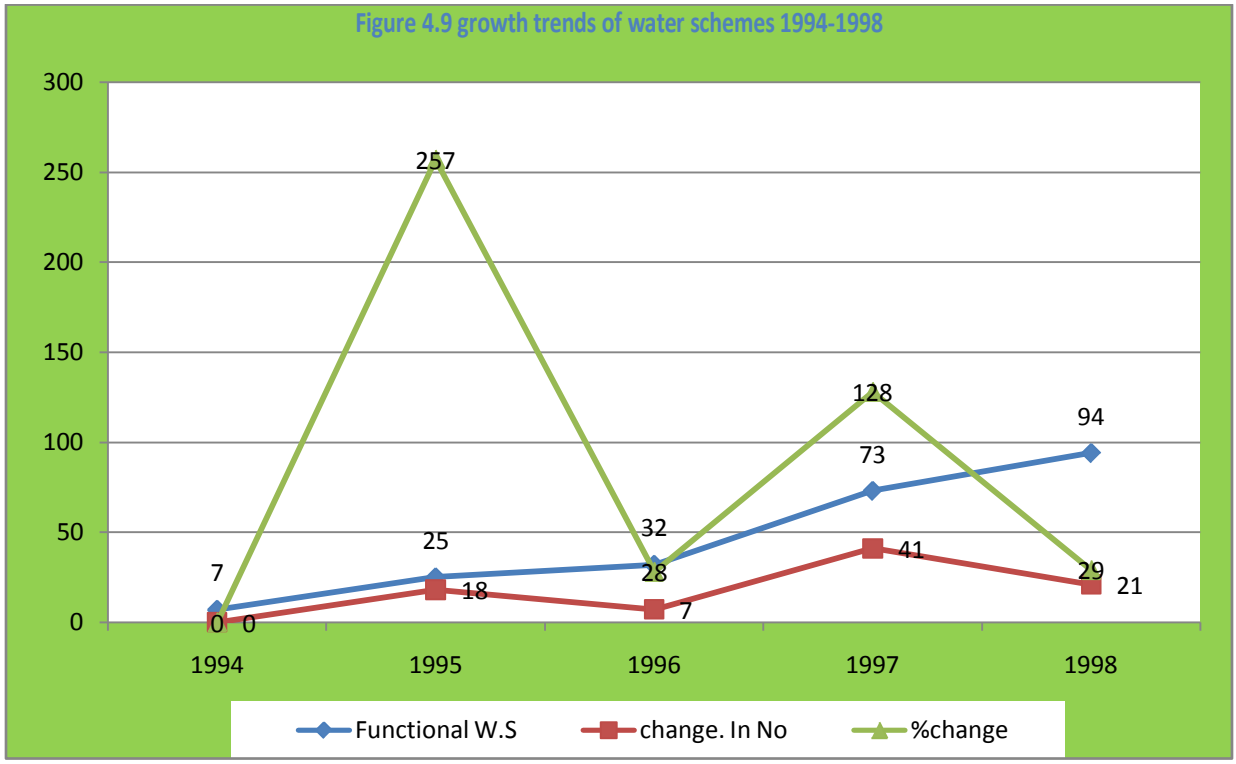
Year	No. of Functional water points	Change. In No	%change	No of non-functional
1994	**7**	**0**	**0**	**0**
1995	**25**	**18**	**257**	**0**
1996	**32**	**7**	**28**	**0**
1997	**73**	**41**	**128**	**0**
1998	**94**	**21**	**29**	**0**
1999	**121**	**32**	**34**	**5**
2000	**144**	**24**	**19**	**6**
2001	**143**	**15**	**10**	**22**
2002	**170**	**33**	**20**	**28**
2003	**198**	**31**	**16**	**31**
2004	**211**	**24**	**10**	**42**
2005	**238**	**29**	**11**	**44**
2006	**238**	**18**	**6.2**	**62**
2007	**258**	**24**	**8**	**66**
2008	**278**	**20**	**6**	**66**
2009	**292**	**35**	**10**	**87**
2010	**296**	**21**	**6**	**104**
2011	**334**	**42**	**11**	**108**
2012	**360**	**35**	**8**	**117**
2013	**396**	**43**	**9**	**124**

Source: AWWRMO, 2013

In order to evaluate the growth trends of water schemes in each five years plan of the Woreda, the researcher has attempted to examine the issues by classifying into four categories as follows.

4.6.1. Growth Trend of Water Schemes from 1994 –1998

To solve clean water service provision problems in Ahferom Woreda, drilling water schemes was started in 1994 by the two most dominant Non-Governmental Organizations called REST and Orthodox constructed 5 and 2 water schemes each respectively.



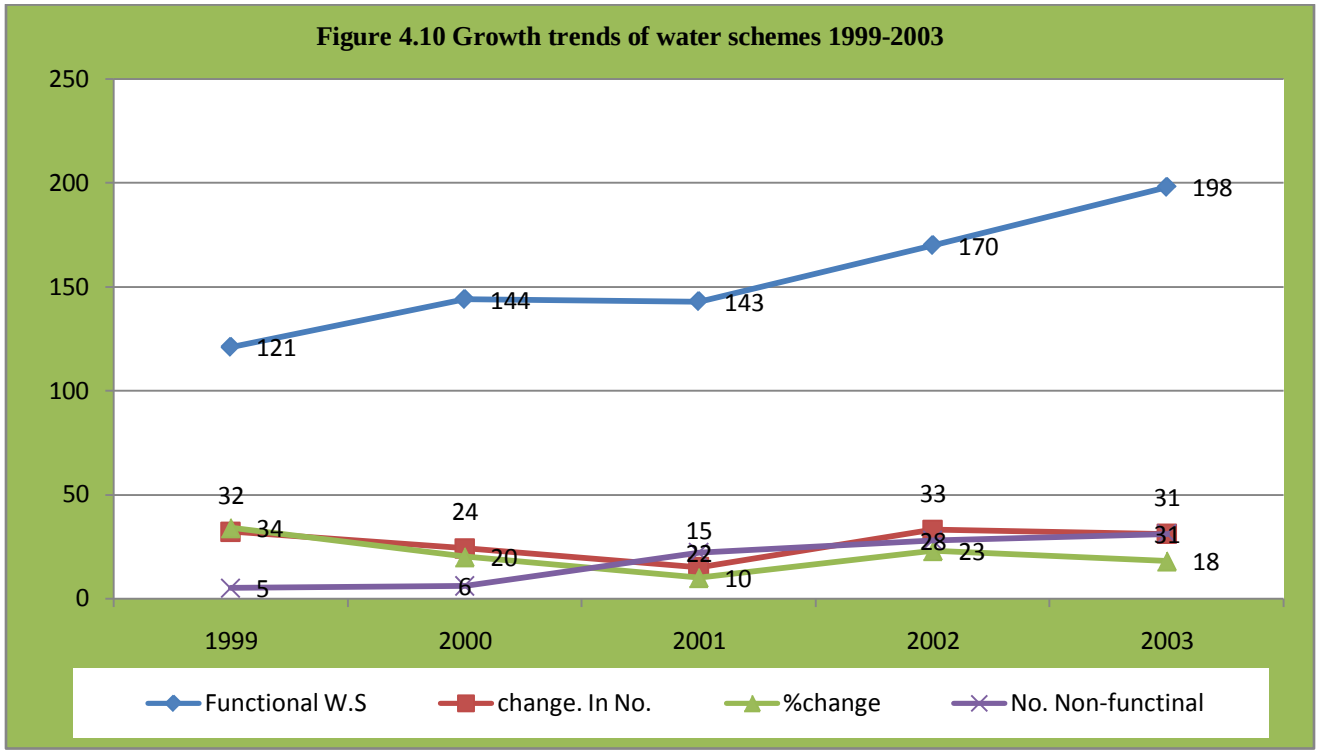
Source: AWWRMO, 2013

As it is shown in table 4.5 and figure 4.12 above, the number of water schemes constructed in this five year plan of the Woreda was 94. The number of water schemes constructed before the base year (1994) was seven, and then the number of water schemes increased by 25(257%), 32(28%), 73(128%) and 94(29%) from 1995 to 1998 respectively. Again, as it is shown in table 4.4, since the water schemes were new, all were productive (functional).

Even though, the construction of water schemes in the five years above was showing positive increment, the growth trend is different from one year to another. Comparatively, a steady increment of water schemes had been observed in 1995 and 1997 (18 and 41 water schemes) respectively. In general, 91.4% growth rate of water schemes was observed from 1994 to1998.

4.6.2 Growth Trend of Water Scheme from 1999 – 2003

In the first years of the period 1999- 2003, the number of water schemes grown from 94 to 198 (by 13.1% growth rate). In this five year construction period, almost similar growth trend (with a small decline in 2001) is observed in all consecutive years.



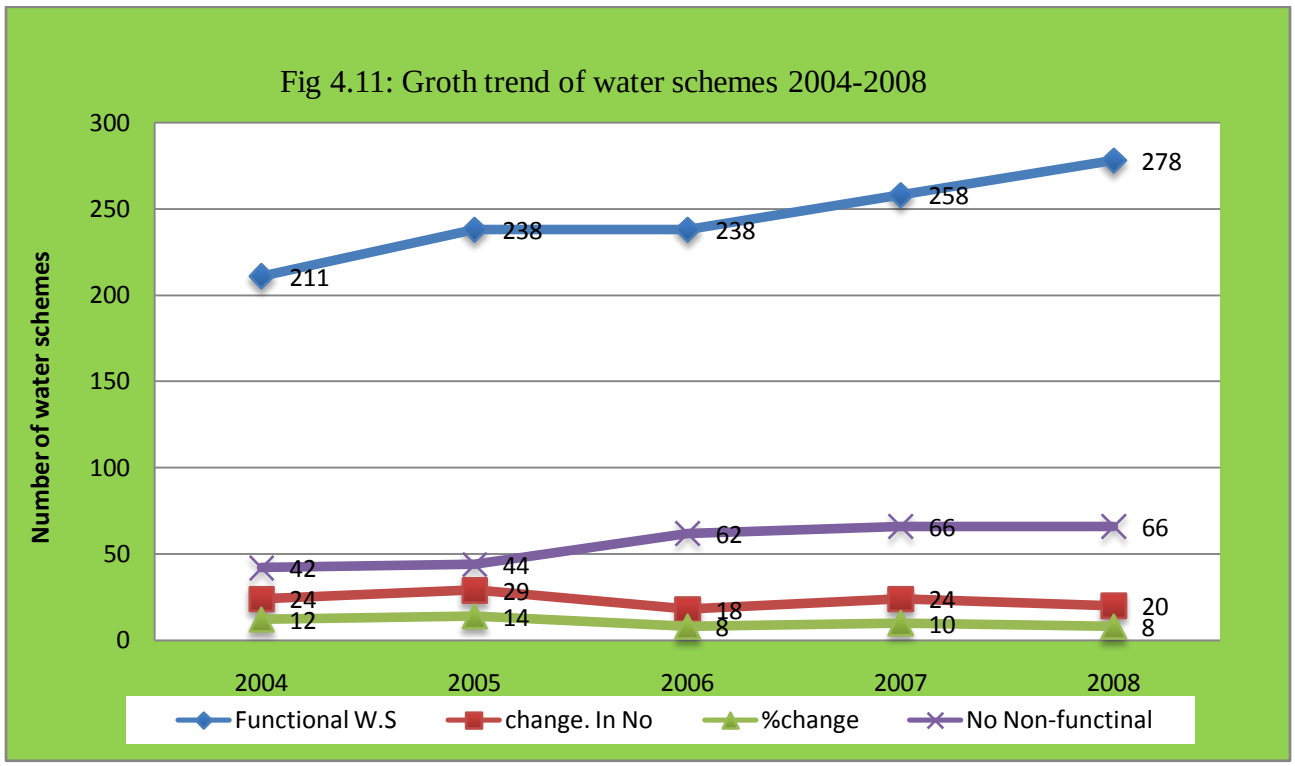
Source: AWWRMO, 2013

As it is clearly indicated in table 4.4 and fig.4.13, the absolute number and percentage growths of water schemes in each year (from 1999 – 2003) are 32(34%), 24(20%), 15(10%), 33(23%) and 31(18%) respectively. Comparatively, from 1999 to 2002 growth trend is higher than the other three years. Even though clean water sources in the study area were growing positively from year to year, about six of the total water schemes became non-functional. Because of these, those people who had been expected to get potable water supply service failed to get the service. As a result, many people were forced to travel longer distances to get safe water or to use from unprotected sources. As per the regional standard, one water point is constructed to serve on average 316 beneficiaries. Therefore, in these five years about 1,896 people were exposed to shortage of safe water and water related problems.

4.6.3 Growth Trend of Water Schemes from 2004-2008

Just like the two successive five years progresses of water schemes shown in the preceding sections, the 2004 – 2008 trends are increasing positively. The growth trends; however, are not as fast as that of the above ten years.

There were 278 water schemes in the period 2004 – 2008 (excluding the non-functional ones). On the other hand, in this period, the number of non-functional water points rose to 66 and about 20,856 people were exposed to shortage of safe water and other water related problems.

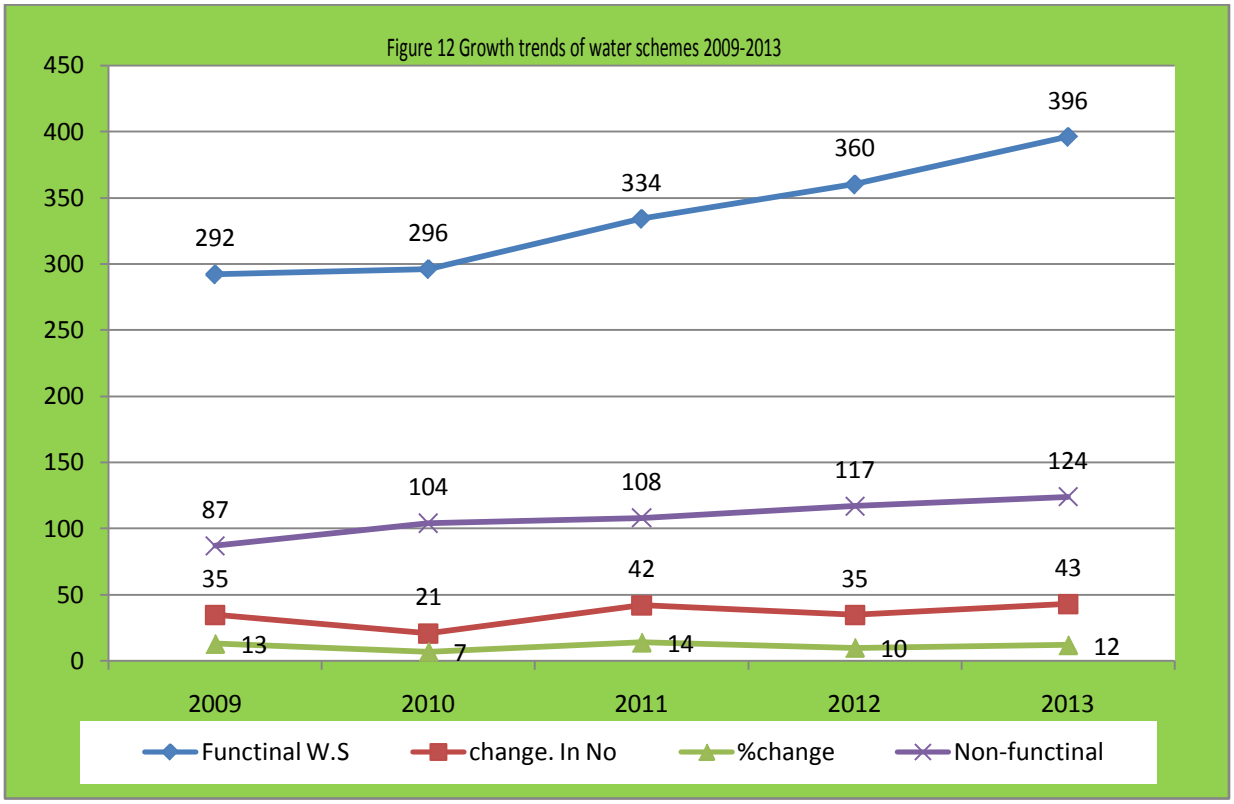


Source: AWWRMO, 2013

As indicated in table 4.4 and fig 4.14 (from the functional water points), the annual growth of water schemes in the years 2004-2008 include 24(12%), 29(14%), 18(18%), 24(10%) and 20(8%) respectively. Comparatively, in 2004 –2008, the growth trend is not that much different from the previous successive years. The average growth rate of water schemes observed from 2004 – 2008 is 7.1%.

4.6.4 Growth Trend of Water Schemes in 2009 – 2013

In the period 2009 – 2013, the number of functional and non-functional water schemes reached to 396 and 124 respectively. In this case, we can understand that those people who were expected (supposed) to be served by non-functional water schemes were deprived from potable water. According the regional standard (1999), on average one water schemes is assigned to serve 316 people. Therefore, considering the regional standard and computing the ratio of non-functional water schemes, about 39,184 beneficiaries didn't get the access to clean water sources.

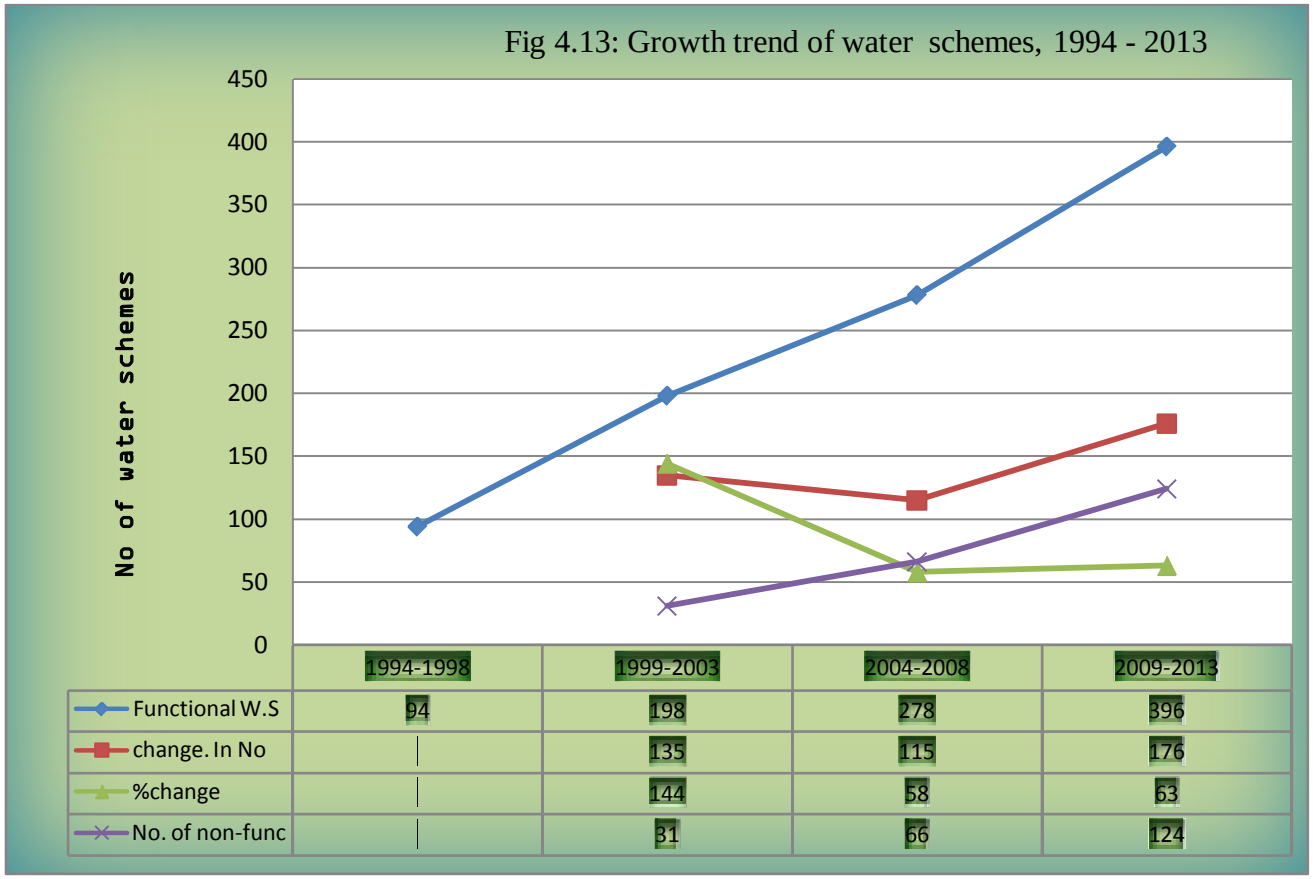


Source: AWWRMO, 2013

As clearly shown in table 4.2 and fig 4.11 the water schemes growth in 2009 – 2013 was 13 %(35 water schemes), 7 % (21 water schemes), 14 %(42 water schemes), 10% (35 water schemes) and 12% (43 water schemes). Comparatively the highest and the lowest growth in percent were shown in 2003 E.C 14% and 7%. The growth rate of water schemes in 2009-2013 was 7.9%.

4.6.5 Summary of Growth Trend of Water Schemes in 20 years

As clearly presented in the preceding sections of this chapter, growth trends of water schemes in 1994-1998, 1999 –2003, 2004-2008, and 2009- 2013 have shown positive increments. These also indicate that there was continuous increase in the number of water schemes throughout the past 20 years.



Source: AWWRMO, 2013

As indicated in table 4.4 and fig 4.16, 520 water schemes were constructed in Ahferom Woreda in the period 1994 – 2013. Of them, 396 are functional and 124 are non-functional. Comparatively, the highest and lowest percentage growths of water schemes were observed in 1994-1998 and1999-2004 respectively. In general, there was 23.9% average growth rate of water schemes throughout the past twenty years.

4.7 Factors Influencing Sustainability of Rural Potable Water Supply

This part of this unit is intended to address and elaborate the critical factors determining the functionality and sustainability of water supply facilities in the study area. So, to identify the basic causes of non-functionality of potable water sources; nine important inquires related to potable water source problems were prepared and filled by the focus group of the study. These are lack of sense of ownership by the beneficiaries, lack of awareness on water supply and sanitation, poor management system, weakness in maintenance and operation system, construction quality problem, over utilization, lack of access to spare parts and poor quality, poor financial capacity of the community to repair the broken water schemes and lack of training to the water committee. Of these expected problems, except the two (lack of awareness on water

supply and sanitation and construction quality problem) all factors are significant at 0.05 significant level. Similarly, a thesis conducted in Ofla Woreda by Misgina (2011), ensured that the reasons for un-sustainability of water schemes are over utilization (over population), quality of pumper machines, lack of technicians (skilled man power), and irresponsibility of the beneficiaries to the clean water sources. These are the main barriers to the non-functionality of potable water sources. Similar to these findings, the African Development Fund reports (2005) reveal that lack of funds for operation and maintenance, inadequate community mobilization, and filling of irresponsibility, lack of spare parts to repair broken water schemes are the important factors to the non-functionality of water schemes. (Pearson, x^2)

Table 4.6: Associations among opinions survey responses

S/N	Item	Respondents	Strongly Agree		Agree		Disagree		Total		Computed X^2
			N	%	N	%	N	%	N	%	
1	Lack of Ownership of beneficiaries	Woreda Water Experts	11	78.5	2	14.3	1	7.2	14	100	3.554***
		Water Committee	10	50	9	45	1	5	20	100	
		Total	21	61.8	11	32.4	2	5.8	34	100	
2	Over utilization and miss use (over population) of water schemes	Woreda Water Experts	12	85.7	1	7.1	1	7.1	14	100	2.635***
		Water Committee	13	65	6	30	1	5	20	100	
		Total	25	73.5	7	20.6	2	5.9	34	100	
3	Poor management system	Woreda Water Experts	7	50	5	35.7	2	14.3	14	100	3.869***
		Water Committee	16	80	2	10	2	10	20	100	
		Total	23	95.8	7	20.6	4	11.8	34	100	
4	Weakness in operation and maintenance system	Woreda Water Experts	11	78.5	2	14.3	1	7.1	14	100	0.069***
		Water Committee	16	80	3	15	1	5	20	100	
		Total	27	79.4	5	14.7	2	5.9	34	100	
5	Construction quality problem	Woreda Water Experts	8	57.1	1	7.1	5	35.7	14	100	11.626###
		Water Committee	1	5	2	10	17	85	20	100	

S/N	Item	Respondents	Strongly Agree		Agree		Disagree		Total		Computed X^2
			N	%	N	%	N	%	N	%	
		Total	9	26.5	3	8.8	22	64.7	34	100	
6	Lack of awareness	Woreda Experts	3	21.4	1	7.1	10	71.4	14	100	9.521###
		Water Committee	17	85	2	10	1	5	20	100	
		Total	20	58.8	3	8.8	11	32.4	34	100	
7	Lack of spare part access and quality	Woreda Experts	8	57.1	4	28.6	2	14.3	14	100	5.100***
		Water Committee	4	20	12	60	4	20	20	100	
		Total	12	35.3	16	47.1	6	17.6	34	100	
8	Financial capacity of the community to repair broken water schemes	Woreda Experts	1	7.1	4	28.6	9	64.3	14	100	3.294***
		Water Committee	1	5	12	60	7	35	20	100	
		Total	2	5.9	16	47.1	16	47.1	34	100	
9	Lack of training to the water committee	Woreda Experts	3	21.4	6	42.9	5	35.7	14	100	
		Water Committee	18	90	1	5	1	5	20	100	2.47***
		Total	21	61.8	7	20.6	6	17.6	34	100	

Source: Own survey, 2013 Signs: ***= Significant at 0.05 of 2 DF ###= Insignificant at 0.05 of 2 DF

4.7.1 Lack of Ownership from the Beneficiaries

Lack of ownership refers to the feeling of irresponsiveness of beneficiaries in the usage of potable water sources. Beneficiaries do not count as their own property and basic for their life. This leads to use the water sources carelessly and keep silent when they see someone else improperly use the public property.

As indicated in table 4.5 above, for item 1, respondents were asked whether the lack of ownership of the beneficiaries is a factor that affects the functionality of water schemes. In this respect, 11(78.5%) Woreda experts and 10 (50%) of water committee respondents strongly agree that lack of ownership of the beneficiaries is a factor that affect the functionality of water schemes in their district. Besides, 2 (14.3%) of Woreda experts, 9 (45%) of Water Committee respondents agree that, lack of ownership of the beneficiaries is a factor that affects the functionality of water schemes in their district. On the other hand insignificant number, 1(7.2%) of Woreda experts and 1(5%) of the Water Committee respondents disagree that lack of ownership of the beneficiaries is a factor that affects the functionality of water schemes in their

districts. The chi-square test is employed to check whether there exists opinion difference between two groups or not. As a result, the computed value x^2 = 3.554 is less than the tabulated value of x^2=5.9915 (DF=2) at 0.05 level of significance which implies there is no statistically significant difference between the respondents' responses. So, lack of ownership in the beneficiaries could be the factor to the non-functionality of water schemes.

4.7.2 Over Utilization and Improper Usage

Opinion of the respondents about the impact of over utilization and miss-use (over population) of water schemes are reflected in table 4.5 of the total respondents about 12 (85.7%) Woreda officials and experts, and 13(65 %) of the water committee members strongly agree that over utilization and miss-use (over population) of water schemes are the determinant factors of non-functionality of water schemes. Furthermore, 1(7.1 %) of Woreda experts and officials, and 6 (30 %) of the water committee agreed that over utilization and miss-use are influential factors of non-functionality of potable water sources. On the contrary, very little number that is 1(7.1 %) of Woreda experts and officials and 1(5 %) of water committee disagree that over utilization and improper utilization of the beneficiaries could be a reason for the non-functionality of water schemes. Therefore, from the opinion of the respondents; it is clear that over utilization and miss- use of water sources by the society have significant effect on the non-functionality of water schemes. The chi-square test is employed to calculated and check whether there exists opinion difference among two groups. As a result, the computed value x^2 =2.635 is less than the tabulated value of x^2=5.9915 (DF=2) at 0.05 level of significance which implies that there is no statistically significant difference between the respondents' responses. So, over utilization and miss-use of the beneficiaries could be a factor to the non-functionality of water schemes.

4.7.3 Weaknesses in Operation and Maintenance System

Operation and maintenance (O&M) covers the efficient day-to-day running of the water supply facilities and regular preventive maintenance and assurance of proper use.

As it is shown in table 4.5 (item 4), target groups were asked whether operation and maintenance problems are the factors affecting the sustainability of water schemes. In this regard, about 11 (78.5%) Woreda experts and 16 (80%) of water committee respondents strongly agree that operation and maintenance problems are factors affecting the functionality and sustainability of water schemes in their district. On the other side, about 2 (14.3%) of Woreda experts and officials, and 3 (15%) of water committee respondents agree that, operation and maintenance problems are the most crucial factors affecting the functionality and sustainability of water

schemes in their district. Only insignificant number of the respondents, 1 (7.2%) of Woreda experts and 1 (5%) of the water committee respondents disagree that operation and maintenance problems are the factors that affect the functionality of water schemes in their districts. In this scenario chi-square test is employed to calculate and evaluate the similarities and difference of the respondents' opinion. As a result, the computed value x^2 = 0.069 is absolutely less than the tabulated value of x^2=5.9915, (DF=2) at 0.05 level of significance. Therefore, operation and maintenance problems are basic factors to the non-functionality of water schemes**.**

4.7.4 Lack of Access to Quality Spare Parts

Operation and maintenance (O&M) implies the efficient day-to-day running of the water supply facilities, regular preventive maintenance and assurance of proper use. The availability of spare parts is a critical factor to keep the system working properly. Adequate supply of spare parts and maintenance tools are obviously very important to long-term functionality the water schemes.

Supply chains are now recognized as one of the key determinants of sustainability (Davis and Liyer, 2002). As it is shown in table 4.5 (item 7), target groups were asked about lack of spare part access and quality as factors to the non-functionality of water schemes. In this regard, about 8 (57.1%) Woreda experts and officials, and 4 (20%) of water committee respondents strongly agree that lack of spare part access and quality are factors that affect the functionality and sustainability of water schemes in their district. On the other side, about 4 (28.6%) of Woreda experts and officials, and 12 (60%) of water committee respondents agree that spare part access and quality problems are determinant factors affecting the functionality and sustainability of water schemes in their district. From the respondents, only 2 (14.3%) of Woreda experts and water resource management officials, and 4 (20%) of the water committee respondents disagree that spare part access and quality problem are factors that affect the functionality of water schemes in their district. In this scenario chi-square test is employed to calculate and evaluate the similarities and differences of the respondents' opinions. As a result, the computed value x^2 = 5.100 is less than the tabulated value of x^2=5.9915 (DF=2) at 0.05 level of significance. This implies that there are no significant differences among the respondents' opinions. Therefore spare part access and quality problems are basic factors to the non-functionality of water schemes**.**

4.7.5 Poor Financial Capacity of the Community

Financial capacity in the society and un-sustainability of water schemes are reflected in table 4.5. In this regard, of the total respondents 2 (5.9 percent) strongly agree that financial capacity of

beneficiaries is one of the determinant factors for the non-functionality of water points. On the other side about 16 (47.1%) of the respondents agreed on the issue of financial capacity of the beneficiaries has negative impact on the sustainability of the water schemes. The remaining 16 (47.1%) respondents disagreed or said no impact on the sustainability of water schemes. In this issue, chi-square test is used to calculate and to check the similarities and differences of the respondents' attitudes. As a result, the computed value x^2 =3.294 is less than the tabulated value of x^2=5.9915 (DF=2) at 0.05 level of significance. In this item the respondents are at most with the same attitudes. Therefore, financial capacity is a determinant factor to the non-functionality of water schemes**.**

4.7.6 Lack of Training to the Water Committee

Training provides knowledge of how to operate water supply facilities, and prevent major problems. As indicated in table 4.5, respondents were asked about whether or not lack of training to water committee is basic for the non-functionality of water schemes. Of all the respondents about 21 (61.8%) respondents strongly agreed, 7 (20.6%) respondents agreed, and 6 (17.6%) respondents disagreed. In this case, the chi-square test calculated the similarities and difference of the respondents' opinion. As a result, the computed value x^2 = 2.47 is absolutely less than the tabulated value of x^2=5.9915 (DF=2) at 0.05 level of significance. This implies that, the respondents are on the same understandings. So, from the opinion of the respondents, shortage of training for the water committee has an impact in the sustainability of water schemes**.** The same result has been explored in Quarit Woreda, Amara Region: raising awareness and providing training to water management bodies (water committee) could be important to equip users with the right knowledge in managing their scheme and responding to system failure. Moreover, by creating awareness and training, the potential benefits of clean water could be promoted. The community will then be willing to take responsibility for handling operation and maintenance issues which will create a sustainable system.

4.7.7 Poor Management System

As it is shown in table 4.5, respondents were asked about whether or not poor management system is a case for non-functionality of water schemes. In this case, of all the respondents about 23 (95.8%), 7 (20.6%), and 4 (11.8%) respondents were replied strongly agree, agree and disagree respectively. The chi-square test has computed the similarities and differences of the respondents' opinions. As a result, the computed value x^2 = 3.869 is less than the tabulated value of x^2=5.9915 (DF=2) at 0.05 level of significance. This indicates the respondents were with the

same opinion. So, from the opinion of the respondents poor management system has negative impact in the productivity of water schemes**.**

4.7.8 Lack of Awareness on Potable Water Supply and Sanitation

Table 4.5 indicates that whether or not lack of awareness is a reason for the non-functionality of water schemes. In this regard, about 20 (58.8%) Woreda experts and members of water committee strongly agree that lack of awareness is the basic reason for the non- functionality of water schemes. On the other hand, 3 (8%) Woreda experts and water committee respondents agreed that lack of awareness is a basic reason for the non-functionality of water schemes. Contrary to these, about 11(32.4%) disagreed. The chi-square test has computed the similarities and differences of the respondents' opinions. As a result, the computed value $\boldsymbol{x^2}$ = 9.521 is greater than the tabulated value of $\boldsymbol{x^2}$=5.9915 (DF=2) at 0.05 level of significance. This clearly indicates that the respondents are with different opinions. So, from the opinions of the respondents lack of awareness has no significant relationship with un-sustainability of water schemes**.**

4.8.9 Construction Quality Problems

Construction quality and un-sustainability of water schemes are reflected in table 4.5. In this regard, of the total respondents 9 (26.5%) strongly agree that construction quality is one of the determinant factors for the non-functionality of water schemes. On the other side, 3 (8.8%) respondents were replied agree that construction quality has negative impact on sustainability of water schemes. The remaining 22 (74.7%) disagreed on the impact construction quality on sustainability of water points. In this case, chi-square test is employed to calculate and check the similarities and differences of the respondents' attitudes. As a result, the computed value x^2 =11.626 is greater than the tabulated value of x^2=5.9915 (DF = 2) at 0.05 level of significance. This indicates that the majority of the respondents replied as it is not a factor. Therefore, construction quality has no significant influence on the non-functionality of water schemes.

UNIT FIVE

Conclusion and Recommendations

5.1 Introduction

The study was conducted in Ahferom Woreda on the accessibility assessment of potable water in the rural communities. Accordingly to meet the objectives of the study the needed information were collected from the concerned body of the Woreda and out of the Woreda and analyzed. The short and the expected result and recommendations are provided blow.

5.2 Conclusion

The rural development strategy of the Woreda declares improving potable water supply facilities to the rural people as their priority. Accordingly a lot of effort has been done hand in hand with the NGOs but still the accessibility with proportion of the beneficiaries' was not enough. In order to improve the accessibility coverage of safe water sources identifying the areas which are accessible and inaccessible is needed. In this regard, the researcher has been collected the data from the Woreda and analyzed the issues, type of technology introduced, spatial distribution and coverage, actual per capita, growth trend of water schemes, accessibility coverage and the determinant factors which influences the sustainability of water schemes were analyzed. As a result, the study identified 520 water schemes in the study area. Of the total 396 (76.2%) and 124(23.8%) were functional and non-functional respectively and also found out three types of potable water technologies Hand dug well, Shallow well and protected springs were introduced to the study area. Hand dug well covered majority of the Woreda (62 %) followed by Shallow well (26 percent) and Protected spring (11.9%). The roles of governmental and non-governmental organizations were also analyzed. In this case nearly half of the water technologies were constructed by NGOs especially the REST (48%) and Orthodox (15%).

The spatial coverage of water schemes was found that, one water scheme to 3.25 square kilometer area and 2.36 water schemes to 1000 beneficiaries.

The study also analyzed about the growth rate of water schemes. As a result, a positive increment has been observed from time to time but not in similar ranges throughout the four of the five years plan of the Woreda. But, a steady increment has been observed in the first five year (1994-1998) and the third (2004-2008). In general the average growth of water schemes throughout the twenty years was 23.7%.

The actual average potable water per capita of the beneficiaries in the rural area was assessed by measuring the productivity of each water scheme in each tabias and kushets and finally divided

to the dwellers. The result was 7.6 l/p/day. But, there was no equal distribution of water schemes and ratio in liter. Some are in risk of shortage of safe water and the others were comparatively moderately accessible. In comparison with the regional standard the woreda is obtaining half of the regional standard (15l/p/d).

The accessibility coverage within 1.5km radius of distance travel and 15 l/p/day also analyzed, the result was found below the regional coverage which is 39% (**65,463**) population were within 1.5km radius and 15l/p/day access. In this issue when we use only distance as parameter for assessment of accessibility, about 79 % (**132,526**) population were accessible within the travel distance of 1.5km from the nearest water scheme.

In this study the determinant factors to the non-functionality of water schemes was also analyzed these are: lack of ownership in the beneficiaries, poor management system, weakness in maintenance and operation system, lack of spare part accesses and quality, Financial capacity of the community to repair the breakdown water schemes and training to the water committee and poor management system are accepted by the respondents as they are the key problems to non-functionality of water schemes in their districts.

5.3 Recommendations

To enhance the accessibility coverage and to meet the needed objective and MDGs in the study area the study suggests the following points:

As it is clearly stated in the result of the study there is a big problem in the distribution of water schemes and accessibility coverage exists. Due to this reason, large number of population did not have accesses to clean water sources. The success of any program could be achievable when we have healthy, educated and productive society and also to meet the goals of the country safe water accessibility within shortest travel distance is mandatory. To do that:

- Governmental and non-governmental organizations should invest their capital to the expansion of clean water sources in the community of the woreda specially in the rural part since majority of the society lives in that area. In addition to this, at the time of site selection for digging water schemes it is advisable to identify the severely affected and the number of inhabitants.
- AWWRMO should have to do a lot in the improvement of clean water sources by having close communication, support and guidance with the

regional and national government bodies further with the non-governmental organizations.

Organizations that involved in rural potable water development have to consider factors that affect the functionality potable water schemes. As stated in the most influencing factors in this regarded are poor management system, weakness in maintenance and operation system, lack of spare part accessibility and quality, poor Financial capacity of the community to repair the breakdown water schemes and training to the water committee. So, the member of water committee and water resource management office of the Woreda, regional government and NGOs should have integrity on the fronts of the obstacles of sustainability of water schemes. by

- Solving the problem of maintenance and operation problem of the community giving technical assistance to the water committee minimum monthly or maximum three months. this program could:
    - Enable them how to identify the water scheme problems and finding out the possible solutions
    - Mack them exercise disseminating and assembling of their respective water scheme accessories.
    - Make them identify where could be their potential areas for required spare parts and skilled man power whenever the problem more than their capacity
- Giving awareness about the necessity of clean water supply facilities in improvement of their economy and their health in general. By doing so, the people develop the feeling of responsibility and to handle effectively and to protect from external and internal factors that can damage water schemes.
- Management system must be fully participative to the beneficiaries especially to the women because their nearest to the natural resource and are responsible to fetch water. Participate the beneficiaries with the management officers and technicians have fruit full impact. Firstly, management office can contact with the beneficiaries freely and able to obtain the needed information and assistance. Secondly,
- Another important suggestion is the Woreda management office and experts has to have scheduled suppression on the healthy status of water schemes before stopping its working and activities of the water committee and also the guards.
- In order to solve safe water access problem, AWWRMO and water committee with the support of woreda administrative body and NGOs should work hard to repair the non-

functional W.S. Also, it is better to give an attention on the basic problems of water schemes.

- Woreda water resource management is expected to do additional W.S in the severely affected areas.

REFERENCES

ADF (2005): Ethiopia; Rural Water Supply and Sanitation Program appraisal report. African Development Fund, infrastructure department; north, east and south, ONIN June 2005.

African Development Bank, unpublished: Rural Water Supply and sanitation initiative Frame workfor Implementation; "a regional response to Africa's' Rural Drinking Water and Sanitation Crises"

Admasu M., Kumie A. and Fentahun M. (2003). Sustainability of Drinking Water Supply Projects in Rural of North Gondar, Ethiopia, Ethiopian. J. Health Dev. (3):221-229.

AWWRMO(Ahferom Woreda Water Resources Management Office), 20013. Unpublished annual report and Strategic plan

Algemene rekemkamer,(2008) : Drinking water in developing countries.

Ben Crow, (2001): Gender, Class, and Access to Water: Three Cases in a Poor and Crowded Delta

Churchill, A. et al (1987): "Rural Water Supply and Sanitation: Time for a Change", World Bank Discussion Papers 18, the World Bank, Washington DC. [cited in: water partner international,2006), http://www.water.org/crisis/waterfacts.htm

Crow B. (2001). Water: gender and material inequalities in the global south University of California, Santa Cruz

Desalegn (1999): "Water Resource Development in Ethiopia: Issues of Sustainability and Participation**"**. Dessalegn Rahmato, Addis Ababa, June 1999: Forum for Social Studies

EWRMP (Ethiopian Water Resource Management Policy), 2001. The Federal Democratic Republic of Ethiopia Ministry of Water Resources Ethiopian Water resources Management Policy.

Gebrehiwot M. (2006) An Assessment of Challenges of Sustainable Rural Water Supply: The Case of OflaWoreda in Tigray Region. Msc Thesis, Regional Local Development Study (RLDS). A.A.U. Ethiopia.

Geertman & Van, E., (1995). A GIS based model for goals achievement analysis and design, and Models of Accessibility Potential Planning.

Gleick, p. etal, 2001. Emerging threats to the worlds fresh water Resources. A Report of the gujarati D., 1999. Esentials of Economics, second edution, Mc graw Hill, New yourka

Hans Van Damme (2001): "Domestic Water Supply, Hygiene, and Sanitation," Focus 9 •

Brief 3 of 14 • October 2001. International Food Policy Research Institute, 2033 K STREET, N.W., WASHINGTON, D.C. 20006-1002, U.S.A.

Habtamu A.,(2004). Factors Affecting the Sustainability of Rural Water Supply Systems: the case of Mecha Woreda, Amhara Region, Ethiopia.

Harvey P.A. and Reed R.A., UK (2007). Sustainable rural water supply in rural Africa

Haysom A. (2006). The study of the factors affecting sustainability of rural water supply in Tanzania, Dare Selam. Master's thesis water management, community water supply option Cranfield University Silsoe institute of water and the environment.

Jennifer S. and Traives K., 1997. Making Rural Water Supply Sustainable: Report on the Impact of Project Rules.

Kirubaharan J., (2011): Access to drinking water: case of Tankefed villages in Thane district Maharashtra

Michael H. (2006). Drinking water quality assessment and treatment in east Timor a case study: Tangkae, the University of East Timor.

Misgina G.(2006): challenges of sustainability of rural water supply

MOWR (2001): "Ethiopian Water Sector Strategy" The Federal Democratic Republic of Ethiopia Ministry of Water Resources 2001

Pratiksha Tambekar et al, Pravin Morey, R. J. Batra and R. G. Weginwar 2012). Quality assessment of drinking water

REST (2003): "Tigray Regional Development Profile", REST Report for 2003.Tigray Regional development. PDF

Rose, A.D. (2009). Domestic water supply an evaluation of the impacts challenges and prospect on women in rural house hold, Uganda. LUMES, Lund University.

Sutton S. (2008). Access to sanitation and safe water: Global participation and local actions. The risks of a technology-based MDG indicator for rural water supply. 33rd WEDC International Conference, Accra, Ghana.

Tanja Maidorn, Hani Sewilam,(2011) "Drinking Water Loss Reduction: Developing Capacity for Applying Solutions"

UN (United Nations), 2010. Resolutions Adopted by General Assembly; the Human Rights to Water and Sanitation.

UN (United Nations), 2011. The Millennium Development Goals Report; we can End poverty by 2015

UNDP, (2006): Human Development Report Interactive World Map

http://hdr.undp.org/statistics/data/hdi_rank_map.cfm (accessed: 28th August 2006).
UNICEF, (2010): Progress on sanitation and drinking water. New York: UNICEF.
UNICEF, (2010): Progress on sanitation and drinking water. New York: UNICEF.
UNICEF, (2012): Poor People Missing out on Safe Water and Basic Sanitation: on World Water Day, Addis Abeba, Ethiopia.
WaSH, (2005): Financing water, sanitation and hygiene in Ethiopia: Making every drop count Water, Sanitation and Hygiene for all (WASH), Tearfund 2005
Water Partner International (2006): Water facts, http://www.water.org/crisis/waterfacts.htm
Water Aid (2009). Water, sanitation and hygiene for development. Advocacy for change. World
World Health Organization (2000). Disinfectants and disinfectant by products. (Environmental health criteria 216). Geneva: world health organization
WHO, (2006). Water Sanitation and accessibility World Health Organization.
WHO/UNICEF (2000): Global Water Supply and Sanitation Assessment Report World Health Organization and United Nations Children's Fund, 2000
WHO/UNICEF, (2006) a snapshot of drinking water and sanitation in Africa
WHO/UNICEF, (2006): Joint Monitoring Program for Water Supply and Sanitation; Meeting the MDG drinking Water and sanitation target: amid-term assessment of progress
WHO/UNICEF (2012): Progress on Sanitation and Drinking Water
WHO/UNICEF, (2012): progress of drinking water and sanitation
WRRI (Water Resource Research), 2008. History of drinking water; Water and Environmental center Alaska
WSSCC, (2008): Sustainable Water Supply and Sanitation Progress Report
WWW.SAFEWATER.ORG: WHAT IS THE PURPOSE OF DRINKING WATER QUALITY GUIDELINES/REGULATIONS?
Zemenu A. (2012): challenges of sustainable rural water supply: case of quarit woreda, amhara region.

M EKELLE UNIVERSITY

COLEEGE OF SOCIAL SCINCE AND LANGUAGES

DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

QUESTIONNAIRE TO BE Filed BY: AHFEROM WOREDA WATER RESOURCE OFFICE AND WATER COMMITTEE MEMBERS

The main purpose of this questionnaire is to gather the necessary information about the level of clean water accessibility of your woreda. That is, to assess how much is satisfactory to the beneficiary, to assess the growth level in a given time, and to check whether they are evenly distributed to the beneficiaries, to identify the core problems for their sustainability of clean water sources and finally to give fruitful recommendations or solutions by the concerned body to full the distributional gap and accessibility problem in the woreda. So that, your contribution in providing a real and honest information plays a prominent role to the researcher to do successful research, to decision makers and sponsors to invest their capital in drinking water and it can also be benchmark to the management office of the study area. By thinking this, please give your hand to my work to be fruitful.

Thank you in advance for your co-operation!

GENERAL DIRECTION:

1. **No need of writing your name**
2. **please put the correct figure on the table provided**
3. **Please make tick in front of yes or no options and write clearly on the provided space to the open ended questions.**

Appendix-I

Water points of Ahferom woreda from 1994-2013

No	Tabia	Pop	Kushet	Pop	scheme type	GPS reading in degree			depth in m	static water level	Yield L/second	beneficiaries	average distance travel in km	Time single trip	status of service	year of construction	source of finance or donors	water committee	fence	watch man
						Easting	Northing	Elevation												
1	X		a		1.HDW															
					2. SPD															
					3.SW															
			b		1.HDW															
					2. SPD															
					3.SW															
			c		1.HDW															
					2. SPD															
					3.SW															
			d		1.HDW															
					2. SPD															
					3.SW															

Appendix-II

Questionnaire to be answered by member of Ahferom woreda Water resource office and water committee's representative in each tabia.

1. When was construction of improved water technology commenced in Ethiopia? _____ What about in your woreda? _____
2. Mention the water technologies introduced to your woreda? and which of them are more costly?_____
   _____
   _____
   _____
   _____
   _____
3. Who is the donors/source of finance for construction of water schemes in your woreda?
   _____
   _____
   _____
   _____
   _____
   _____

5. Factors influencing sustainability of water schemes

1. What are the major causes for un sustainability of clean water sources?

   a. Lack of ownership 1. Strongly agree 2. Agree 3. Dis-agree

   b. Lack of education on water supply and sanitation yes

   1. Strongly agree 2. Agree 3. Dis-agree

   c. poor management system 1. Strongly agree 2. Agree 3. Dis-agree

d. Weakness in operation and maintenance system

1. Strongly agree 2. Agree 3. Dis-agree

e. Construction quality problem 1. Strongly agree 2. Agree 3. Dis-agree

f. Over utilization/serving over its capacity

1. Strongly agree 2. Agree 3. Dis-agree

g. Pup failure/machines quality 1. Strongly agree 2. Agree 3. Dis-agree

h. Financial capacity of the community to repair the breakdown water points

1. Strongly agree 2. Agree 3. Dis-agree

i. Spare part access and quality supply

1. Strongly agree 2. Agree 3. Dis-agree

j. Management problem 1. Strongly agree 2. Agree 3. Dis-agree

6. Could you add up more significant suggestions, comments and unstated facts on what has been discussed earlier regarding issues of water schemes in your woreda?

_____

_____

_____

_____

_____

_____

_____

Appendices

Appendix-III

Tabia level Distribution and spatial coverage of water schemes and per capita of the beneficiaries

S/NO	Name of Tabia	No Pop	AREA Squ.km	Popn density	No W.S	W.S per area	W.S per beneficiary	W.S per beneficiary * 1000	Beneficiaries per W.S	L/p/day
1	May-hamato	5981	136.39	44	3	0.022	0.00050	0.502	1994	1
2	Hoyamedeb	8063	234.54	34	13	0.055	0.00161	1.612	620	3.8
3	Semhal	6885	144.33	48	14	0.097	0.00203	2.033	492	3.7
4	Zban guila	9089	70.37	129	13	0.184	0.00143	1.430	699	4.5
5	Erdi Jeganu	8704	95.68	91	15	0.157	0.00172	1.723	580	3.6
6	Bete gebez	6935	50.43	138	17	0.337	0.00245	2.451	408	4.8
7	Mezbr	6724	40.29	167	20	0.496	0.00297	2.974	336	7.3
8	T.Megaria tsemri	6312	41.43	152	19	0.458	0.00301	3.010	332	9.9
9	L.Megaria tsemri	8171	40.3	203	28	0.694	0.00343	3.427	292	11.2
10	Degoz	5108	52.94	96	20	0.377	0.00392	3.915	255	7.8
11	Sero	3741	61.37	61	29	0.472	0.00775	7.752	129	9.2
12	Maysuru	5333	26.24	203	14	0.533	0.00263	2.625	381	5.6
13	Endamariam	4582	28.56	160	19	0.665	0.00415	4.147	241	4.2
14	Adi-zata	9319	35.02	266	24	0.685	0.00258	2.575	388	11.4
15	Tahtay daeraka	9359	27.54	340	20	0.726	0.00214	2.137	468	11.3
16	Endalashen	4005	11.31	354	14	1.237	0.00350	3.496	286	4.2
17	May Keyahat	4029	12	336	13	1.083	0.00323	3.227	310	4.5
18	Sefo	5374	12.88	417	8	0.612	0.00149	1.489	672	3
19	Emba Ahferom	5388	13.54	398	8	0.591	0.00148	1.485	674	4.1
20	Edaga Arbi	7940	32.31	246	16	0.495	0.00202	2.015	496	5.2
21	Kudo	5348	17.82	300	9	0.505	0.00168	1.683	594	3.3
22	Mishig	7716	26.36	293	15	0.569	0.00194	1.944	514	4.4
23	Adibereto	5120	14.48	354	6	0.414	0.00117	1.172	853	3.5
24	Adisatra	7051	11.63	606	6	0.515	0.00085	0.851	1175	4.2
25	Edaga Hamus	5497	29.97	183	14	0.47	0.00255	2.547	393	6.3
26	Agamo	587	8.8	67	2	0.227	0.00341	3.407	294	6.7
27	Adi-yiekoro	4762	11.57	412	17	1.469	0.00357	3.570	280	11.4
	TOTAL	167123	**1288.1**	130	396	0.307	0.00237	2.384	422	7.58

Appendix-IV

Kushet level distribution of water schemes and ratio to the beneficiaries

S.No	Name of Tabia	Name of Kushet	Easting	Northing	W.S	Production of each Water Schemes in Litter per Second													Litter a day	sec.a day	per day	pop	PWA
1	May_Hamato	May-kremto	0511979	1610064	3	0.022	0.01	0.02											0.056	86400	4,838	1541	3
		Kelelie	0512061	1600228	0														0	86400	0	1466	0
		Wnth	0508629	1614157	0														0	86400	0	1517	0
		Lieto	0508825	1610942	0														0	86400	0	1457	0
	Total				3	0.022	0.01	0.02											0.056	86400	4,838	5981	1
2	Hoyamedeb	Hoya	0517225	1603980	4	0.01	0.15	0.01	0.02										0.17	86400	14,688	2676	5.4
		Medeb	0516822	1596372	5	0.015	0.11	0.02	0.01	0.03									0.145	86400	12,528	2698	4.6
		Belesa	0519465	1606859	4	0.013	0.02	0.01	0.11										0.043	86400	3,715	2689	1.4
	Total				13	0.06	0.29	0.06	0.14	0.03									0.358	86400	30,931	8063	4
3	Semhal	Enda-ergab	0513664	1603534	2	0.02	0.01												0.03	86400	2,592	1748	1.4
		Endabastifanos	0505436	1606189	4	0.01	0.12	0.03	0.02										0.16	86400	13,824	1802	8
		Maysagla	0511385	1604490	6	0.01	0.02	0.02	0.01	0.11	0.13								0.055	86400	4,752	1664	3
		Mebrat	0512639	1601338	2	0.02	0.03												0.05	86400	4,320	1671	2.5
	Total				14	0.06	0.18	0.05	0.03	0.11	0.13								0.295	86400	25,488	6885	3.7
4	Zbanguila	Hbret	0503598	1591749	1	0.05													0.05	86400	4,320	2461	1.7
		Tseguaro	0504558	1598793	6	0.1	0.2	0.01	0	0.02	0.05								0.31	86400	26,784	2168	12.3
		Guila	0508113	1596238	4	0.01	0.02	0.05	0.01										0.08	86400	6,912	2370	3
		Endamariam1	0501568	1600293	2	0.02	0.02												0.04	86400	3,456	2090	1.7
	Total				13	0.18	0.24	0.06	0.01	0.02	0.05								0.48	86400	41,472	9089	4.7
5	Erdijeganu	Mayliham	0517795	1591819	3	0.01	0.02	0.05											0.08	86400	6,912	1978	3.5
		A/Keleto	0524361	1592279	1	0.03													0.03	86400	2,592	2364	1
		E/rebue	0519226	1591202	6	0.03	0.13	0.02	0.01	0.11	0.01								0.18	86400	15,552	2583	6
		Embadekena	0518016	1593918	5	0.03	0.04	0.01	0.03	0.13									0.08	86400	6,912	1779	4
	Total				15	0.1	0.19	0.08	0.04	0.24	0.01								0.37	86400	31,968	8704	3.7
6	Betegebez	Adi-kelkel	0510555	1587061	4	0.03	0.01	0.01	0.02										0.05	86400	4,320	1831	2.4
		Dekihdug	0506207	1586615	5	0.02	0.01	0.02	0.01	0.02									0.05	86400	4,320	1904	2.2
		Endagebrat	0511069	1587812	3	0.02	0.01	0.02											0.05	86400	4,320	1658	2.6
		kedena	0511681	1590381	5	0.21	0.01	0.02	0.03	0.01									0.24	86400	20,736	1542	13.4
	Total				17	0.28	0.04	0.07	0.06	0.03									0.39	86400	33,696	6935	5

S.No	Name of Tabia	Name of Kushet	Easting	Northing	W.S	Production of each Water Schemes in Litter per Second													Litter a day	sec.a day	per day	pop	PWA
7	Mezbr	Debrebrhan	0503817	1584927	5	0.03	0.01	0.11	0.01	0.02									0.15	86400	12,960	1646	8
		May-shewit	0505566	1583406	7	0.05	0.1	0.15	0.01	0.02	0.02	0.02							0.3	86400	25,920	1828	14
		Endagergs	0503311	1585835	7	0.02	0.01	0.01	0.03	0.01	0.04	0.05							0.177	86400	15,293	1900	8
		Adi-senay	0503970	1586893	1	0.01													0.01	86400	864	1350	1
	Total				20	0.11	0.12	0.27	0.05	0.05	0.06	0.07							0.637	86400	55,037	6724	8
8	T_m_Tsemri	Endajewergs	0507499	1582542	2	0.015	0.02												0.035	86400	3,024	1453	2
		Liham	0509086	1579344	7	0.01	0.05	0.11	0.1	0.02	0.03	0.01							0.17	86400	14,688	1641	9
		Telele	0509230	1581580	4	0.01	0.2	0.01	0.01										0.22	86400	19,008	1514	12.5
		May awhi	0507484	1585161	6	0.03	0.16	0.05	0.02	0.01	0.02								0.24	86400	20,736	1704	12
	Total				19	0.065	0.43	0.17	0.13	0.03	0.05	0.01							0.665	86400	57,456	6312	9
9	L_m_tsemri	Munguda	0511048	1576822	9	0.11	0.2	0.2	0.03	0.15	0.01	0.21	0.1	0.13					0.51	86400	44,064	2451	18
		Adekers	0508170	1575734	7	0.12	0.1	0.04	0.08	0.11	0.02	0.01							0.26	86400	22,464	2288	10
		Guldam	0505918	1577082	6	0.05	0.02	0.05	0.05	0.23	0.03								0.12	86400	10,368	1634	6.3
		Lhuts	0504959	1577855	6	0.14	0.02	0.01	0.02	0.27	0.02								0.171	86400	14,774	1798	8.2
	Total				28	0.42	0.34	0.3	0.18	0.76	0.08	0.22	0.1	0.13					1.061	86400	91,670	8171	11.2
10	Degos	Adikoho	0515188	1579523	5	0.08	0.03	0.01	0.04	0.03									0.122	86400	10,541	1130	9.3
		Adiraesi	0515510	1581069	6	0.011	0.03	0.06	0.08	0.05	0.02								0.102	86400	8,813	1106	8
		Dibere	0515292	1583439	4	0.021	0.03	0.04	0.05										0.091	86400	7,862	1568	5
		Hatsina	0515089	1585518	5	0.031	0.01	0.1	0.02	0.03									0.144	86400	12,442	1304	9.5
	Total				20	0.143	0.1	0.21	0.19	0.11	0.02								0.459	86400	39,658	5108	8
11	Sero	May-liham	0524100	1583278	13	0.03	0.03	0.01	0.04	0.04	0.02	0.02	0.1	0.03	0.01	0.02	0.01	0.08	0.07	86400	6,048	1030	6
		May-weyni	0523580	1579860	5	0.01	0.09	0.02	0.01	0.01									0.12	86400	10,368	1103	9.3
		Erasur	0522111	1585618	7	0.02	0.08	0.02	0.02	0.03	0.21	0.21							0.12	86400	10,368	955	11
		Adi-wekae	0522989	1587235	4	0.05	0.03	0.01	0.03										0.09	86400	7,776	653	12
	Total				29	0.11	0.23	0.06	0.1	0.08	0.23	0.23	0.1	0.03	0.01	0.02	0.01	0.08	0.4	86400	34,560	3741	9.2
12	May_suru	Adi-gudad	0519249	1577898	7	0.04	0.06	0.01	0.04	0.06	0.03	0.01							0.112	86400	9,677	1775	5.5
		Adi-lemlem	0519323	1578690	4	0.011	0.06	0.07	0.03										0.141	86400	12,182	1744	7
		Hagere-selam	0520867	1580230	3	0.022	0.02	0.05											0.092	86400	7,949	1814	4.3
	Total				14	0.073	0.14	0.13	0.07	0.06	0.03	0.01							0.345	86400	29,808	5333	5.6
13	Endamariam	May-bezo	0515629	1576520	6	0.01	0.03	0.02	0.02	0.03	0.04								0.151	86400	13,046	1517	8.6
		May-gundi	0518361	1576082	6	0.01	0.01	0.01	0.02	0.01	0.02								0.082	86400	7,085	1097	6.5
		Adi-nekua	0518593	1574486	3	0.01	0.01	0.01											0.033	86400	2,851	1171	2.4
		Menadk	0517454	1577064	4	0.013	0.01	0.01	0.01										0.048	86400	4,147	797	5.2
	Total				19	0.043	0.07	0.05	0.05	0.04	0.06								0.314	86400	27,130	4582	6
14	Adi_zata	Adi-wer	0509685	1569037	6	0.051	0.05	0.04	0.05	0.05	0.05								0.144	86400	12,442	2757	5

S.No	Name of Tabia	Name of Kushet	Easting	Northing	W.S	Production of each Water Schemes in Litter per Second												Litter a day	sec.a day	per day	pop	PWA
		Adi-frngi	0507033	1571153	3	0.07	0.06	0.06										0.19	86400	16,416	1394	12
		Adi-tsalka	0507039	1573521	3	0.04	0.06	0.04										0.143	86400	12,355	2565	5
		Edagakedam	0508991	1572495	12	0.07	0.06	0.05	0.03	0.05	0.05	0.06	0.1	0.011	0.06	0.06	0.05	0.181	86400	15,638	2603	6
	Total				24	0.231	0.23	0.2	0.08	0.1	0.1	0.06	0.1	0.011	0.06	0.06	0.05	1.238	86400	106,963	9319	11.4
15	T_daeraka	May-meriet	0512682	1568946	6	0.04	0.05	0.04	0.05	0.02	0.05							0.247	86400	21,341	2654	8
		May-hanber	0515182	1573067	3	0.05	0.02	0.04										0.105	86400	9,072	2236	4
		Genadf	0512607	1573147	5	0.034	0.05	0.43	0.04	0.01								0.565	86400	48,816	2004	24
		Adi-menabr	0512374	1571798	6	0.04	0.06	0.05	0.06	0.06	0.04							0.312	86400	26,957	2465	11
	Total				20	0.164	0.18	0.56	0.15	0.09	0.09							1.229	86400	106,186	9359	11.3
16	Endalashen	Gezet	0515202	1569302	4	0.02	0.01	0.01	0.02									0.043	86400	3,715	1381	2.7
		Adi-hiso	0516813	1570806	5	0.02	0.01	0.01	0.05	0.02								0.045	86400	3,888	1220	3
		Adi-wray	0518489	1569980	1	0.05												0.05	86400	4,320	709	6
		Adi-Teklo	0518031	1569790	4	0.03	0.01	0.02	0.04									0.058	86400	5,011	695	7.2
	Total				14	0.12	0.03	0.04	0.11	0.02								0.196	86400	16,934	4005	4.2
17	May_keyahat	Atsabo'	0519238	1572102	5	0.02	0.01	0	0.01	0.03								0.076	86400	6,566	969	7
		May-keyahat	0517388	1571756	4	0.01	0.02	0	0.01									0.034	86400	2,938	1106	2.6
		Hnflo	0518560	1573100	1	0.03												0.03	86400	2,592	1058	2.4
		Adi-kesho	0516530	1572614	3	0.03	0.02	0.01										0.061	86400	5,270	896	6
	Total				13	0.09	0.05	0.02	0.03	0.03								0.212	86400	18,317	4029	4.5
18	Sefo	Adi-bula	0521585	1571548	1	0.021												0.021	86400	1,814	1459	1.2
		Ksad-ere	0521377	1573342	4	0.011	0.02	0.04	0.01									0.083	86400	7,171	1305	5.5
		Adi-abito	0523093	1571308	2	0.02	0.03											0.05	86400	4,320	1542	3
		Adi-mereta	0521194	1572335	1	0.031												0.031	86400	2,678	1068	2.5
	Total				8	0.083	0.05	0.04	0.01									0.185	86400	15,984	5374	3
19	Emba_ahferom	May-arbaa'	0522616	1576610	1	0.041												0.041	86400	3,542	1254	2
		Kelli	0522596	1576547	1	0.052												0.052	86400	4,493	1454	3
		May-shewa	0523753	1575611	4	0.02	0.06	0.02	0.03									0.102	86400	8,813	1635	5.4
		Demberbera	0522300	1574787	2	0.042	0.02											0.063	86400	5,443	1045	5
	Total				8	0.155	0.08	0.02	0.03									0.258	86400	22,291	5388	4
20	Edaga_arbi	Waera	0526098	1573752	5	0.02	0.03	0.05	0.03	0.03								0.157	86400	13,565	2461	5.5
		Smeche-zala	0529268	1568507	3	0.02	0.01	0.02										0.053	86400	4,579	2382	2
		May-tebay	0524863	1570427	2	0.013	0.04											0.053	86400	4,579	1112	4
		May-deraam	0527182	1570467	6	0.041	0.06	0.03	0.04	0.03	0.02							0.22	86400	19,008	1985	9.5
	Total				16	0.094	0.14	0.1	0.07	0.06	0.02							0.483	86400	41,731	7940	5.2

S.No	Name of Tabia	Name of Kushet	Easting	Northing	W.S	Production of each Water Schemes in Litter per Second													Litter a day	sec.a day	per day	pop	PWA
21	Kudo	Adi-hayam	0524899	1568268	1	0.041													0.041	86400	3,542	1616	2
		Tsetse	0526015	1568534	4	0.021	0.02	0.04	0.02										0.087	86400	7,517	1466	5
		Tsehan	0524504	1567206	4	0.032	0.01	0.03	0.02										0.074	86400	6,394	1410	4.5
		Amus	0524390	1567306	0														0	86400	0	856	0
	Total				9	0.094	0.03	0.07	0.04										0.202	86400	17,453	5348	3.2
22	Mishig	Agam	0522404	1566254	6	0.05	0.04	0.04	0.01	0.01	0.01								0.157	86400	13,565	2160	6.3
		Kebersi	0525030	1565510	5	0.03	0.02	0.01	0.02	0.05									0.132	86400	11,405	2006	5.7
		Agazna	0521315	1566122	2	0.03	0.02												0.053	86400	4,579	1852	2.4
		Hanyen	0520928	1565800	2	0.021	0.03												0.052	86400	4,493	1698	2.6
	Total				15	0.131	0.11	0.05	0.03	0.06	0.01								0.394	86400	34,042	7716	4.4
23	L_hahayle	Adi-tserae	0519159	1566684	1	0.05													0.05	86400	4,320	1710	2.5
		Zbanhahayle	0518329	1565764	3	0.04	0.04	0.02											0.097	86400	8,381	1662	5
		Drhasema	0518164	1565436	2	0.042	0.02												0.063	86400	5,443	897	6
		Kole	0520324	1568865	0														0	86400	0	851	0
	Total				6	0.132	0.06	0.02											0.21	86400	18,144	5120	3.5
24	Daero_anbesa	Azmera	0518303	1562733	1	0.05													0.05	86400	4,320	1842	2.3
		Meshal	0517274	1561191	5	0.051	0.03	0.04	0.05	0.02									0.118	86400	10,195	1703	6
		Sye	0517763	1562416	0														0	86400	0	1574	0
		Debri	0518343	1563148	0														0	86400	0	1932	0
	Total				6	0.101	0.03	0.04	0.05	0.02									0.168	86400	14,515	7051	2
25	Edaga_hamus	Hadush-adi	0514637	1567169	4	0.042	0.04	0.03	0.02										0.114	86400	9,850	1385	7
		Endamariam2	0508991	1572495	2	0.04	0.03												0.07	86400	6,048	1209	5
		May-haramz	0515421	1563974	4	0.021	0.04	0.03	0.03										0.097	86400	8,381	1341	6.2
		May-asgele	0515708	1565939	4	0.051	0.03	0.04	0.03										0.121	86400	10,454	1562	6.7
	Total				14	0.154	0.15	0.1	0.08										0.402	86400	34,733	5497	6.3
26	Agamo	Laelay-agam	0510446	1564427	1	0.021													0.021	86400	1,814	184	10
		Tahtay-agam	0511071	1565130	1	0.025													0.025	86400	2,160	154	14
		Blay-tisha	0511417	1566559	0														0	86400	0	249	0
	Total				2	0.046													0.046	86400	3,974	587	7
27	Adi_yiekoro	Lma't	0508239	1566046	9	0.012	0.02	0.05	0.02	0.05	0.03	0.02	0	0.026					0.249	86400	21,514	1214	18
		Daero	0507346	1567100	3	0.031	0.04	0.11											0.183	86400	15,811	1689	9.3
		Medebti	0506261	1566339	5	0.021	0.02	0.02	0.03	0.1									0.196	86400	16,934	1002	25
		Alagsa	0505317	1566411	0														0	86400	0	857	0
	Total				17	0.064	0.08	0.19	0.06	0.15	0.03	0.02	0	0.026					0.628	86400	54,259	4762	11.3942