EVALUATING THE SUSTAINABILITY OF WATER SUPPLY SCHEMES AND SEASONAL WATER QUALITY OF POTABLE WATER SUPPLY IN RURAL AREAS OF EFRATA GIDIM WOREDA, NORTH SHOWA ZONE

MASTER OF SCIENCE THESIS

MEKETE AGIZEW

HAWASSA UNIVERSITY, HAWASSA, ETHIOPIA

June 2018

EVALUATING THE SUSTAINABILITY OF WATER SUPPLY SCHEMES AND SEASONAL WATER QUALITY OF POTABLE WATER SUPPLY IN RURAL AREAS OF EFRATA GIDIM WOREDA, NORTH SHOWA ZONE

BY: MEKETE AGIZEW

MAJOR ADVISOR: ABRAHAM W/MICHAEL (PhD)

CO-ADVISOR: MIHRET DANANTO (PhD)

A THESIS SUBMITTED TO THE

DEPARTMENT OF BIOSYSTEMS ENGINEERING, INSTITUTE OF TECHNOLOGY, SCHOOL OF GRADUATE STUDIES,

HAWASSA UNIVERSITY,

HAWASSA, ETHIOPIA

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN WATER RESOURCES ENGINEERING AND MANAGEMENT

June 2018

Hawassa, Ethiopia

DEDICATION

I dedicate this to my dearst wife, Balemlay, my father and brother who supported and encouraged me throughout the period of this study.

STATEMENT OF THE AUTHOR

I, Mekete Agizew, hereby declare that this thesis: *“ Evaluate the Sustainability and seasonal quality of Rural Water Supply in Efrata Gidim Woreda, North Showa, Amhara Regional State”* is my own work and has not been submitted for any degree in any other university. It is being submitted for the degree of Master of Science in Water Resources Engineering and Management at Hawassa University, and all sources of material used for this thesis have been dully acknowledged.

Name: Mekete Agizew

Signature: --------------------

Email address: geni.mam09@gmail.com

Place: Hawassa University, Hawassa

Date of submission: June, 2018

ACKNOWLEDGEMENT

Above all, I would like to thank the awesome and Almighty God who gave me this opportunity and ordered success in my life. I am also very much indebted to several people that have contributed to the successful completion of my study in different ways.

First and foremost, I would like to express my most sincere and heartfelt thanks to the invaluable guidance, support and inspiration of my punctual advisors Dr. Abraham W/Michael and Dr. Mihret Dananto who guided me tirelessly throughout my study; I am extremely grateful for their continuous encouragement, critical observation, comments and valuable time.

Thirdly, I am greatly indebted to the experts of Efrata Gidim Woreda Water Management Office and the Woreda Health Office for their limitless professional support and discussion on issues related to the Woreda water supply.

I would also like to thank the school of Biosystems and Environmental Engineering and Efrata Gidim Woreda Water Management for their support by providing laboratory equipments for Bacteriological water quality analysis.

TABLE OF CONTENTS

ABBREVIATIONS AND ACRONYMS

ADF	Africa Development Fund
CSA	Central Statistical Authority
EGWAO	Efrata Gidim Woreda Agriculture Office
EGWWHO	Efrata Gidim Woreda Health Office
EGWWMO	Efrata Gidim Woreda Water Management Office
EC	Electrical Conductivity
EPA	Environmental Protection Agency
ES	Ethiopian Standards
FDRE	Federal Democratic Republic of Ethiopia
GIS	Geographic Information System
GPS	Global Positioning System
IRC	International Risk Conference
JMP	Joint Monitoring Programme
Km	Kilometer
LPCD	Liters Per Capita Per Day
MLR	Multiple Linear Regression
MoWE	Ministry of Water and Energy
MoWR	Ministry of Water Resources
NMSA	National Meteorology Service Agency
NWI	National Wash Inventory
O&M	Operations and Maintenance
RWSN	Rural Water Supply Network
SPSS	Statistical Package for Social Science
TDS	Total Dissolved Solids
TC	Total Coliform
TTC	Thermotolerant coliform
UNICEF	United Nations International Children's and Emergency Fund
USAID	U.S. Agency for International Development
VIF	Variance Inflation Factors

VLOM	Village Level Operation and Maintenance
WHO	World Health Organization
WPC	Water Point Committee

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIX

ABSTRACT

Sustainability of rural water supply schemes is very important for continued service of water for the society. Low sustainability of water supply schemes makes the community to return to unprotected source. This study was conducted in Efrata Gidim Woreda, North Showa Zone, to evaluate the sustainability of water supply schemes and quality of potable water supply. For the study, four Kebele administrations and 359 households were randomly selected for primary data sources. A total of 16 water samples were collected and examined for physico-chemical and bacteriological water quality analysis from source; 8 for wet and 8 for dry season. Office document review of quantities and specification of schemes constructed were also conducted. Multiple linear regression model was applied to identify determinant of biophysical and technical factors influencing the sustainability of water supply schemes. One way ANOVA, logit and MLR was employed to see the statistical difference of the variables at 5% significant level and correlation was also done to observe associations of variables. From the 19 schemes observed; 52.63% of them were on spot spring. From the total improved springs (n=8), 37.5% were semi functional and 25% were not functional due to maintenance and spring development problems. From the total shallow wells (n=6) observed 50% of them were non-functional due to low penetration, breakage of U-seal and maintenance problems. The findings revealed that the actual performance of water points were low due to non spring development problems, clogging of the spout, poor quality gravel selection during well development, low water points protection, lack of follow up, low depth of penetration and maintenance. Major problem concerning the recovery of water supply schemes operation and maintenance cost was lack of enforcement. In Zembo and Lay Saramba Kebeles, 6 to 7 percent of the operation and maintenance costs were recovered while Dulit Yegelda and Yemelewo schemes recovered below 1%. On average, the community consumes 6.57liters of water per head. Low quantity per capita consumption was a common thrend of the Woreda (almost all residents took less than 25 litres of potable water per household). It was observed that sustainability of water supply schemes influenced by willingness to pay (p=0.044), O&M (p=0.001), lack of training (p=0.001), and participation (p=0.01). Among determinant of sustainability, age (p=0.009), access to spare part (p=0.001), construction quality (p=0.001) was found to be statistically significant. The physicochemical test of data analysis showed that (EC, pH, TDS, chloride, nitrate, iron and fluoride) were within the standard of ES and WHO but magnesium and phosphate was above the standard. Temperature differences (p=0.002) between wet and dry seasons were found to be highly significant due to seasonality. Nitrate (p=0.013) was found significantly different between wet and dry season too due to organic waste, surface runoff from agricultural land with fertilizer during wet season. In terms of microbial result, the drinking water showed total and fecal coliform contamination at the source which makes it not suitable for drinking water purpose.

Key words: *determinant, water supply, maintenance, water quality, Efrata Gidim, Amhara.*

1. INTRODUCTION

1.1 Background and Justification

According to a report of USAID (2009) more than one billion people do not have access to safe drinking water. In Africa, around 300 million people do not have access to safe drinking water. That means Africa has the lowest total water supply coverage of the other continents in the world (ADF, 2005). Water is life and especially potable water is essential for life and health. So, access to drinking water, improves overall socio-economic and environmental existence (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. As Harvey and Read (2007) reported that community issues like perceived lack of ownership, lack of education on water supply and sanitation, poor management system and limited demand are related to low sustainability rates of water supply systems. This is a summary of rural water supply sustainability challenges by Well (1998).

"Insufficient water facilities, poor physical structures, low reliability of the service and facility designs and low awareness about their uses are some of the factors that affect the continued functioning of the rural water supply systems. In addition to these inappropriate technology use is also one of the factors. The sustainability of rural water supply systems is correlated with institutional, social, technical, environmental and financial dimensions".

Enhancing the capacity of the community in planning, implementation, development and maintenance of rural water supply systems are the first step towards the sustainability development of rural water supply schemes. To examine the impact of the water supply system socio-economically, the full impact should be taken under consideration (UNICEF, 1999).

Rural water supply system provides potable water to rural communities for domestic uses (for example, drinking, cooking, bathing, and hygiene), and requires the supply of high-quality water on a continuous basis. In the rural area, families especially women spend a considerable amount of time trying to provide sufficient water for these uses. The potable water systems usually replace traditional sources of water, such as rivers, unprotected spring and open wells, which are often contaminated and far from the household. Improved rural water solutions include a range of technologies from protected spring and wells equipped with manually operated hand pumps to more complex gravity-flow or pumped piped water systems connected to houses or public stand posts.

A great deal of attention has recently been given to the question of sustaining rural services? (i.e. How to ensure, systems will continue to function and produce the intended benefits after project completion), and, how to improve services delivery. The discussion on sustainability of rural water supply project is very wide and the issue it encompasses will be multi-dimensional. It deals with the technical, health, economical, Institutional, environmental, social and political issues (Jennifer and Travis, 2003). In addition to constructing new water supply schemes, attention should be given to operation and maintenance of the existing schemes, in order to achieve the envisaged objectives. Substantial achievements will not be achieved unless the factors contributing to poor implementation of the old schemes are fully explored. Previous experiences should also be taken into account in the new schemes to avoid repetition of problems. In this context, great attention has to be paid to the fundamentals of sustainability, that is monitoring and evaluation (Issays, 1988). Evaluation of impact is a longer-term activity.

Efrata Gidim Woreda is characterized by potential surface and ground water source. Despite the ground water supply potential of the Woreda, it is not possible to construct and maintain non-functional water supply schemes in all Kebeles. Even in Kebeles of functioning schemes themselves are not providing reliable and adequate services for different reasons to respective communities (EGWWMO, 2018).

This study was conducted in Efrata Gidim Woreda, North Showa, Amhara Regional state, the water supply sustainability problem are still untouched and unsolved problems. The investigator considered from his observation and experience that the problem of water in Efrata Gidim is growing from time to time. Improving the water supply sustainability and evaluating seasonal variation of water quality at the source has a number of advantages for the society of the Woreda as well as for the government socially and economically.

1.2 Statement of the Problem

In Ethiopia 33% of rural water supply schemes are non-functional at any time, owing to lack of funds for operation and maintenance, inadequate community mobilization and commitment and a lack of spare parts (MoWR, 2007). Inventory result of National Wash Inventory (NWI) shows that the rural water supply scheme functionality has been improved and reaches 75.53% and it was better for Amhara region (79.62%) MoWE (2013). These may be due to implementation of a large number of water supply schemes through the community managed project approach.

Efrata Gidim is one of the Woreda found in rural Ethiopia, where 36% of water supply schemes are not functional due to social, economical, environmental, institutional and technical reasons (EGWWMO, 2018). Thus, the communities are forced to use water from unprotected water sources, which they may share with their animals. Sustainability of water supply schemes are supposedly very sounding problem in the study area. It was observed that there are several factors in the community that were likely resulting to the none sustainability of water supply schemes. In addition, seasonal variation also had impact on water quality based on the public complaint.

The other major problems related to water in the study area are microbiological pollution. Moreover, pesticides and fertilizers used in agricultural fields impose additional burden in the study area. Jardia, bilharzia, typhoid, diarrhea, leptospirosis, malaria, gastroenteritis, hepatitis, campylobacteriosis and salmonellosis are the most prevalent water associated communicable diseases and people suffer in the study area that varies from season to season (EGWHO, 2018). Hence, this research evaluated the sustainability of water supply schemes; identify the determinants of water supply schemes and quality of water at the source.

1.3 Objective of the Study

1.3.1 General objective

The overall objective of the study was to evaluate the sustainability of schemes and seasonal water quality variation of rural water supply schemes in Efrata Gidim Woreda, North Showa, Amhara Regional State.

1.3.2 Specific objectives

The following specific objectives were addressed to attain the overall objective of the study. The specific objective were:

1. To conduct an inventory of water supply schemes in the study area.
2. To assess and identify the determinates of water supply schemes sustainability.
3. To evaluate water quality of schemes in dry and wet season.

1.4 Research Questions

In order to address the above issues, the study were attempted to answer the following four research questions:

- What is the present design discharge and actual discharge of water supply scheme in the study area?
- What are the determinants of technical and environmental factors on sustainability of water supply schemes?
- What are the determinants of socio-economic and institutional factors on sustainability of water supply schemes?
- Does the seasonal water quality in the study area fulfill the established standards?

1.5 Significance of the Study

This study investigated important information concerning type, number, design and actual discharge of water supply schemes, determinant of technical and environmental factors for sustainability of water supply schemes using multinomial regression model and determinant of socio-economic and institutional factors for sustainability of water supply schemes using logit model. The study also evaluated seasonal variation of drinking water quality at point/ source.

The findings of the study will serve as an input to rural water supply actors to intervene and take effective approach to sustain the water supply schemes and contribute in the rural water supply framework.

1.6 Scope of the Study

The focus of this study is on sustainability and seasonal quality of water supply in the rural part of Efrata Gidim Woreda. This study specifically emphases on evaluation of rural water supply sustainability and potable water quality. The study area is limited to rural Kebeles in the Worda. The study covers selected four Kebeles of water supply where data generated from selected water supply schemes and household beneficiaries. The main problem that the researcher encountered in the course of this study was lack of adequate information due to improper document handling by the Woreda Water Office, and study period(Augest-January/2017). Due to poor documentation of the data in the offices, it was laborious to get the necessary and relevant information. Because of the absence of in depth previous research on water supply in the study area, it was difficult to see parameters thoroughly and to do a comparative study or deal with another side of the previous study. It is also worth mentioning that lack of sufficient amount of money had an objectionable upshot on the study.

2. LITERATURE REVIEW

2.1 Factors Affecting Sustainability of Water Supply Schemes

Rural water supply system sustainability and functionality are performance indicators of service delivery. Functionality is a simple snapshot view of whether or not water supply systems are working at the time of inspection. It can not on its own tell us anything about the reasons for the particular state that the water point is in, or why it may be providing an adequate service, intermittent service or no service at all. Functionality data are of limited value, but they are often the best indications of inadequacies in sustainable service provision (Carter et al, 2010). While rural water supply scheme sustainability is whether or not facilities provide the designed level of service (water quantity and quality) continues over the designed time period (Abrams, 2013).

Sustainability of water supply schemes is whether benefits from the service continue satisfactorily until the end of the design life. Benefits include health benefits through providing improved quality of water from protected source, water delivery to reduce time spent and convenience (Mebrahtu, 2012). Sustainable rural water supply is defined as one in which the water sources are not over-exploited but naturally replenished, facilities are maintained in a functional state which also ensures a reliable and adequate water supply and also benefits of the supply continue to be realized by all users over a prolonged period of time.

Thus, the dimensions of sustainability of a water supply scheme and its service delivery are multifaceted. According to (Mukherjee and Wijk, 2003) there are five key sustainability areas, which discussed below.

2.1.1 Technical indicators

This refers to the reliable and correct functioning of the technology and, for water supplies, the delivery of enough water of an acceptable quality. Important dimensions of technical factors include: technology selection(complexity of the technology); construction quality; technical skills needed to operate and maintain the system; the availability, accessibility of spare parts and age of schemes.

In general, the technical issues relating to the technology selection, spare part supply, construction quality, technician for operation and maintenance and age of rural water supply system are the most determinant of water supply sustainability. Because water system sustainability depends on a number of factors, which vary between community and type of scheme, therefore, measuring sustainability is a difficult task. This study bases its analysis on indicators that measures the technical aspect. The main aim of technical evaluation is to investigate determinant factor for the sustainability of the village water supply and to look for remedial measures. Sustainability is the capacity of project to continue to deliver its intended benefits over the design period (Issays, 1988).

The sustainability of water supply facilities mainly depends on a timely and regular maintenance and operation of the system. However, in most developing countries, including Ethiopia, it has been found out that operation and maintenance of water supply facilities is in a poor state of condition and the sustainability of the schemes at stake. Ethiopia about 35% of the installed hand pumps are non-operational because of either minor or major technical faults (RWSN, 2010).

Type of technology: Inappropriate choice of technology and/or poor system design can threaten sustainability (Bhandari and Grant, 2007). Poor choice or design may be due to ignorance (either on the part of contractors, and/or by users, if they play a major role in system choice) or sometimes incentives (e.g. if installers are offered bribes by suppliers to select a particular technical option). Proliferation of many different types of technologies makes it harder to ensure that spare parts and expertise are available for maintenance and repairs; standardisation is helpful (Lockwood and Smits, 2011).

The use of appropriate technologies, which are low cost, easy to maintain, simple to use, and readily available is one response to challenge of sustainability. Appropriate technologies are integral to the concept of village operation and maintenance (VLOM) which emerged in the water decade (Hayson, 2006). The VLOM concept includes the development of hand pumps specifically, designed to be maintained by village care takers, but also extends into the institutional arrangements needed to ensure that skills, and tools and spare parts are available when needed (Arlosoroff et al, 1987).

Construction quality of water supply schemes: Construction quality is one of the most important factors influencing sustainability of water supply systems (Sara and Katz, 1997), yet this is often hard to quantify. It is in turn affected both by the availability of resources and the quality of supervision. However, many projects rely on unskilled 'supervision' by community members, or very sporadic site visits by district government staff.

From experience it is not uncommon for the failure of water supply schemes because of quality problems. Common construction quality problems that result in scheme dis-functionality are :

- Partial penetration of an aquifer of well.
- Poor casing arrangement of well.
- Poor gravel packing and poor estimation of well yield.
- Improper site selection due to poor or lack of feasibility study
- Poor pipe installation of springs.

Such kind of well completion problems eventually results in well dry up and as a result the schemes will be abandoned (Harney and Reed, 2004).

Technician for operation and maintenance: For hand pumps, there should be trained caretakers those can undertake maintenance when needed. The caretakers should be capable of doing preventive maintenance work, replacement of worn out parts, and maintain breakage. Therefore, in order to discharge those responsibilities, the caretakers should have necessary trainings from the very beginning of scheme installation. There performance also should be evaluated in continual bases. At the same times the caretakers should be provided with necessary tool kits those required for maintenance purposes. However, if necessary skills and tool kits community hand pump care takers were not provided, the sustainability of schemes will be compromised (Arlosoroft et al, 1987).

Spare part supply: The problem of spare parts for rural water schemes primarily attributed to lack of formal supply chain mechanism. Hence, lack of spare parts has been a major constraint in sustainability of water supplies and has been a recurring problem. In some cases, it has lead to the complete abandonment of the water supply system (Davis and Brikke, 1995).

If sustainability is to be achieved, it should be ensured that after appropriate technology is chosen, spare parts for that type of technology are made readily available (Musonda, 2004).

Age of water supply schemes: Intuitively, the age of a water supply system is likely to affect its functionality; common sense suggests that older water supply schemes is less likely to be operational than newer water supply schemes.

2.1.2 Environmental and human health factors

The following are major issues to be considered under these factors: quality of the water source (this will determine whether the water needs to be treated); the quantity of water; reliability and distance of water supply schemes from residential house of household's.

Distance from water supply schemes: If water collection distance is more than 1km far from residence, there is an increased risk that people will fail to meet their minimum water needs (JMP, 2010); hence, this is recommended as a criterion for a basic level of service (WHO, 2011).

Reliability of water source: Reliable water source is the one, which gives quantity of water throughout the year with the design discharge. If the water source stops or reduces the yield then the source of water is not reliable source.

Quality of water: Water quality typically considered to have four aspects: microbial, chemical, bacteriological and acceptability (i.e. taste, odour and appearance) (WHO, 2011). For users, the most salient aspects are often taste and hardness: excessively salty water cannot be drunk, and excessively hard water cannot be used for washing. Bacteriological water safety is especially important for drinking water, and is often of particular concern to water point installers but users may not be aware of this issue, or may not value it highly (Bhandari and Grant, 2007). In fact, it is likely that a significant minority of 'clean' water sources do not deliver adequately clean water (JMP, 2012). The JMP is making efforts to improve assessment of water quality through its Rapid Assessment of drinking Water quality methodology (JMP, 2010), but there is a long way to go before quality is routinely monitored. Of course, only a few of the 'basic access' 25 LPCD are needed for drinking, and lower quality water may be acceptable for other uses such as washing; in practice, households may use different sources for different purposes, depending on the required balance between water quality and convenience. Additionally, increased quantity of water is often more important than increased quality, because many diseases are 'water-washed' rather than 'waterborne / faecal-oral' (Thompson et al, 2012). In summary, both quantity and quality of water are significant factors influencing the achievement of benefits from rural water supply.

Quantity of water use: A reasonably accurate estimate of the amount of water that must be supplied is needed early in the planning stage of project development. The average daily demand is especially important since it may be used to assess the ability of available sources to meet continuing demands and to size raw water storage facilities that may be required to meet sustained demands during dry periods. Later, during the actual design process, the peak demand must be known to properly size pumps and pipelines, estimate pressure losses, and determine finished water storage requirements so that sufficient water can be supplied during peak demand periods. For small community water supply quantity of water refers to the volume of water required on individual bases for the various daily household purposes .The quantity of water to be provided in rural water supply schemes expressed in terms of liters per capita per day (LPCD).

The quantity of water any source produce is called yield. Refers to the volume of water required on individual bases for the various daily household purposes. Quantity of water to be provided in rural water supply schemes of 25 liters per capita per day (LPCD) (UNICEF and WHO, 2012).

2.1.3 Social sustainability

Users will only sustain services that satisfy their expectation. This means serves which they can easily access, that are in accordance with their socio-cultural preferences and practices, and services that they consider worth the cost they incur to obtain them. Under these factors vital aspects include: community participation, acceptance and satisfaction of water supply schemes.

Community participation: Rural Water supply schemes activities are not likely to achieve their objectives without the active and continuous participation of the users, during pre-planning, planning implementation, and operation and maintenance. Concept of community participations means, that the community plays an active role in its own affairs by sharing and exercising decision- making and implementation (IRC, 1987).

A fundamental element of sustainability of water supply scheme is the participation of the community and its support for continued upkeep of the systems. The water agencies have to initiate proactive measures like awareness building, community mobilization, constitution of community-based institutions like water user association and water committee, strengthening democratic process in them and broad basing involvement of community by transferring responsibility and authority to them in all aspects of implementation and operation and maintenance of schemes. According Zemenu (2012) participation of all water user before and after construction improve over all sustainability of schemes.

Villagers should be encouraged to nominate a person or committee to be responsible for looking after the village scheme, collecting charges, and perform similar tasks .The best evidence of participation is village willingness to contribute to construction costs and to pay an adequate fee for water use once the system is in operation (Smet and Christine, 2002).

Acceptance: When beneficiaries show active participation in the development of their schemes, it is an important indicator for community scheme acceptance. Community acceptance is very important for continued functioning of water supply schemes. Before constructing water supply schemes the user community must accept it unless, it is not safe.

Satisfaction: This measure overall consumer satisfaction with the water schemes. consumer satisfaction as an indicator of sustainability of water supply schemes is also reflected by the continuous support and participation of the community in water supply related issues. Consumers are more likely to be satisfied with results such as quantity of water, quality of water, distance to residence and operation and maintenance. It is expected that under such circumstances, users express a higher sense of ownership, greater confidence in their ability to maintain the water system.

2.1.4 Financial sustainability

System can only continuances function if financial resources meet at least the costs of operation, maintenance, and common repairs.

Sources of Fund: Funding for rural water supply may derive from three sources: tariffs (user payments), taxes (domestic revenue), and transfers (aid) from donors, including bilateral, multilateral and non-governmental (Trémolet and Rama, 2012).

Tariffs are consumer contributions for water and sanitation services. In most countries in the World, including the US and Europe, consumer tariffs cover minor maintenance as well as a part of major maintenance. However, tariffs rarely cover the full cost of major maintenance or replacement, nor do they pay for the staff in regional and district departments that are responsible to ensure that services are provided.

Taxes are domestic taxpayer contributions to the government. Taxation is how high-income countries have achieved universal access to water and sanitation. A steady and robust tax revenue system at national and local level allows governments to receive loans, use them to improve and expand their services and repay the loans.

Transfers are funding provided by external aid agencies. From 2012 to 2015, external aid commitments for water and sanitation, as a portion of total aid commitments, have steadily declined from 6.2% to 3.8%. The hard numbers demonstrate this is a significant cut in aid contributions.

Trust of water committee: Trust is important just, in terms of whether users trust that their committee will look after their funds correctly. Yet there is evidence suggesting that in some instances these are significant factors on sustainability (Kleemeier 2000, Campbell 2009).

Willingness and ability to pay for services: Providing services which people can afford is a pre-condition for cost recovery (partial cost-recovery in rural water supply case in Ethiopia). Being able to pay for something and being willing to do so, however, do not always go hand in hand. From economists points of view demand is only real or "effective" when it is accompanied by willingness to pay, in cash or kind, for goods or services offered. From this points of view, "willingness to pay" and "demand" essentially mean the same things (Evans 1992).

In order to the communities meet the cost of operation and maintenance, community member is willing to pay for the services. Willingness to pay for the service is influenced by number of factors. For example, a community with a river and near-by is prepared to pay much less for a hand pump than a community with similar income who has to walk kilometers to fetch water. This is why a survey should be willingness to pay (Briscoe and De Ferrani 1998, cited in Musonda, 2004).

Operation and maintenance cost: Failure adequately cover costs of improved water supply services in developing countries has been identified as major constraints to achieving the goals of safe water supply for all on a sustainable basis. In recent years, increased community financing through user payment for service has been strongly promoted as a solution (Evans, 1992). In this regard, according to (Getachew,2002), even small water supply systems require investment of operation and maintenance. These are often costly and thought to be beyond the financial capacity of community, however, experience shows the communities are willing to shoulder portions of the investment costs and to pay for full operation and maintenance provided that they are in need of the service and appropriate community promotion exercise is being carried out.

As far as payment for water supply service is concerned, Ethiopian water resources management policy (1999) promote that for rural water supply schemes partial cost recovery principle to be applied i.e. user communities should cover operation and maintenance costs. Such kind of payment is proposed to be effected through different tariff structures. The tariff structure that is adopted for rural water supply schemes that provide communicable services like hand pumps and public stand posts is flat rate tariff, in which all beneficiaries are expected to contribute equal amount either in cash or kind in fixed time interval for instance, on monthly basis or daily.

2.1.5 Institutional sustainability

To keep systems operational, accessible and widely used, communities need institution. Institutions have cultural characteristics, agreed and valued procedures and rules for operation, and varying capacities for management and accountability. Under these factors vital aspects include: capacity building, information transfer and implementing drinking water policies.

Capacity building: Training provides knowledge of how to operate water system, and prevent major problems. It also informs the communities that it is their responsibility to maintaining the system, not the projects' or the governments'. It, in addition, educates people about potential health benefits of protecting the water source, and thus enhances their willingness to sustain the system. Therefore, in addition to training for water committee members, education about the linkages between unsafe water and disease should be integrated to water supply schemes of rural areas (Gebre Amanuale, 1997; Churchill, 1987).

Information transfer between user community and actors: Information asymmetries between different actors involved in rural water supply are also a significant constraint. For example, district water officers often do not know which water points need repair, or where the greatest need for new investment lies. Donors do not know enough about long-term sustainability or cost-effectiveness of their investments in the sector. Water users do not know how much has been spent on providing services to them. These information gaps mean that it is very hard for citizens to hold the state to account for service provision 'long route' to accountability (World Bank, 2004), or for donors to know how cost-effective their grants have been. Improved information transmission can have a significant positive impact. The power of access to information in improving public water supply schemes services through deterring misappropriation of funds and increasing focus on problem of water supply schemes.

Implementing drinking water supply policy: The Water Resources Management policy (1999) in the section of drinking water supply clearly elaborated detail policies on institutional, technical, financial, social and environmental issues that should be considered in provision and sustainable management of drinking water supply schemes. Some of the policies include:

- Develop standard and criteria for the design quality control, materials and technologies in water supply and for operation and maintenance procedures;
- Ensure that the management of water supply systems schemes to be at the lowest and most efficient level of institutional setup, which provides for the full participation of users to promote effective decision making at the lowest practical level;
- Regulate, guide and mange the import of water supply technologies and materials.

2.2 Inventory Survey of Water Supply Schemes

Preliminary survey was done on the selected Kebele to identify type and number of Water supply schemes. It provides measurable and representative data for evaluation and problem analysis purposes. In addition, it was used as bench mark data for important indicators on the availability, accessibility and utilization of water schemes. According to (Brikké and Bredero, 2003) all the points listed below should be addressed in the survey:

- Types of water supply schemes
- Functional and non-functional water supply schemes
- Discharge of water supply schemes

2.3 Water Quality

It is very essential and important to test the water before it is used for drinking, domestic, Agricultural or industrial purpose. Water quality is a measure of the condition of water relative to the requirements of one or more biotic species and to any human need or purpose and it is most frequently used by reference to a set of standards against which compliance can be assessed. Water must be tested with different physico-chemical parameters. Selection of parameters for testing of water is solely depends upon for what purpose we going to use that water and what extent we need its quality and purity. Water does content different types of floating, dissolved, suspended and microbiological as well as bacteriological impurities. Monitoring the quality of water facilitates; evaluation of nature and extent of pollution, effectiveness of pollutant control measures, water quality trends and prioritization of pollution control efforts (Diersing-Nancy, 2009). The available sources for a potable water supply are groundwater and surface water. Therefore, it should be protected, used and maintained in an appropriate way. There are several parameters used to determine the suitability of water and the health contaminants such as microbiological, physical, chemical, and microscopic examinations, which may be found both in untreated and treated water.

2.3.1 Bacteriological water quality aspects

An indicator organism is an organism that can provide information about the health of a water body through the organism's presence, condition, or numbers. The most common bacteriological water quality indicators include TC, FC and E.coli. Tests for the indicator should be applicable to all types of water and the test should detect only the indicator organisms thus not giving false-positive reactions. Another reason for using simple indicator tests is that pollution is often intermittent and/or undetectable. Total coliforms are the ones that are commonly measured as indicator bacteria for drinking water quality. They are defined as aerobic and facultatively anaerobic non spore forming bacteria that ferment lactose at 37 ^{0}C with the production of acid and gas within 24-48 hours (Hurst *et al.,* 2002). E.Coli bacteria specifically used to indicate faecal contamination Escherichia coli (E.coli), a thermotolerant coliform, is found to be the most numerous in animal or human faeces of the total coliform group, rarely grows in the environment and is considered the most specific indicator of faecal contamination in drinking water. In rural villages and urban areas of Ethiopia, the main contaminants for water are human excreta, animal waste, liquid waste from factories, garages, pesticides from different sources. Water sources contaminated with these wastes is not fit for human use, unless it is made safe or treated (FDRE and MoH, 2007).

2.3.2 Physico-chemical water quality aspects

The physical and chemical parameters on drinking water have health impact when the parameters were above the standard (Diersing-Nancy, 2009). The physical parameters are temperature, electrical conductivity, pH and turbidity where as chemical parameters are total dissolved solids (TDS), hardness, fluoride, chlorine, nitrates, irons and total chlorine or residual chlorine.

Temperature expressing how hot or cold water. Temperature is an important factor to consider when assessing water quality. In addition to its own effects, temperature influences several other parameters and can alter the physical and chemical properties of water. It has an impact on many reactions including the rate of disinfectant decay and by-product formation (Volk et al, 2002). An aesthetic objective is set for maximum water temperature to aid in selection of the best water source or the best placement for a water intake. It is desirable that the temperature of drinking water should not exceed 15ºC because the palatability of water is enhanced by its coolness. In addition to cool water tasting better than warm water, temperatures above 15 degree Celsius can speed up the growth of nuisance organisms such as algae, which can intensify, taste, odour and colour problems. Temperature also affects water treatment. If nutrients are available, the microbial activity (as measured by heteroplate count) increases significantly at water temperatures above 15ºC in the absence of a disinfectant residual. Therefore, water supplies generally tend to keep the temperature as low as possible in order to minimize the bacterial growth. Keeping the temperature low reduces the risk for pathogenic proliferation and survival since the optimal temperature for most pathogens is close to the human body temperature (Volk et al, 2002).

pH is the most important water quality parameter. Measurement of pH relates to the acidity or alkalinity of the water. Low pH levels cause severe corrosion of metals in the distribution systems while high pH values result in progressive decrease in the efficiency of the chlorine disinfection process**.** pH values ranging from 3 to 10.5 could favor both the growth of indicator and pathogenic microorganisms in drinking water.

Electrical Conductivity (EC) is the electrical conductivity (EC) of water a measure of its ability to carry an electric current; the more dissolved ions solutes in a water, the greater its electric conductivity. Pure water is a poor conductor of electricity. Water shows significant conductivity when dissolved salts are presented. These ions, which come from the breakdown of compounds and conduct electricity because they are negatively or positively charged when dissolved in water.

Turbidity is a measure of the amount of suspended particle in the water. It is another key parameter in drinking water and it has health effect when the turbidity level is above the standard. Turbidity can be caused by silt, sand, mud, bacteria and chemical precipitates. It indicates water quality and filtration effectiveness. Turbidity of natural water is caused by the presence of compounds such as clay, mud, organic matter, bacteria and algae (WHO, 2003). Turbidity has to be correlated with bacterial contamination, and the probable existence of pathogens that are of human health concern (Olson, 2004).

Total dissolved solids (TDS) In water, total dissolved solids are composed mainly of carbonates, bicarbonates, chlorides, phosphates and nitrates of calcium, magnesium, sodium, potassium and manganese, organic matter, salt and other particles (Mahananda, 2010). (Suspended solids are any particles/substances that are neither dissolved nor settled in the water, such as wood pulp). In general, the total dissolved solids concentration is the sum of the cations (positively charged) and anions (negatively charged) ions in the water. High TDS results in undesirable taste which could be salty, bitter, or metallic. It could also indicate the presence of toxic minerals.

Hardness is measure of concentration of calcium and magnesium salt in water, is important variable for drinking water quality.The effect of hardness is scale in utensils and hot water system in boilers. Soap scum's sources are dissolved calcium and magnesium from soil and aquifer minerals containing limestone or dolomite. Magnesium is the major contributor to hardness and like calcium, concentration of magnesium above 150mg/l especially if present with sulfate can cause gastrointestinal irritation and diarrhea; some salts of magnesium in water are toxic by ingestion or inhalation, concentration of magnesium greater than 125mg/l also can have a cathartic and diuretic effect (Cairn Cross, 1990; Hutton 1996). The Treatment of hard Water is Softener Ion Exchanger and Reverse Osmosis process.

Fluoride the presence of fluoride in ground water is attributed to the geological deposits, geo-chemistry of the location and the application of fertilizer like rock phosphate. The use of rock phosphate or fluoroappetite fertilizer can also generate fluoride ions on dissolution. Fluoride is beneficial to certain extent, when present in concentration of 0.8 to 1.0 mg/L for calcification of dental enamel especially for the children below eight years of age. However, it causes dental fluorosis, if present in excess of 1.5 mg/L and skeletal fluorosis beyond 3 mg/L, if such water is consumed for about 8 to 10 years (Jayanta and Siba, 2009).

Chloride occur naturally in all types of waters. In natural freshwaters, however, its concentration remains quite low and is generally less than that of sulphates and bicarbonates. Therefore, the chloride concentration serves as an indicator of pollution. A related health problem of chlorine contamination in drinking water includes Eye/nose irritation; Anemia; Infants and young children: nervous system effects. Chloride may be increased in surface water since it is concentrated in human and animal urine reaching water courses.

Nitrates are an essential source of (N) for plants. When nitrogen fertilizers are used to enrich soils, nitrates may be carried by rain, irrigation and other surface waters through the soil into ground water. Human and animal wastes can also contribute to nitrate contamination of ground water. The significant sources of nitrates are chemical fertilizers from cultivated lands, drainage from livestock feeds, as well as domestic and industrial sources. Natural waters in their unpolluted state contain only minute quantities of nitrates. High nitrate concentrations in drinking water are linked to health problems such as methemoglobinemia in infants, stomach cancer in adults (Wolfe and Patz, 2002).

Iron can get into drinking water from the use of iron coagulants or from corrosion of galvanized iron, steel and cast-iron pipes in the distribution system. Some surface waters also have iron problems, particularly related to colloidal iron. Excessive oral intake of iron has been shown to induce gastrointestinal distress including vomiting, diarrhea, and abdominal pain (Cook et al, 1990). The major disadvantage of the presence of iron in water is that it increases the hazard of pathogenic organisms because most of these organisms need iron to grow (Khan, 2001).

2.3.3 Water quality standards and guidelines

The World Health Organization (WHO) drinking water quality guidelines provide international norms on water quality and human health that are used as the basis for regulation and standard setting, in developing and developed countries worldwide. These guidelines are adopted by many countries as national guidelines to follow. These countries including Ethiopia set drinking water quality guidelines based on the WHO guidelines but may modify these based on what is achievable in the country.

Table 2-1 Maximum allowable concentrations of water quality parameters(water quality parameters for drinking purpose source (ES, 2002 and WHO, 2008))

Parameter		Unite	WHO Guideline	Ethiopia standard
Bacteriological parameters	EE.Coli/Total and thermo tolerant coliform bacteria	CFU	0/100ml	0/100ml
Physical parameters	Temperature	^{o}C	<15	
	Turbidity	NTU	5	7
	EC	µs/cm	1000	1500
	pH	pH	6.5-8.5	6.5-8.5
	TDS	mg/l	1000	1000
	Nitrate	mg/l	50	50
	Chloride	mg/l	250	250
chemical parameters	Fluoride	mg/l	1.5	3
	Total hardness ($CaCO_3$)	mg/l	300	300
	Iron	mg/l	0.3	0.4
	Magnesium	mg/l	50	50
	Phosphate	mg/l	0.005	0.02

In my study area, 36% of water supply schemes are not functional due to financial, social, environmental, technical and institutional and water quality problems. So that this thesis work is supposed to find techniques mechanisms and options to improve the sustainability of water points to identify the existing problems which are threatening the sustainability of water supply schemes and to evaluate water quality parameter at source.

3. MATERIALS AND METHODS

3.1 Area Description

3.1.1 Geographical location

Efrata Gidim Woreda is located in North Showa Zone of the Amhara Regional State. The Woreda is located 144 km from Debre Birhan and 275 km from Addis Ababa. This Woreda is located 10°, 30′ 50″ N-10°, 5′ 25″ N, latitude and 39°, 48′ 00″ E-39°, 59′ 20″ E longitude (from study area map). The Woreda covers 19 Kebele's including 16 rural and 3 urban.

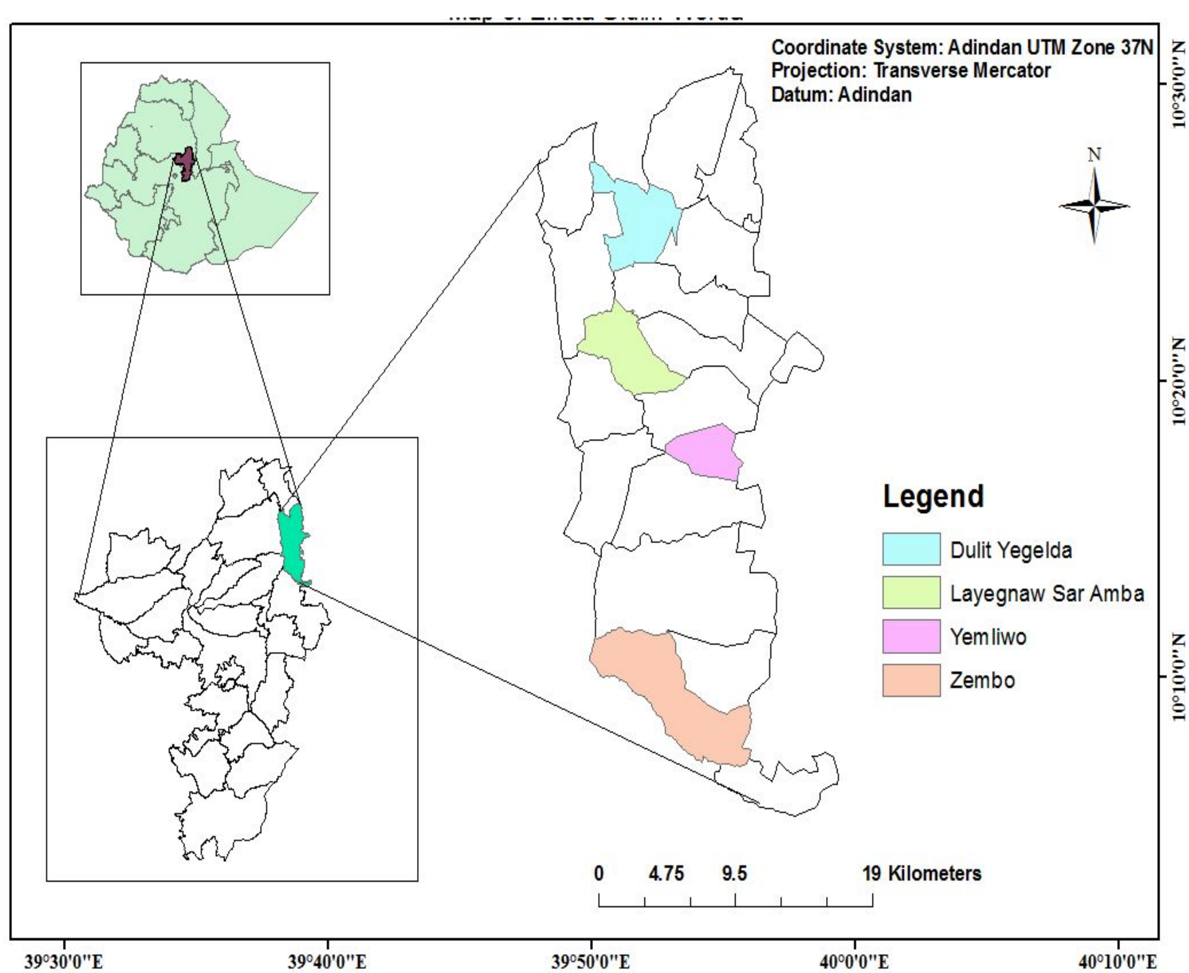

Figure 3.1 Location map of study area source (done by researcher, 2018)

3.1.2 Socio-economic and demography

Farming is the backbone of the economy of the study Woredas. It is estimated that 86% of the total income of the study area comes from agriculture (EGWAO, 2018). Most of the people derive their livelihood from this sector. The role of livestock in the study area is less important than that of crop farming. The data from the Woreda indicates springs (protected and unprotected), shallow wells, hand dug well and boreholes as the major sources of water for human and livestock consumption. The selection of schemes was conducted based on public compliant.

The Woreda has a total population of 136,667, of whom 68,923 are men and 67,744 are women; 109,937 or 80% are rural inhabitants (CSA, 2017). The total number of households are 21,067 with average family size of 6.5, which was computed by dividing the total number of people living in the Woreda by the number of total households. In the selected 4 Kebele, there was 3526 household's.

3.1.3 Topography and climate

The average altitude of the Woreda varies from 1465-2751 m.a.s.l and covers a total area of 516.8 square kilometer characterized by rugged terrain, covered with some indigenous trees, bushes and eucalyptus trees.

The most common used classification systems are the traditional and the agro-ecological Zones. According to the traditional classification system, this mainly relies on altitude and temperature; there are five climatic Zones namely: Wurch (cold climate at more than 3000 Mts. altitude), Dega (temperate like climate-highlands with 2500-3000 Mts.altitude), Woina Dega (warm at 1500-2500 Mts. altitude), Kola (hot and arid type, less than 1500m in altitude), and Berha (hot and hyper-arid type) climate (NMSA, 2017). According to the Ethiopian agro, climatic classification Efrata Gidim Woreda incorporates 22% Dega, 62% Woinadega and 16% Kolla (EGWAO, 2018).

The monthly rainfall distributions of the study area indicate that July and August are the wettest months of the year and January and December was the hottest month of the year as shown (Figure 3.2).

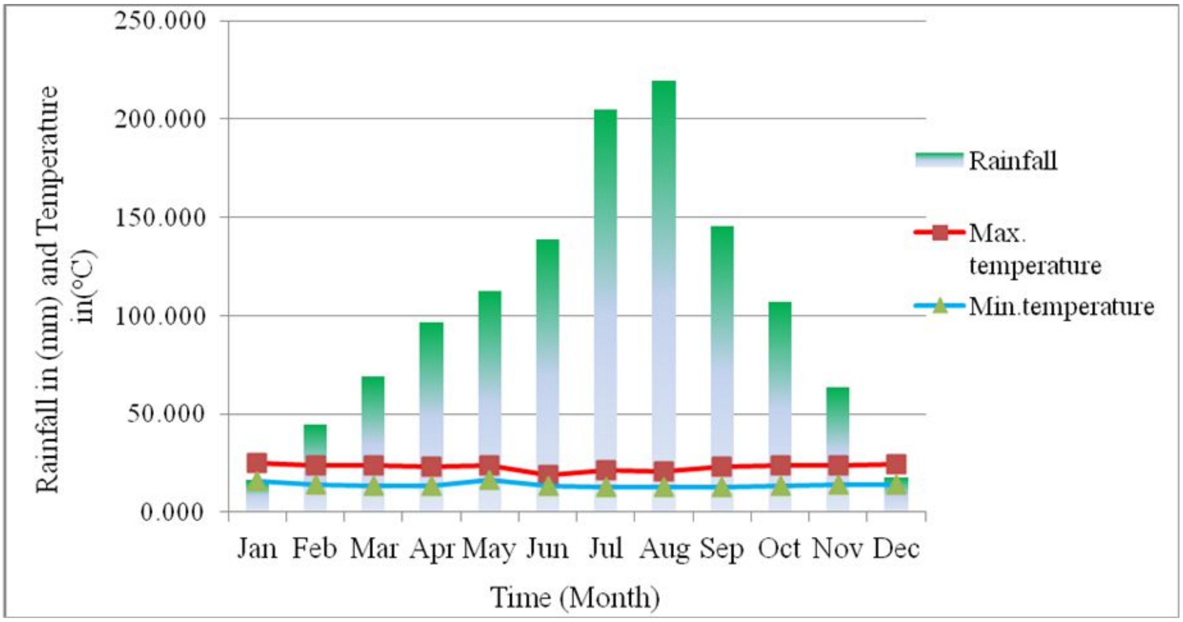

Figure 3.2 Mean annual rainfall, minimum and maximum temperature

3.2 Data Sources

To acquire the required information needed to meet the objectives of the study, Multiple data gathering instruments employed. The questionnaires were both close and open-ended questions. The close ended questions were meant to capture direct answers from the respondents, while the open ended questions were to arrive at relevant information that could not be obtained by the close ended questions. The questionnaires were supported by personal in depth interview and transect walk. Structured and unstructured interview, personal observation and document analysis were the principal means of gathering the data used in the study. The researcher supervised and managed the interview of the key informant. Interviewers were recruited and given short-term training, so that they would collect the primary data using structured questionnaires. The water source/points of the study area, the source/point of location were carried out using GPS and G.I.S software.

3.2.1 Primary data collection

Primary data were collected from the respondents by using household survey, key informant interviews(structured and unstructured interview) and personal observations of water supply in the study area.

Household survey:- For the evaluation of sustainability rural water supply systems, five indicators have been taken in to consideration according to Mukherjee and Wijk, (2003). These indicators mainly focused on technical, environmental, financial, social and institutional sustainability of water supply schemes. Technical factor (type of technology selection, construction quality, technician skill and availability, spare part supply and age of schemes). Environmental factor (distance, quality of water, quantity of water and reliability of source). Under social factor (participation, acceptance and satisfaction), financial factor (availability of fund, trust of committee, willingness to pay, operation and maintenance cost), institutional factor (capacity building, information transfer and implementing water policies), With the help of assistants physically administered the questionnaires to interview and pretesting was made before the data collection. Totally four research assistants were selected one for each Kebele to interview the public. The research assistants were selected based on four criteria a) acceptance b) previous involvement in administering interview, c) Understanding of the local language and d) College/university graduates. The researcher briefed them on the purpose and process of the research, guided them throughout the research process.

Key informants interviews:- Were carried out to collect background information on type of technology, construction quality, technician, spare part supply, age of schemes, reliability, quality of water, participation, source of fund, operation and maintenance, capacity building and information transfer of the study area. The interviews were held with selected individuals of three Worda and two Zone Water Office experts who were believed to have good knowledge about the subject matter and experience.

Personal observation and site visits:- It was employed to observe and record the status of water supply at water points. Photographs were part of the assessment instruments to pick up the status of different water supply schemes. Field observations using structured checklists and unstructured checklists administered. Observation can be used as a supportive or supplementary technique to collect data that may complement or set in perspective data obtained by other means. These were basically carried out at the water points and households of the locality. Data for the observation include mainly type of technology, construction quality of schemes (observable part of schemes: drainage, well taped, site selection, pipe installation, quality of gravel they use and protection of schemes(fence)), spare part availability at Kebele and Woreda store, how far is the schemes from residence of HHS, quality of water (observing its color, testing, smelling) and measuring the quantity of water. Protection, management and hygiene of schemes with regard to implementing water policies.

3.2.2 Secondary data collection

Secondary data collected from different data sources such as publications, research documents and reports of various organizations. A detailed literature review of the related documents on water supply system and its sustainability made. The purpose of the literature study was to see what have been done before and what the gaps were hitherto so that the researcher able to come up with theories, which used to make analytical generalizations of the empirical data to be collected. Document was reviewed at the Woreda, construction quality of schemes, year of construction of schemes, previous measurement of water quality, specification and bill of quantities was done.

Financial data analysis:- a simple calculation highlights the scale of the discrepancy of actual and theoretical be, let *Fa* be the amount that is actually in the Maintenance Fund, and *Ft* be the amount that should theoretically be in there - based on the number of households using the water point (*h*), the frequency of payments (*f*), the size of payments (*p*), the age of the water point (*y*), and the amount expended so far on maintenance and repairs (*m*))(Equation 3.1).

$$Ft = (p*f*h*y)-m \tag{3.1}$$

3.3 Sampling Techniques

For this study, from the 16 rural Kebele administrations in Efrata Gidim Woreda, due to budget and time constraint 25% from the total Kebeles of the Woreda were selected by using purposive and proportionate based climatic zonation for sustainability of water supply schemes.

Efrata Gidim Woreda has three agro-climatic Zones from which 22% was “Kolla”, 62% was “Woinadega” and 16 % was “Dega.” One sample Kebele were selected proportionally from “Kolla” agro-climatic Zone, two-sample Kebeles was selected from Woindega whilst the remaining one Kebele was selected purposive and proportionate based climatic zonation as shown Figure (3.3).

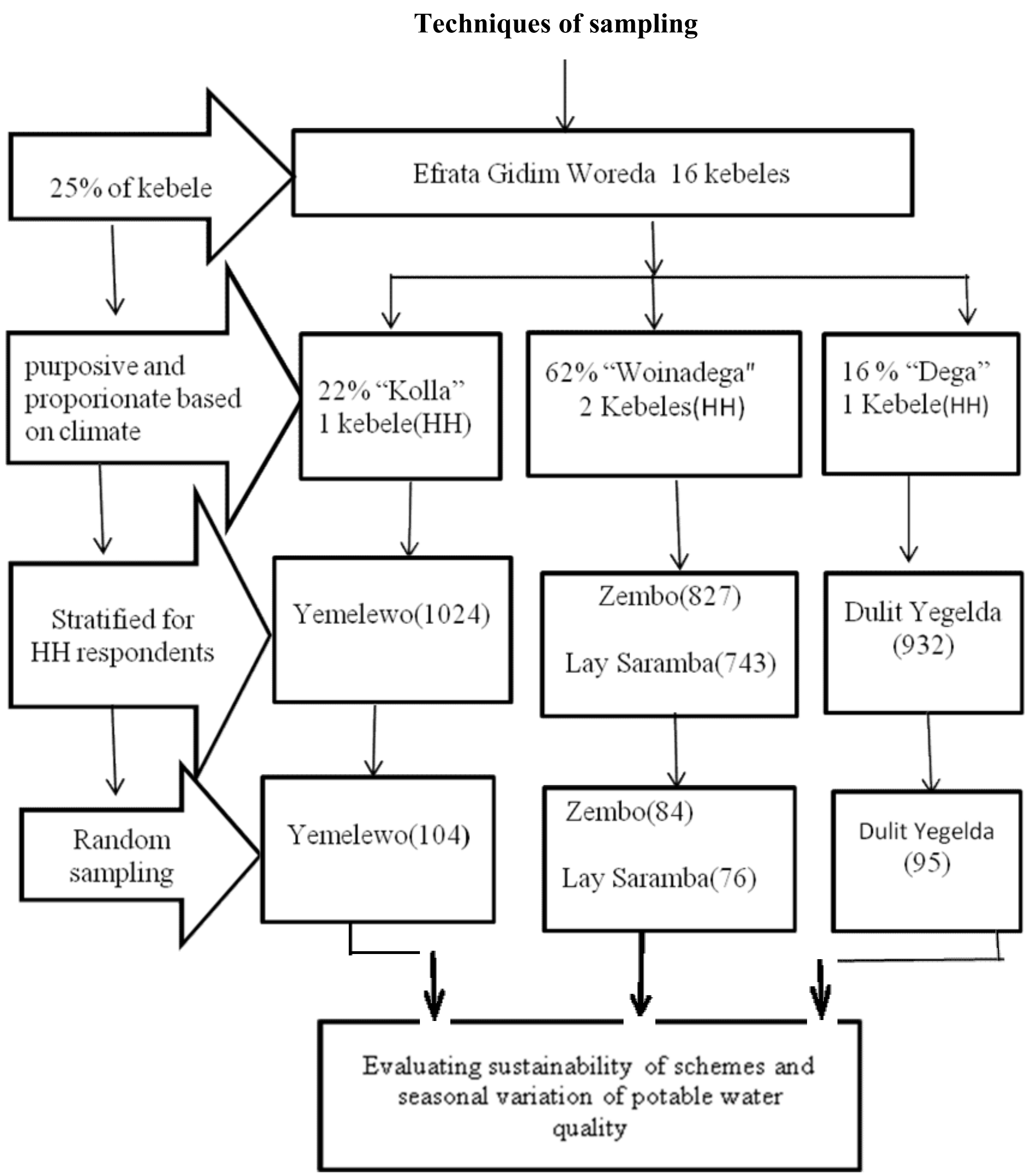

Figure 3.3 Schematic presentation of sampling design

3.3.1 Sample size determination

Beneficiaries were the main primary data sources in this study. In order to ensure the generalization of the finding to larger population, the study considered adequate sample respondent for selection through appropriate techniques. The number of sample HHs was determined by using the formula developed by (Yamane, 1967).

Sample household's was computed using (Equation 3.2).

$$n = \frac{N}{1 + N(e^2)} \qquad (3.2)$$

Where :-

n is the sample size,

N is the population size,

e is the level of precision(0.05).

$$n = \frac{3526}{1 + 3526(0.05^2)} = 359$$

Proportion of sample in each Kebele was computed using (Equation 3.3).

$$P_i = \frac{N_i}{N} \qquad (3.3)$$

Where: P_i = Population index

N_i = HHs in each Kebele,

N = Total HHs of 4 Kebele

Number of sample in each Kebele was computed using (Equation 3.4).

$$n_i = P_i * n \qquad (3.4)$$

Where n_i = Sample size of each Kebele,

P_i = Population index

n = is the total sample size of 4 Kebele

Accordingly, the sample size (n) of the study was 359. The total 359 households (HH) were selected from four Kebeles as sample populations developed by Yemane (1967) for primary data source were distributed to each Kebeles proportionally. Since all research methods have their own advantage and disadvantages, it is a common practice to try to reduce the disadvantages as much as possible by incorporating method of triangulation in order to fill the gaps of employed research methods.

Table 3.1 Total number of sample HHs for target area

No.	Kebele	Village	Total HHs	Sampled HHS
1	Dulit Yegelda	Azaji Amba Tach Woyera Lay Woyera Dahana	932	95
2	Zembo	Zembaba Guluwuha	827	84
3	Lay Saramba	Addise Amba Goshber Tunsha Amba	743	76
4	Yemelewo	Muzanba Menter Wuha Yemelewa	1024	104
		Total	3526	359

3.4 Inventory Survey

Before starting data, collection inventory survey was done in the study area using field observation, transect walk and measurement, which is used to list out the types, number and comparing design discharge vs. actual discharge of water supply schemes in the study area. Measurement of actaual discharge was done using bucket and stopwatch were used to measure actual discharge of schemes in the study area and the discharge was computed using (Equation 3.5).

$$Q = \frac{VB}{TTB} \qquad (3.5)$$

Where, Q = discharge of schemes

VB = volume of container

TTB = time taken to fill container

The discharge of river were measured using float method. The measured actual discharge was used to calculate the supply of water from water source in liter/day.

3.4.1 Water supply in Efrata Gidim Woreda

As indicated by the Woreda and Zonal water Office, there is a huge ground and surface water potential in the Woreda. Despite the ground water supply potential of the Woreda, it is not possible to construct enough water schemes in all Kebeles. Even in Kebeles where there are improved water schemes, the water supply is not adequate for all, and the functioning schemes themselves are not providing reliable and adequate services for different reasons to respective communities. In Efrata Gidim Woreda; 36% of water schemes are non-functional, 75% of schemes cannot cover operation, maintenance costs, 84% of the scheme catchments were poorly managed, 85% of schemes does not give the design discharge and 46% of schemes were far from 1kilometer from residence of HHs (EGWWMO, 2018).

Table 3.2 Existing water supply schemes in Efrata Gidim Woreda.

Water Supply schemes	On-spot spring	Spring with distribution	Shallow well	Hand dug well	Borehole	Others
No	44	4	21	15	4	5

(Source; EGWWMO, 2018)

3.4.2 Domestic water demand

Water use in the house for different use. The domestic use include water requirement for drinking, cooking, bathing, washing of clothes, utensils and house, and flushing of water closest. Therefore, the daily domestic water demand (DWD) is calculated by adopting the percapiuta water consumption recommended for rural communities is 25L/c/d (WHO, 2012)(equation 3.6)

$$DWD = Pn*AWD \qquad (3.6)$$

Where, DWD = domestic water demand

Pn = population at n year

AWD = average percapita domestic water demand

3.5 Model Specification to Identify Determinants of Technical and Biophysical Schemes Sustainability

In this study, econometric model analysis was used to estimate relationship among technical, environmental factor and sustainability of schemes. Explanatory variables include selected technical and biophysical factors that were assumed to influence sustainability of water supply schemes in the study area. Changes in the dependent variables are explained by reference to changes in the explanatory variables. The response of technical and biophysical sustainability of water supply schemes of each sampled household was used as the dependent variable. The sustainability technical and biophysical of water supply schemes determinants have been done following the regression techniques in linear form. Because a linear regression model is different from the logistic regression model is that the outcome variable in linear regression is continuous. Multiple regression analysis is more amenable, because it allows us to explicitly control for many other factors, which simultaneously affect the dependent variable. Furthermore, multiple regression models can accommodate many explanatory variables that may be correlated (Gujarati, 2004).

3.5.1 Multiple linear regression analysis

Multiple Linear Regression (MLR) analysis was a statistical procedure that was used to examine more closely the relationship between a number of independent (explanatory) variables and the dependent (response) variable by fitting a linear (in the parameters) equation to observed data.

The goal of MLR is to find an equation that can predict the dependent variable as a function of several independent variables (Coelho-Barros et al., 2008). The MLR equation, given by (Euation 3.7).

$$Y_i - B_0 + B_1 X_{1i} + B_2 X_{2i} + \dots + B_K X_{Ki} + \in i \qquad (3.7)$$

Where, y is the dependent variable (sustainability of water supply schemes). x_1, x_2, …..x_k are the independent variables (age of water supply schemes, technician of water supply schemes, spare part supply, type of technology selection, construction quality , distance to the scheme, quantity of water use, reliability of water source and water quality of schemes). *i* index the n sample observations. β_0 is the y intercept (the value of y when all of the explanatory variables x_1, x_2..., x_k are equal to zero). β_1, β_2, …, β_k are the estimated multiple regression coefficients (each regression coefficient represents the change in the dependent variable relative to a unit change in the respective independent variable) and the term ε is a random error term (Gujarati, 2004). The existence of multicolinearity problems was checked before entering the selected variables in to the model in terms of variance inflation factor (VIF) for continuous and contingency coefficient for dummy and discrete variables, respectively. The reason for this is that the existence of multicolinearity affects seriously the parameters estimated. The reason for choosing the multi linear regression, the dependant variable was more than two responses (strongly-disagree, disagree, neither agree nor disagree, agree and strongly agree). The independent variables have continuous data (water use per household, distance from residential and age of schemes) whereas, Technician of water supply schemes, spare part supply, type of technology selection, construction quality, reliability of water supply and water quality of schemes have more than two response.

3.5.2 Dependent variable (technical and biophysical) sustainability of schemes

The dependent variable, sustainability of water supply schemes, was obtained by asking the water supply schemes sustainable. It is hypothesized to be a function of the likert scale.

3.5.3 Independent variables (technical and biophysical) sustainability of schemes

A. Technical factors

Type of technology selection: - Inappropriate choice of technology and/or poor scheme design can threaten sustainability (Bhandari and Grant 2007). Poor choice or design may be due to ignorance (either on the part of contractors, and/or by users, if they play a major role in system choice) or sometimes incentives (e.g. if installers are offered bribes by suppliers to select a particular technical option).

Construction quality: - Construction quality is one of the most important factors influencing sustainability of water supply systems (Sara and Katz, 1997), yet this is often hard to quantify. It is in turn affected both by the availability of resources and the quality of supervision. However, many projects rely on unskilled 'supervision' by community members, or very sporadic site visits by district government staff.

Technician for operation and maintenance: Well-trained and skilled technicians were needed to preventive maintenance work, replacement of worn out parts and maintain breakage.

Spare part supply: - The measure of supply of required spare parts and services for smooth maintenance of the scheme. Lack of spare parts supply has significantly contributed to the failure of the scheme.

Age of schemes: - As the age of schemes increase the functionality of water supply schemes reduced.

B. Environmental factors

Distance of schemes:- Used to estimate how the water points/sources are spatially distributed in the study area. Their should be at least 25 liters of water per person per day from an improved water source within a distance of 1 kilometer.

Reliability of water source:- Reliable water source is the one, which gives quantity of water throughout the year with the design discharge. Reliability is significant factor on sustainability of water supply schemes.

Water quality:- Is a measure of the condition of water relative to the requirements of one or more biotic species and to any human need or purpose and it is most frequently used by reference to a set of standards against which compliance can be assessed.

Quantity of water use : - Refers to the volume of water required on individual bases for the various daily household purposes. Quantity of water to be provided in rural water supply schemes of 25 liters per capita per day (LPCD) (UNICEF and WHO, 2012).

3.6 Model Specification Determinants of Socio-Economic and Institutional Schemes Sustainability

Since the study aims at assessing socio-economic and institutional factor influencing the sustainability of rural water supply scheme it can be modeled using logistic regression model.

Logistic regression can be used to model data where the response variable is binary, a factor variable with two levels. For example, a variable Y with two categories `yes' / `no' or `good' / `bad'. In this case, it represents the sustainability of rural water supply scheme specific to types of schemes presented in the study area in such a way that sustainable is equivalent to 'yes' and not sustainable is equivalent to 'no' to make the model more specific to the sustainability status of source it represents the probability of a particular source status as 'sustainable' or 'not-sustainable' when a field visit is conducted by the researcher.

The model calculates the probability of an outcome at time t, P (Y_t = (sustainable) and P (Y_t = not-sustainable) = 1- P(Y = sustainable) given some regression variables X1, $X_{2\ldots}$Xk as follows: logistic regression (Equation 3.8).

$$P(Yi = \text{sustainable}) = \frac{\exp\left(a_0 + a_1X_1 + a_2X_2 \ldots \ldots akXk\right)}{1 + \exp\left(a_0 + a_1X_1 + a_2X_2 \ldots \ldots akXk\right)} \qquad (3.8)$$

Where:

The regression coeffects $\alpha_0 + \alpha_1 + \ldots \alpha k$ are model parameters, which are estimated with a data set.

$X_1 + X_2 + ...Xk$ independent regression variables of the regression model.

Y_i is the response (dependent) variable for ith scheme – a factor variable with two levels

The reason for choosing logistic regression model was dependent variable have two responses that are sustainable or not sustainable and the independent responses were binary variable.

3.6.1 Dependent variable for socio-economic and institutional schemes sustainability

The dependent variable, socio-economic and institutional sustainability of water supply schemes, was obtained by asking the socio-economic and institutional sustainability of water supply schemes.

3.6.2 Independent variables for socio-economic and institutional indicator of schemes sustainability

The study involves both dependent and independent variable and these variables are defined and their expected relationships are explained in the table below.

Table 3.3 List of independent variable

Variable name	Variable definition	Variable relationships
Social factor	Social sustainability is binary response Variable which measures the sustainability of rural water supply schemes	The study hypothesizes that social sustainability of rural water supply scheme is a function of acceptance, satisfaction and participation (site selection design and construction).
X_1 – Participation	Participation of society on the construction of water supply schemes.	The study suspects significant relationship between acceptance and participation
X_2 – Acceptance	Acceptance of society accepting the construction of schemes and installed schemes	Accepting the construction and installed schemes have significance effect on the sustainability of schemes
X_3 – Satisfaction	Water user satisfied with the quality, quantity and operation and maintenance of water schemes	Satisfaction have significant effect on the sustainability of water supply schemes
Financial factor	Financial sustainability is binary response Variable which measures the sustainability of rural water supply scheme	The study hypothesizes that financial sustainability of rural water supply scheme is a function of source of fund, willingness to pay, trust of water committee and operation and maintenance cost

X_4 – Source of fund	Source finance is needed to pay for spare parts, caretaker and skilled people to keep water points	Source of fund have significant effect on the sustainability of schemes
X_5– Trust	Firm belief of representative water committee on payment fee of water	This has significance effect on the sustainability of water supply schemes
X_6 – Willingness to pay	Prepared to pay fee of water	Willingness to pay have significant effect on the sustainability of schemes
X_7– operation and maintenance cost	The amount of money paid for operation and maintenance cost	The study suspects significant relationship between saved money per scheme and operation and maintenance cost
Institutional factor	Institutional sustainability is binary response Variable which measures the sustainability of rural water supply scheme	The study hypothesizes that institutional sustainability of rural water supply scheme is a function of capacity building, information transfer and implementing water policies
X_8 – Capacity building	Capacity building on the utilization, operation and maintenance of water supply schemes.	Capacity building have significance effect on the sustainability of schemes
X_9–Information transfer	The transmission of information between user community and serves agent.	This has significance effect on the sustainability of water supply schemes
X_{10}-Implementing water policy	Implementing the activities to safe and sustainable use of water.	This has significance effect on the sustainability of water supply schemes

3 0

3.7 Water Quality Assessment

3.7.1 Sample size for water quality analysis

Seasonal variation of water quality analysis is very important to evaluate the water quality. To analyze selected physico-chemical and bacteriological parameters eight major functional water supply schemes were selected based on the public compliant on the water quality from four sampled Kebeles. Seasonal water quality analysis during the wet month of August 8 samples and dry month of January 8 samples were collected from the same water points. Coordinates of each sampling point were taken using a GPS device. All the analyzed laboratory result compared with the Ethiopian standards and WHO guideline for drinking water quality and interpreted in accordance with the result obtained.

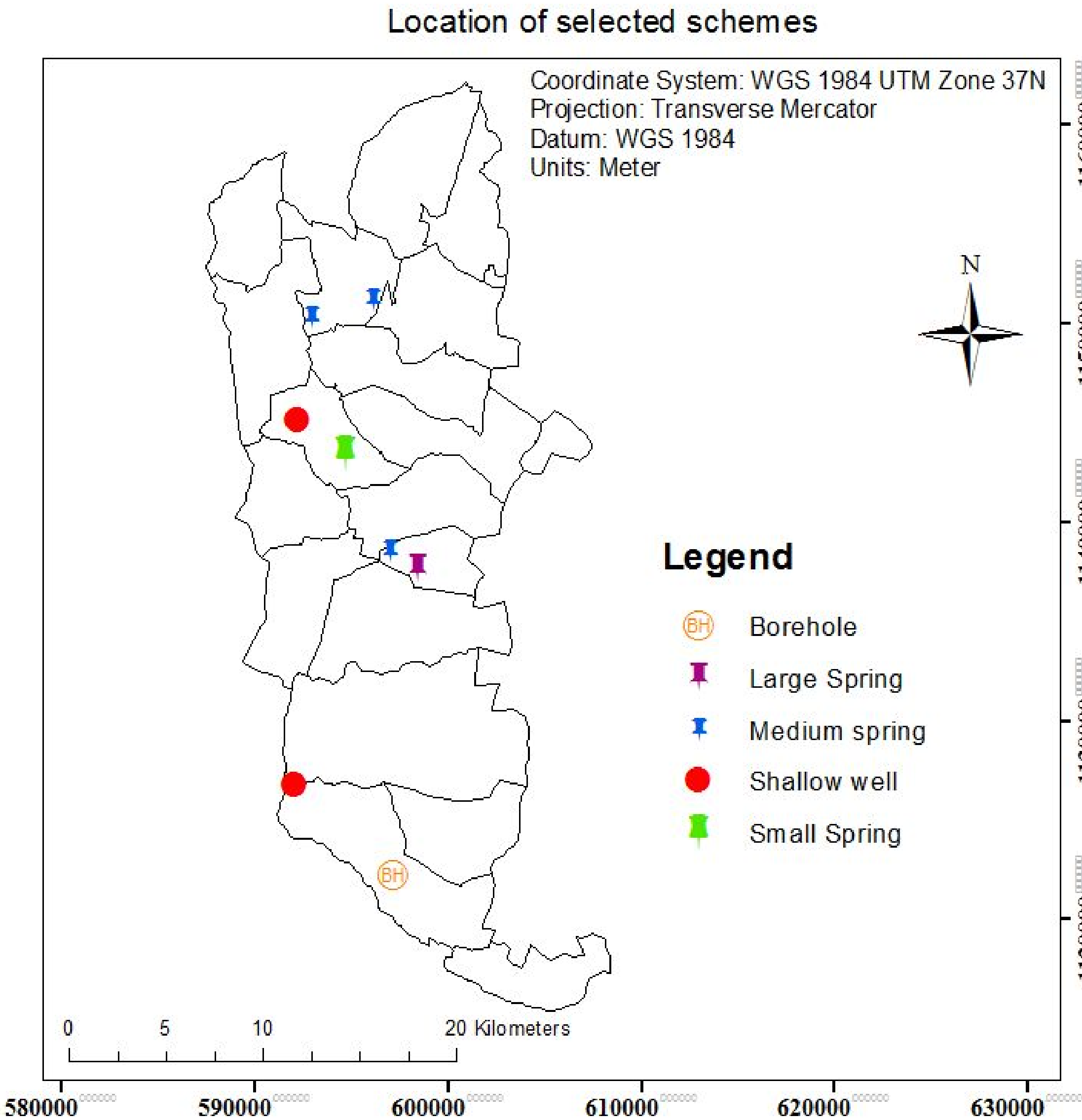

Figure 3.4 Water source map of study area(source done by researcher, 2018)

Table 3.4 Sampled water supply schemes for quality analysis

S. No	Sample Kebele	Existing water supply schemes	Sampled Water supply schemes	Total water supply schemes
1	Zembo	1 Shallow well	1 Shallow well	2
		1 Borehole	1 Borehole	
		1 Small spring		
2	Yemelewo	1 River		
		1 On-spot spring (un-protected)		
		1 Large spring	1 Large spring	2
		1 Medium spring	1 Medium spring	
3	Lay Saramba	1 On-spot spring (un-protected)		
		1 Shallow well	1 Shallow well	2
		1 Small spring	1 Small spring	
4	Dulit Yegelda	2 Medium spring	1 Medium spring	2
		1 Spring with Distribution	1 Medium spring	
		1 Shallow well		
	Total		8 Water supply sample were taken	

3.7.2 Water sampling procedure

Sampling and Analysis Plan were prepared which describes the sample locations, numbers and types of samples to be collected, date and time. The laboratory was checked to ensure that sampling equipment, preservatives, and procedures for sample collection are acceptable. Water sampling and preservation techniques followed the standard methods of water sampling and preservation techniques (APHA, 1998; Hutton, 1996). Before collection, bottles were washed with concentrated nitric acid and distilled water to avoid contamination. Samples were collected in 1000ml polyethylene plastic bottles for different parameters from sampled water supply schemes. The water samples were handled aseptically in sterile glass bottles, labeled and kept in an ice-box during transportation to the laboratory of school of Bio-System and Environmental

Engineering Hawassa University for chemical quality analysis, Efrata Gidim Woreda Water Management Office for bacteriological quality analysis. Bottles were preserved using icebox and a water samples from sampled sites of the study area were taken and studied for the selected physicochemical and bacteriological parameters. The water samples analyzed for both physicochemical and bacteriological parameters were listed in Table (3.5)

Table 3.5 Major physicochemical and bacteriological parameters for the sampled water

S.No	Physicochemical parameters	Bacteriological parameters
1	Temperature	
2	pH	E.coli/ Total and Thermotolerant coliform bacteria
3	Electrical conductivity	
4	Turbidity	
5	Total hardness	
6	Nitrate	
7	chloride	
8	Fluoride	
9	Iron	
10	Phosphate	
11	Total dissolved solids	
12	Magnesium	

3.8 Method of Water Quality Analysis and Instruments

3.8.1 Analysis of bacteriological parameters

Bacteriological analysis (E.coli) was carried out to evaluate through the presence and the abundance of total coliforms (TC) this indicator the risk of other pathogens presence in the water. The procedures include from sterilizing, media preparation, membrane filtration to incubation of the membranes on selective media. Sample was analyzed using membrane filtration method for water quality to determine the degree of contamination (WHO, 2008; APHA, 1998).

Samples were collected from the site following the standard of collection. After that sterilize the Petri dish, WagTech membrane filtration equipment using by dropping alcohol on the cotton by using forceps, preparing 10ml of media using distilled water and five cup of lauryl sulphate broth, put the pad on the Petri dish and saturate it using the media. Three samples from each site were mixed into one and the composite samples were mixed thoroughly by shaking and filtered under laboratory hood, using WagTech membrane filtration apparatus and membranes, pore size 0.45µm, 47mm diameter. The membranes then transferred aseptically to saturated pad of Petri dishes. Prepared culture dishes were inverted and the incubator was calibrated at 37°C. Upon completion of the incubation period (24 hour) typical Yellow Colonies were seen, which are characteristic of total coliform on the surface of membrane filter then counted using a low power binocular wide field-dissecting microscope, with a cool white fluorescent light. The faecale coliform measurement follow similar procedure except incubator calibrated at 44 °C.

3.8.2 Analysis of physico-chemical parameters

On-site analyses of pH, temperature, TDS, conductivity and turbidity were carried out at the site of sample collection following the standard of measurement. Measuring steps of 3 In1 function digital TDS EC meter temperature tester pen conductivity water quality measurement tools, Press ON/OFF button then value of each sample was taken after submerging it into the water/solution height upto 4cm from the beginning of TDS meter. Waiting until the display stabilizes, the TDS meter automatically compensates for temperature variations once the readout is stabilized (30-45 seconds).TDS value stabillizes 4 seconds. After usage, shake off water from your meter or wipe it with a tissue and probe was rinsed with distilled water to avoid cross contamination among different samples.

pH meter: The pH of the water sample was measured by using pH meter (pH-200, Model SP-P2). The pH meter was digital automatic calibrated to (pH 4.0, 7.0 and 10.0) and it has automatic temperature compensation. Before taking the measurements, the value of each sample was taken after submerging the PH probe in the water sample and holding for a couple of minute to achieve a stabilized reading. After the measurement of each sample, probe was rinsed with distilled water to avoid cross contamination among different samples.

Turbidity tube: It is very important to measure the turbidity of domestic water supplies, as these supplies often undergo some type of water treatment which can be affected by turbidity. Turbidity can be measured using either an electronic turbidity meter or a turbidity tube. Steps to measure turbidity, making sure that they fit squarely, took a sample of water from the water source. Hold the tube in one hand near the bottom and look into the open end with your head about 10 to 20 centimetres above the tube, so that you can clearly see the black circle, cross or other murk on the bottom of the tube. Slowly pour the water sample into the tube, waiting for air bubbles to rise, until the mark on the bottom of the tube just disappears. Stop pouring the water sample into the tube and look at the level of water in the tube, for turbidity tubes scale marked on the side, read the number on the nearest line to the water level. That was the turbidity of the water. After use, wash the tube in clean water and store the two parts of the tube where they cannot be damaged. Their measurements were taken immediately after the samples were collected on each site.

Laboratory analysis of magnesium, total hardness, chloride, Fluoride, nitrate, phosphate and Iron were done. For instance, magnesium, total hardness, chloride and Fluoride was determined by photometric measurements by adjusting the wavelength (580 µm) of paqualab photometer and keeping their reaction periods and analytical reagents analyzed by using their respective standards. Nitrate and phosphate were measured by photometric measurements by adjusting the wavelength (560 µm) of paqualab photometer, keeping their reaction periods and analytical reagents were analyzed and Iron was determined by adjusting wavelength (520 µm) of paqualab photometer by following standard methods (APHA, 1998) and using a standard laboratory setup. All chemicals and reagents that were used for this analysis were analytical grade. Equipment cleaned and sterilized thoroughly before each use to avoid secondary contamination and ensure accurate results.

Table 3.6 Instrument used to measure bacteriological and physico-chemical test

No.	Parameters	Instruments used to measure
1	E.Colli(TC and FC)	Wagtech Potatest Water Quality Kit
2	pH	pH-meter(pH-200, Model SP-P_2
3	TDS, EC and T	Digital 3in1 tester LCD TDS, EC meter and Temperature Pen (Model = YT-TDS2-A)
4	Chemical elements	Paqualab Photometer

3.9 Methods of Data Analysis

After gathering the data, relevant statistical methods of analysis were used in order to come up with the appropriate result. The results are presented in both quantitative and qualitative terms. The SPSS version 20 and statistical tools like arithmetic mean, minimum, maximum, standard deviation, percentages, tables, maps, bar graphs and explanation building descriptive and statistical methods were used to analyze findings. After computing the descriptive statistics, multiple linear regression models and logit model were employed to identify the statistically significant sustainability of water supply schemes determinant variables in the study area and associations of the variables respectively.

Results of water quality analysis from the source of dry and wet season variation were compared against standards set by Ethiopian standards (2002) and WHO (2008). Moreover, ANOVA was used to determine the significant differences in the mean values of the water quality parameters at the various sampled sites at $p<0.05$ significant level.

3.10 Ethical Consideration

Before conducting the data collection activity, the researcher was informed the research purpose and convince the concerned bodies. Thus, collection of data was undertaken after obtaining permission from the concerned offices. With regard to data collection at the household level, study objectives was clearly explained to the household. Each household has been told that the information provided would be confidential and used only for the research purpose.

4. RESULTS AND DISCUSSION

4.1 Water Point Characterization and Their Current Status

In efrata gidium woreda their was 93 water supply schemes from thise 44(47.3%) was spring and 21(22.6) was shallow wells while the rest (30%) was others. hand dug well equipped with hand-pumps, collection tanks, stand posts and protected springs where characterized under micro schemes while gravity schemes or point sources with collection tanks supplying more than four communal standpipes characterized under macro schemes (GOS, 2003). Springs, shallow wells and boreholes were the main source of water for household used in the study area where the schemes are functional. When the protected springs, shallow well and boreholes were not functional: unprotected springs, rivers, hand dug wells and ponds were mentioned as alternative sources of water used by the respondents. This is the main problem in Kebeles where the sources/water points were not functional or when the sources/points get unpredictable in dry (Jan–December) time. The working hours of the sources/water points fall during this period and ease of use of water is erratic. These Kebeles confront water scarcity due to non-functionality or abnormality of existing water supply schemes especially in Zembo and Lay Saraba Kebeles. The normal maintenance period for a water facility as recommended by MoWR (2007) is 2 to 3 days. Acourding to response of water point committee long maintenance period observed to be in excess of 5 months during the study period might contribute to the non-reliability of water services in the study area. Observation and field visit result showed that most of the water points are not neat at all as demonstrated by poor drainage and water stagnation, bad smell and in some of the sources by the presence of livestock waste. Some of them have functional guards. Catchments rehabilitation with the aim of increasing ground water recharge was done around the surroundings of only 23(24.7%) of the water points and 17(25%) have animal troughs.

As far as water supply services are concerned, some development activities has been done by Zonal, Woreda water resources office and NGOs to alleviate the problem of potable water in the Woreda. However, the problem of potable water supply is still very sounding in the Woreda. In addition to this the existing water supply schemes are characterized by very low service coverage, limited service over the day from public distribution points, poor operation and maintenance as specified by key personnel and site observation.

4.1.1 Current status of water supply schemes in the selected kebele

As shown in the figure 4.1, Interims of number of schemes in the study area on-spot spring accounts the highest number and river and borehole accounts the lowest number. From the total water source 52.63% of the study area were on-spot spring (protected and un-protected spring) and the rest 47.37% of them were shallow well, Borehole, spring with distribution and rivers.

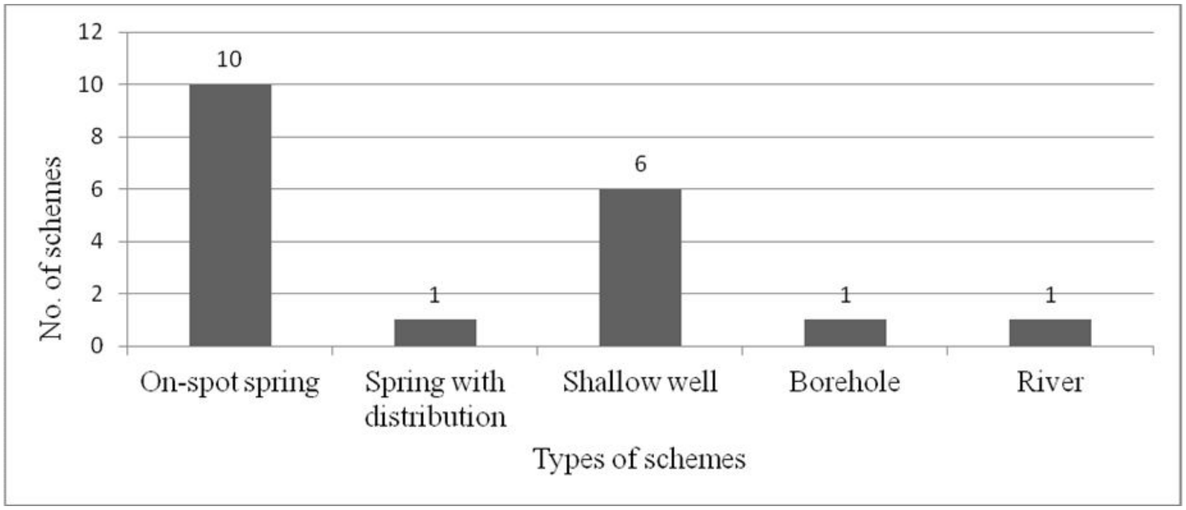

Figure 4.1 Types and numbers of schemes in the study area

As shown in figure 4.2 intermes of number of user, 60% of the study area uses from on-spot spring (protected and un-protected spring) and the rest 40% of them uses from SW, Borehole, spring with distribution system and rivers.

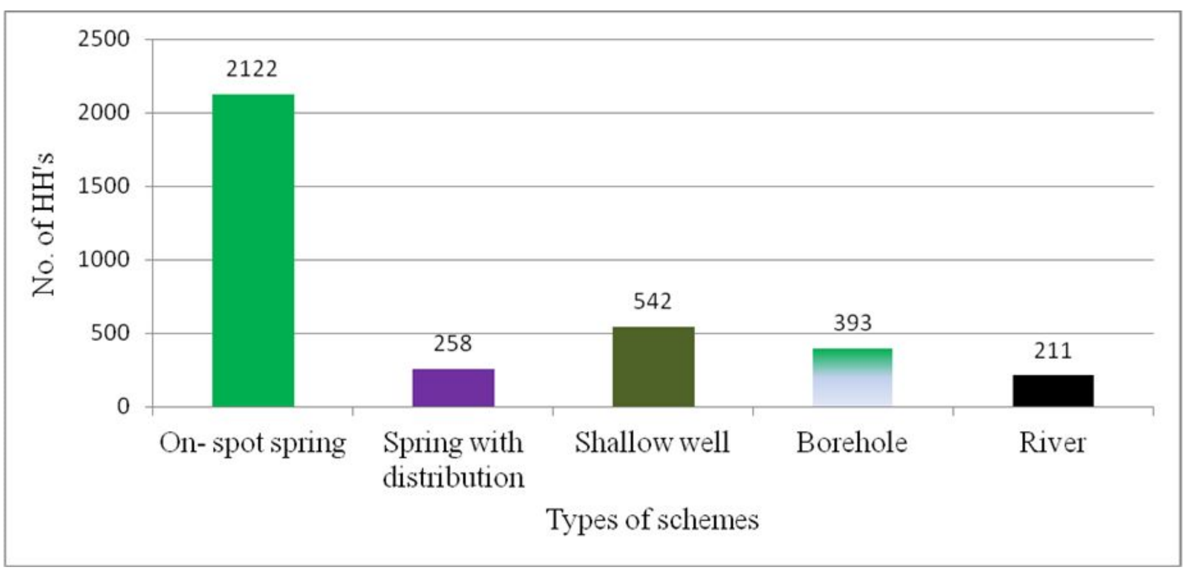

Figure 4.2 Number of users per schemes

4.1.2 Functionality status, domestic water demand and supply

Out of the (8) improved springs, 37.5% of them were semi-functional due to problem of spring development, clogging of spout, operation and maintenance whereas, the rest 25% not functional due to operation, maintenance and lowering of water table. Out of the (6) number of shallow well 50% were non-functional due to small depth of excavation, break of U-seal (part of cylinder) maintenance problem, where as 50% of them were functional which need day to day follow up.

Water use in the house for different use. The domestic use include water requirement for drinking, cooking, bathing, washing of clothes, utensils and house, and flushing of water closest. Therefore, the daily domestic water demand (DWD) is calculated by adopting the percapiuta water consumption recommended for rural communities is 25L/c/d (WHO, 2012). The measured actual discharge was used to calculate the supply of water from water source in liter/s.

Table 4.1 Yield of water supply schemes

Kebele Name	Name of schemes	Yield of source l/s
Yemelewo	Muzanba LS	1.112
Yemelewo	Yemelew Wuha MS	0.23
Zembo	Feredo Wuha SW	0.11
Zembo	Guadegudi B.H	0.12
Zembo	Eselam Wadiate SS	0.13
Dulite Yegelda	Shola Wuha MS	0.21
Dulite Yegelda	Belese Sayesh SS	0.17
Dulite Yegelda	Yegeleda Eyesuse SW	0.145
Dulite Yegelda	Emaye Wuha MS	0.24
Lay Saramba	Stede Wuha SW	0.09
Yemelewo	Meter Wuha SS	0.05
Lay Saramba	Deyare SW	0.07
Lay Saraba	lome wuha spring	0.002
Lay Saramba	ezegeye wuha spring	0.003
Yemelewo	lalo river	1.5
Total yield of source	2,880 L/day	

The water demand of the study area; DWD = 25L/c/d *22,919

= 572,975 L/d or 572.975 m^3/d

The yield of water supply schemes in the study area was 2.880 m^3 /day, therefore the deficite of water supply in the study area was 570.095 m^3/d at the year of 2017. the production of woreda water supply are generally insufficient and there is difference between water supply and domestic demand.

As shown in figure 4.3, None of the improved water supply schemes were not supplying the design discharge due to problem of spring development, clogging of the spout, inappropriate pipe installation, poor quality gravel selection, low protection, gap of Woreda expert follow up, break of U-seal, depth of excavation and maintenance from my observation.

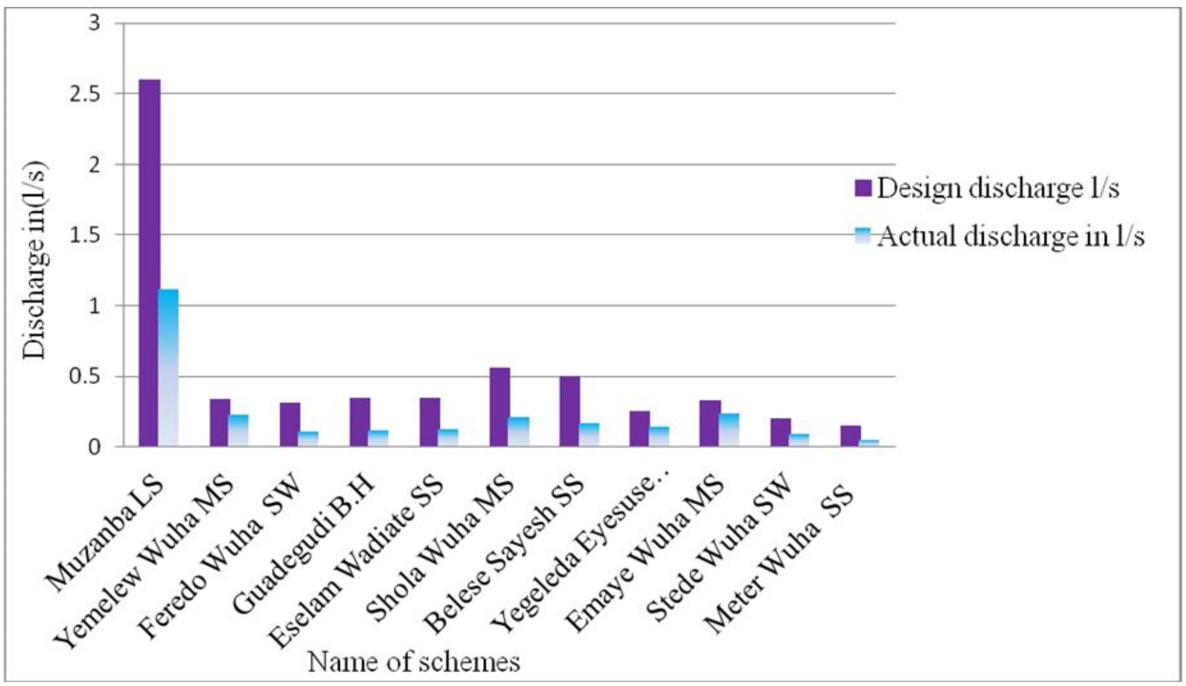

Figure 4.3 Design discharge vs. Actual discharge of dry season.

4.2 Technical and Biophysical Factors on Schemes Sustainability

4.2.1 Technology selection

Technology selection is one of the very important elements in the sustainability of rural water supply schemes. There are so many types of technologies practicing in different areas in the world in different purposes and for different activities. With regard to rural water supply schemes, in the study area, there were almost similar technologies selected by different organizations including governmental, non-governmental, community based Organizations, and communities depending on different factors such as financial (economic). In the study area, according to key informant interview made with Woreda, Zonal Water, Mine and Energy Departments emphasized that shallow wells fitted with hand pumps are the most practical technology in the rural area, this is because, the area is not feasible for hand dug wells even in some Kebeles shallow wells are not feasible, and financial viability is the great problem to select others technology except shallow wells. In some cases spring developments with network distribution when there is a fund from different non-organizations. This technology needs much money for construction and distribution which need much investment. These are some of the ideas from the key informant interview indifferent level of water offices. But these technologies may or may not easily be operatable and manageable by the user communities in the study area. If technologies are not easily operatable within the user communities, the schemes could not be functional for longer time. This was because; their acceptance had great effect on the sustainability of rural water supply schemes.

The survey result shows that for question. "do you agree that the community are selecting technologies for water supply schemes?", 4.2% of the respondents said, "Strongly disagree", 57.9% of them said, "Disagree‟, 5.3% of them said, "Neither agree nor disagree ‟, 27.9% of them said, "Agree‟, and only 4.7% of the respondents said, "Strongly agree". In general, 62.1% of the respondents not selecting technologies for water supply schemes this is critical factor for the sustainability of water supply schemes.

The suitability of the technology is in question as the key informant interviews. Since they were selecting not due to suitability but due to supplying the community with water. They said that they had financial problem for developing boreholes with network distribution that made them to select shallow wells with hand pumps that need lesser hand pump which need much energy to fetch and not easy to operate. The extra deep pump shallow wells encounter repeat breakage which need operation and maintenance many times. But, for spring development with network distribution both the beneficiaries and the government officials were happy or agree except fuel problem for generator. If there is enough capital the technology should be borehole with electricity power and spring developments.

4.2.2 Construction quality

Construction quality plays a great role in water supply schemes sustainability. If this is not practical i.e. the absence of necessary materials, construction and design problem, in adequate follow up during construction, poor quality of head work, poor pipe installation, lack of diversion ditch and animal fence affect the construction quality of the schemes. During observation made on some of developed water points, there construction qualities were poor. For example, pipe installation, setting of spout and drainage ditches were not constructed according to the right standard.

It may be a dangerous for people when a facility breaks down and cannot be repaired because of a fault in the design and construction. The survey result revealed that, 3.2% of the respondents said "strongly disagree", 49.9% of them said "disagree‟, 5% of them said "neither agree nor disagree ‟, 37.9% of them said "agree‟, and only 4.2% of the respondents said "strongly agree". In general, 53.1% of the responded didn't believe on the construction quality of water supply schemes but the rest not because of in 2 Kebeles the schemes developed with the standared and the reality of physical observation was similar with the response of households on construction quality of schemes.

4.2.3 Availability of local technicians and their technical skills

Local technicians are necessary because nearby technicians can understand every problem within the community and can follow the water supply schemes without challenge. Therefore, the absence of local technicians can affect not only their water supply schemes but also the life of themselves as the respondent said.

Majority of the respondents not believe on locale technician's availability and skills some of them agree on the availability and skills of technician. However, this is not the reality during my stay in the study area the hand pump with borehole gate problem and Woreda Water Office Experts had done the operation and maintenance activities. According to key informant interview operation and maintenance activities had been done by Woreda Water Office experts and heavy or major repairs by Zonal and Regional Bureau Experts or Technicians.

Table 4.2 Skills of locale technician and availability

Response	Frequency	Percent
strongly disagree	10	2.8
Disagree	180	50.1
neither agree nor disagree	17	4.7
Agree	148	41.2
strongly agree	4	1.1
Total	359	100.0

4.2.4 Availability of spare Parts

Concerning the availability of spare parts at community level in rural water supply schemes whenever needed, majority of them reported that there is not easily available and accessible. The survey results shows that, 7% of the households respondents strongly disagree, 48% of the household respondents disagree, 5% of the household respondents neither agree nor disagree, 38.2% of the household respondents agree, and the remaining 3.3% responded strongly agree. Most of the household respondent said that, when the schemes fail as a result of unavailability of spare parts, their water supply schemes were stayed for long period of time without maintenance and others said their water supply schemes providing service with problems and maintained by technician. According to key informant interview made with Zonal Water Head and Experts, there were no stores for spare parts at community level and at Woreda they simply store spare parts at the office.

This finding is related with the suggestion of Musonda (2004) who stated that appropriate tools for carrying out repairs should be made available to achieve sustainability. In some areas, 50% or more are non-functional due to difficulties in obtaining spare parts. Furthermore, lack of spare parts has been a major constraint in the sustainability of water supplies.

4.2.5 Age of schemes

The average age of schemes in Yemelewo is 3 years, Zembo is 10.9 years , Lay Saramba is 3.1 years and Dulit Yegelda is 17.15 years. The maximum age of schemes in the study area is 32 years of Dulite Kebele Shoal Wuha spring which was semi-functional due to problem of age, the average age of schemes in study area is 8.62 years and was deviate from the designe life by 3.62 years above the designe life its standared deviation also deviate from the standared by 3.62 years above the designe life of schemes (Table 4.3). However, this varied age of schemes depending on year of construction of schemes. The maximum age of shallow well in the study area was Zembo Kebele Guadegudie borehole, which gives water after ten strokes, its quality of water was deteriorated and its yield is reduced by 0.23L/S.

Table 4.3 Age of water supply schemes in the study area

Statistical parameter	Yemelewo N = 104	Zembo N = 84	Lay Saramba N = 76	Dulit Yegelda N = 95	Woreda min/ max Mean/Std
Minimum	2.00	9.00	1.00	7.00	1
Maximum	5.00	12.00	5.00	32.00	32
Mean	3.0096	10.9167	3.1053	17.1579	8.62
Std. Deviation	1.08382	.47105	1.78571	11.16255	8.364

4.2.6 Distance of schemes from residence of HHs

The average distance of schemes in Yemelewo is 1.32 kilometer, Zembo is 1.10 kilometer, Lay Saramba is 1.26 kilometer and Dulit Yegelda is 1.21 kilometer. The maximum distance of schemes in the study area is 4.5 kilometer, the average distance of schemes in study area is 1.23 kilometer which was deviated from the standard of walking distance to collect water (1km)(Table 4.4). The respondents were asked the approximate distance they travel a household to collect water and responded that they travel average distance of 1.23 kilometer which is above the standared of (WHO ,2012) and 48.75% was in distance greater than 1 kilometer becase of installation of schemes and water source as shown in (Table, 4.4).

Table 4.4 Distance of household from water supply schemes (m)

Statically Parameter	Yemelewo	Zembo	Lay Saramba	Dulit Yegelda	Min/max Mean/Std
Minimum	30.00	50.00	45.00	120.00	30
Maximum	4000.00	3000.00	3500.00	4500.00	4500
Mean	1327.4038	1091.9762	1255.1316	1214.2316	1227.1
Std. Deviation	765.98816	770.84629	821.60101	926.52945	825.11

4.2.7 Reliability of water supply

The survey results shows that, 4.2% of the households respondents strongly disagree, 68.2% of the household respondents disagree, 5% of the household respondents neither agree nor disagree, 18.1% of the household responded agree, and the remaining 4.5% responded strongly agree. They responded were not agreed, on reliability of source due to fluctuation of water and dry up of springs during dry season. The above survey result was in accordance with physical measurement of discharge on field none of schemes yields the design discharge of water supply schemes in the study area.

4.2.8 Water quality

The survey results shows that, 1.1% of the households respondents strongly disagree, 27.3% of the household respondents disagree, 8.1% of the household respondents neither agree nor disagree, 61.8% of the household respondents agree, and the remaining 1.7% responded strongly agree. The respondents were not agreed due to its iron test, turbid and waterborne disease. Physical observation of water supply schemes specially Zembo Kebele Guadegudie borehole have iron test and turbid. This survey result is in accordance with measured value physic-chemical and bacteriological laboratory test of water quality.

Table 4.5 Quality of water

Response	Frequency	Percent
strongly disagree	4	1.1
Disagree	98	27.3
Neither agree nor disagree	29	8.1
Agree	222	61.8
strongly agree	6	1.7
Total	359	100.0

4.2.9 Water use per household

The maximum amount of household's water use in study area is 125 liters/day which is lower than the standared of (WHO, 2012), the average water use in study area is 42.7 litres/day with 6.5 persons per household that means; 6.57 liters per person per day, which is much lower than the standard, set by WHO. However, this varied per household depending on the household size and distance to the water point. This finding was much lower than previously reported research in Tehuledere Woreda Northeast Ethiopia, because of that in the study area there was problem of spring development (the pipe installed in the spring eye was at lower elevation from the collection chamber, the spout installed on the collection chamber above the water level and the collection chamber, and spring eye was not well taped) and problem of shallow well development problem (low depth of penetration, they were not use wire mesh and gravel to filter, and maintenance problem), i.e. average daily domestic water consumption per household, as derived from the sample, is 251.8 litres in the rainy season and 215.9 litres in the dry season (i.e., about 29 and 25 litres per capita in the rainy and dry seasons, respectively (Seid et al, 2003).

Table 4.6 The average water consumption of respondents in litres per household per day

Statically Parameter	Yemelewo N = 104	Zembo N = 84	Lay Saraba N = 76	Dulit Yegelda N = 95	Min/max Mean/Std
Minimum	15.00	17.00	10.00	13.00	10.00
Maximum	125.00	50.00	75.00	105.00	125.00
Mean	60.0481	27.0238	37.2368	42.1053	42.7437
Std. Deviation	24.30086	9.22017	21.12494	21.99588	23.69926

4.3 Factor Analysis

Attempts were made to identify factors responsible for the determinations of rural water supply schemes sustainability. Occurrence of strong multicolinearity problems was checked for the continuous explanatory variables prior to estimation of the model using VIF and contingency coefficient. The result showed there was no strong multicolinearity problems among the explanatory variables included in the model (Appendix 9).

The MLR model result showed that the coefficient of determination i.e. the adjusted R-values was 0.971. This implies that about 97.1% of the variation in the dependent variable is explained by the variation of the independent variables, indicating relatively high explanatory power of the model (Appendix 7). The econometric results were almost indicating that the homoscedasticity assumption was not violated (Appendix 9). Appendix 9 indicates that the model has no omitted variables. As the result signified, the chi-square distribution is suggesting that the linear regression model as the basis of analysis which means that the model is correctly specified (Appendix 7).

4.3.1 Determinants of technical and environmental factors on schemes sustainability

The result indicated that, out of the 9 hypothesized variables which were included in the multiple linear regression models three variables were found to be statistically significant to influence the sustainability of water supply schemes. These were age of water supply schemes, spare part supply, construction quality of schemes (Table 4.7).

Age of schemes: - Age of schemes was highly significant at ($p = 0.009$) probability level and had a negative coefficient of 0.003, which implies that for one year increase in age of schemes, probability of sustainability of water supply scheme decreases by 0.3% (Table 4.7). That means older water supply scheme was less likely to be operational than new schemes.

Spare part supply : - Spare part supply was highly significant at ($p = 0.001$) probability level and had a positive coefficient of 0.801, which implies that for one unite addition of spare part for the Kebele water user, probability of sustainability of water supply schemes increases by 80% (Table 4.7). As the supply of spare part, increases the sustainability of schemes increase. That means when there is breakage of scheme part it is easily replaced by spare part. Several sources (RWSN 2010, de Saint Méloir, 2009) suggest that access to spare parts is a critical factor influencing water point sustainability.

Construction quality : - Construction quality of schemes was highly significant at ($p = 0.001$) probability level and had a positive coefficient of 0.174, which implies that constructing springs and wells according to the standared, probability of sustainability of water supply schemes increases by 17.4% (Table 4.7). Construction quality is one of the most important factors influencing sustainability of water supply schemes (Sara and Katz, 1997) (Table 4.7).

Table 4.7 Multiple linear regression model result

Parameter	B	Std. Error	Beta	T	Sig.	Tolerance	VIF
(Constant)	.103	.062		1.658	.098		
Distance of schemes	-3.91	.000	-.003	-.319	.750	.968	1.033
Water use per HHS	.001	.000	.016	1.686	.093	.922	1.084
Reliability of schemes	.002	.015	.002	.124	.901	.477	2.097
Quality of drinking water	.009	.011	.008	.849	.396	.964	1.037
Age of scheme**	-.003	.001	-.026	-2.625	.009**	.840	1.191
Technician of water supply schemes	.020	.010	.019	1.937	.054	.871	1.148
Spare part availability**	.801	.025	.800	32.563	.000**	.135	7.423
Type of technology selection	.033	.017	.032	1.905	.058	.287	3.488
Construction quality of schemes**	.174	.021	.170	8.399	.000**	.199	5.022

*** Highly significant at 0.01 and* **significant at 0.05*

4. 4 Socio-Economic and Institutional Factors on Schemes Sustainability

4.4.1 Participation, acceptance and satisfaction of HHs

Participation: - The nature of community participation and types of contributions made by sample households respondent's participation on planning, construction, protection, operation, fee of water and maintenance of existing water supply schemes. Regarding participation of community at any one activity of their water supply schemes, the survey result indicated that 60% of sample respondents have made participation while the remaining 40% had not participated due to poor construction quality and problem of immediate maintenance Figure (4.4). There is need of participation from staring to termination, and continuing for future which could help sustainability of the water supply schemes. This finding confirms with Arlosoroff et al. (1987) strongly argued that the highest potential for sustainability is achieved when the community is involved in all activities of water supply schemes.

Acceptance:- More than half of the respondents were accepted improved water supply schemes and 41% of the respondents not accepted the improved water supply schemes due to in appropriate location (distance from residence of HHs) and water quality problem of Zembo Kebele Guadegudie borehole (Figure 4.4)

Satisfaction: - As shown on figure 4. 4 about 69.6% of the respondents are not satisfied from improved water supply schemes usually because of failure of the water point within a short period after development of springs and shallow wells. Forinstance, Lay Saramba Kebele Yedo Spring and Darewuha affridive handpump, Water quality problem of Zembo Kebele Guadegudie borehole and maintenance problem other schemes, and in Yemelewo and Dulit Yegelda there was spring development problems leads to semi-functional. Finaly due to these problem households were not satisfied from the improved schemes.

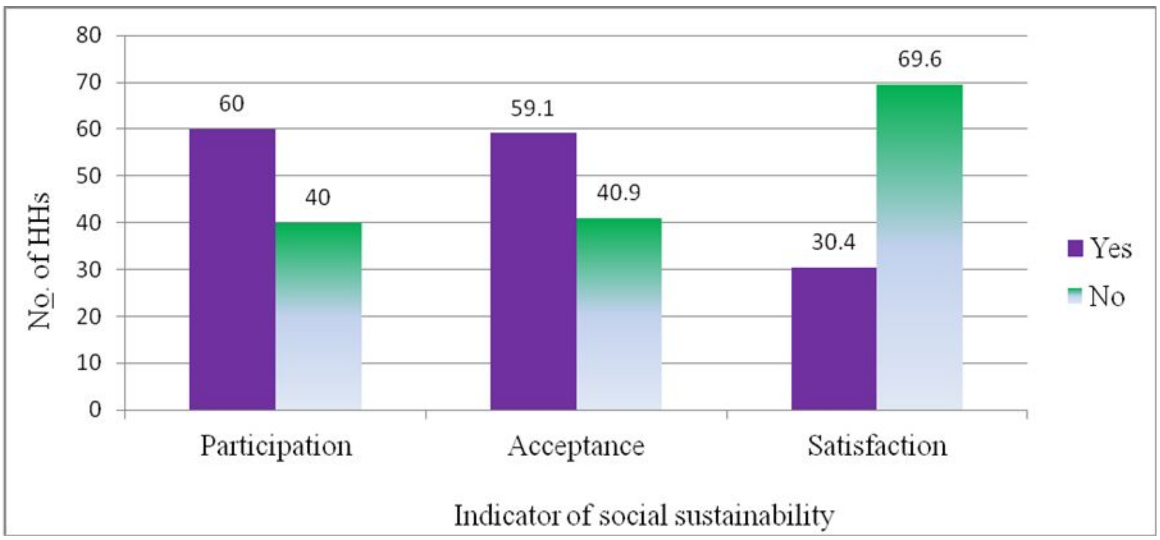

Figure 4.4 Participation, acceptance and satisfaction of HHs

4.4.2 Availability of fund for operation and maintenance cost

Finance is needed to pay for spare parts, caretaker and skilled people to keep water points functioning. According to survey results 79.1% of respondent stated that operation and maintenance cost was covered by the community and the rest 20.9% stated that maintenance cost was covered by governmental and non-governmental organization. The community management water supply schemes was based on the assumption that users will pay regular contributions into a 'water point maintenance fund', so that money will be available in case of breakdown.

In virtually every case the discrepancy is enormous; in only four of the cases does the maintenance fund cover more than one-six and in the rest of cases it covers below 1% as shown (Table 4.8). On average, the amount saved is just 3.73% of what it should be (100%). While it would be unrealistic to expect a 100% savings rate, the sheer scale of this discrepancy strongly suggests that the financial assumptions underpinning the community management model are in serious need of revision.

Table 4.8 Scale of maintenance cost discrepancy

Kebele	Type of scheme	No of HHS	For O&M Costed in Birr	Theoretical Ft	Actual Fa on Bank	Fa as % of Ft
Dulit Yegelda	Medium spring	119	10,131	27,354	250	0.91
	Medium spring	98	20,300	91,714	700	0.76
Zembo	Borehole	117	3112	18,128	1200	6.6
	Shallow well	87	21,151	15,389	1097	7
Lay Saramba	Shallow well	125	7,500	18,000	1145	6.3
	Small spring	113	3,957	19,095	1300	6.8
Yemelewo	Large spring	315	25,161	107,139	1295	1
	Medium spring	151	5,005	25,799	120	0.5

4.4.3 Willingness to pay and trust of water committee

When we observe descriptive statistics of willingness to pay was 65.5% of HHS willing to pay fee. However, the rest not willing to pay fee as the researcher asked the water committee they said that due to unawareness of water user, lack of training and mis-trust of water committee some of them not willing to pay fee.

As shown on figure 4.5, 71.9 % of the HHS stated that they did not trust water committee this will lead to reduction of contribution of money for water supply schemes. Indeed, numerous examples were given by respondents of WPC members misusing funds intended for maintenance and repair of the water point. Typical comments from the respondent: Some people don't contribute because people in the past contributed and the WPC misused the cash, refuse to contribute because they don't believe the WPC, they think that they use the cash for their families and the WPC eats the money they misuse the funds and buy their own needs. The funds are used differently. If one WPC member is sick they use the money to take him to hospital.

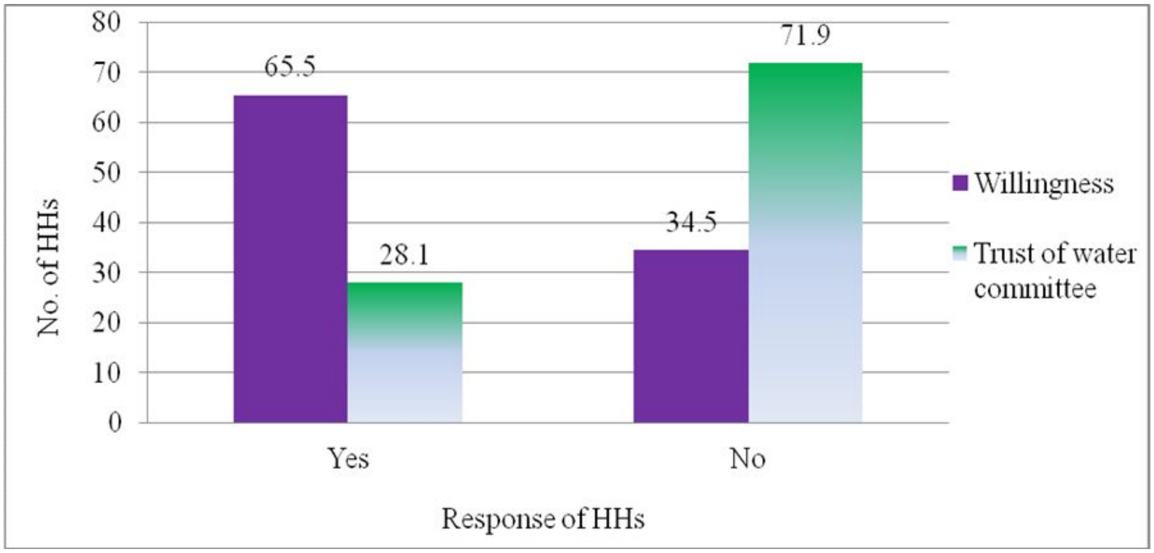

Figure 4.5 Willingness to pay and trust of water committee

4.4.4 Lack of training , information transfer and implementing water policy

Lack of capacity building: - Household and water committee members training play a great role in ensuring the sustainability of the schemes. After discussing with the water committee members, it became clear that most of the communities did not receive training. They simply took the training for the sake of getting per diem. On the other hand there are some village water user committee members who take the responsibility and give education by arranging meetings with other users. The main lack of training was due to small number of technicians at the Woreda office, they did not arrange training at the village level for the communities (especially for WPCs) and the Woreda water management office have shortage of budget to give training for village WPCs. If the community has lack of education or awareness about the water point, they do not take care on the water supply system. The reply of some respondent tell us that as a result of lack of education, there are some community members who steal the wood from the fence of the water point at night for the purpose of fuel. This allows the livestock and children to enter to the water point, to disable the water point and water contamination. These water committees have no rules and regulations to punish such type of people. In some villages they have rules and regulations to govern the community members, to limit the amount of water fetching, type of punishment (punishment of money and if they have no money by labor work) when somebody made mistake, how to contribute monthly water fee and the like.

Information transfer : - About 67.1% of the respondents were not transfer information from Kebele to Woreda of Water Technician due to lack of awareness. This lead to gape of information transmission between user community and Woreda Water Office expert on the problem of water supply schemes.

Implementing water policy: - Drinking water supply policy stipulates the conditions to be considered in provision of water supply systems and to make the service sustainable in rural areas of the country. The policy clearly indicated, the necessity of institutional supports given to the community (users and water suppliers); management of systems at decentralized levels with full participation of the communities starting from planning; the need of coordination among stakeholders with defined rules and regulations technical issues and financial (cost-recovery principle). According to the result of survey respondents about 48.7% of the households not implementing water policies due to lack of awareness and satisfaction as shown (Figure 4. 6).

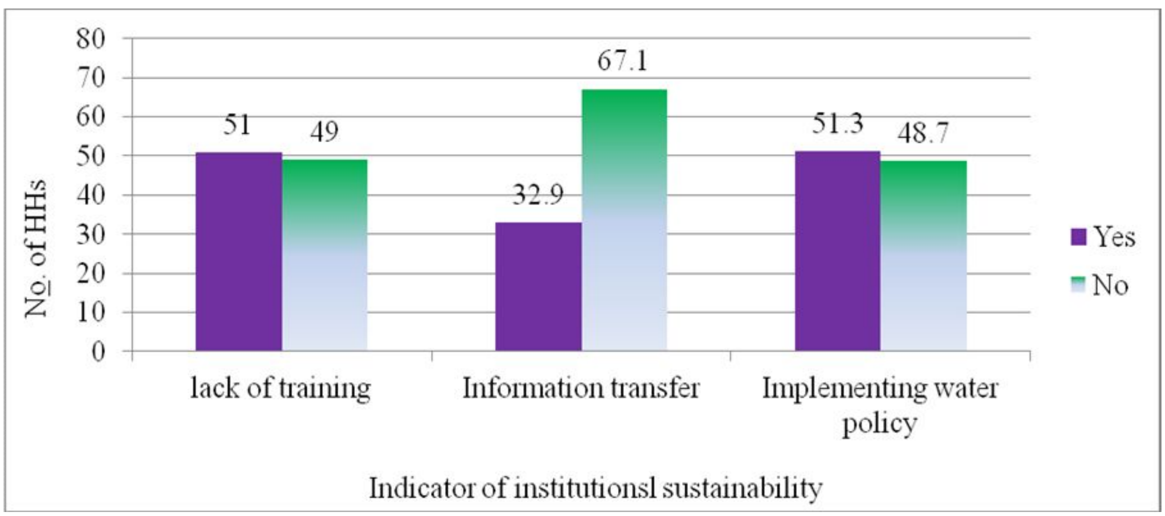

Figure 4-6 Lack of training, information and implementing water policy

4.5 Factor Analysis

Attempts were made to identify factors responsible for the determinations of rural household socio-economic and institutional sustainability of water supply schemes among the sampled households. Occurrence of strong colinearity problems was checked for the categorical explanatory variables prior to estimation of the model using Correlation of estimates (from binary logistic regression). The result showed there was no strong colinearity problems among the explanatory variables included in the model (Appendix 5).

The logit model result showed that the coefficient of determination i.e. Psudo statistics (Cox and Snell R Square and Nagelkerke R Square) values 0.849. This implies that 84.9 of the variation in the dependent variable is explained by the variation of the independent variables, indicating relatively high explanatory power of the model (Appendix 2). The econometric results were almost indicating that the homoscedasticity assumption was not violated (Appendix 6). As the result signified, the Hosmer Lemeshow Test is suggesting that the Logistic Regression Model as the basis of analysis which means that the model is correctly specified (Appendix 3).

4.5.1 Determinants of socio-economic and institutional schemes sustainability

The result indicated that, out of the 10 hypothesized variables which were included in the Binary Logistic regression models 5 variables were found to be statistically significant to influence the sustainability (Appendix 6). These are Operation and maintenance cost, willingness, lack training, acceptance, and participation (Table 4.9).

Operation and maintenance cost: - Operation and maintenance cost was highly significant at ($p = 0.001$) probability level and had a negative coefficient of 3.185, which implies that for the addition of expenditure for operation and maintenance, probability of sustainability decreases by a factor of 0.041 (Table 4.9).

Willingness: - Willingness to pay was statistically significant at ($p = 0.044$) probability level and had a positive coefficient of 1.655, which implies that the addition of one factor prepared to pay fee, probability of sustainability increases by factor of 5.232 (Table 4.9).

Lack of training: - Lack of training was highly significant at ($p = 0.001$) probability level and had a negative coefficient of 5.785, which implies that for reduced training by one in each mounth, probability of sustainability decreases by factor of 0.003 (Table 4.9).

Acceptance: - Acceptance of household was statistically significant at ($p = 0.044$) probability level and had a positive coefficient of 2.148, which implies that for the addition of water user accepted the project by one factor, probability of sustainability increases by factor of 8.569 (Table 4.9).

Participation: - Participation of HHs was highly significant at ($p = 0.01$) probability level and had a positive coefficient of 1.993, which implies that for the addition of water user participation to implement project, protect schemes and fee pay by one factor, probability of sustainability increase by factor of 1.136 (Table 4.9).

Table 4.9 Binary logistic regression result

Parameter	A	S.E.	Wald	Df	Sig.	Exp(A)	95% C.I.for EXP(B)	
							Lower	Upper
Fund(user community)	.403	.711	.322	1	.571	1.497	.371	6.034
Willingness*	1.655	.822	4.052	1	.044*	5.232	1.045	26.205
Trust	.306	.889	.118	1	.731	.736	.129	4.208
Operation_maintenace**	-3.185	.641	24.716	1	.000**	.041	.012	.145
Lack of trianing**	-5.785	1.045	30.660	1	.000**	.003	.000	.024
Information	.315	.578	.297	1	.586	.730	.235	2.264
Implementing policies	.907	.714	1.611	1	.204	.404	.100	1.638
Acceptance*	2.148	1.066	4.059	1	.044*	8.569	1.060	69.276
Participation**	1.993	.770	6.698	1	.010**	1.136	.030	.617
Satisfaction	.442	.904	.239	1	.625	.643	.109	3.778
Constant	4.166	.785	28.172	1	.000	64.459		

*** Highly significant at 0.01 and *significant at 0.05*

4.6 Bacteriological and Physico-Chemical Analysis in Wet and Dry Season

4.6.1 Bacteriological analysis in dry and wet season

The water samples were analyzed for selected bacteriological parameter during the wet month of April and dry month of January to study drinking water quality variation with season.

Table 4.10 The seasonal mean of bacteriological parameter

Parameter	Unit	Wet season		Dry season		Standards	
		Mean	Std	Mean	Std	ES	WHO
TC	CFU	15.25	9.04	9.25	6.541	0	0
TTC	CFU	8.89	7.14	4.25	4.367	0	0

The concentration of TC varied from 3 to 34 and 0 to 23 per 100ml in wet and dry season, respectively (Appendix 12). Mean concentrations were 19.25 per 100ml in wet season and 9.25 per 100ml in dry season. This indicates the presence of contamination in two seasons and the concentration of TC was high in wet season. However, the statistical analysis showed that there was no significant difference P <0.05 between the wet and dry seasons (Appendix 13). In two different seasons the value was beyond the recommended maximum permissible limits of ES and WHO (ES, 2002 and WHO, 2008), except Feredowuha shallow well of dry season because of the well was well protected and deep penetration depth. The study conducted in Ruiru County, Kenya showed that the mean total coliform values for the sampled shallow well are 31.49 CFU/100ml (wet season) and 0.05 CFU/100ml (dry season) (Otieno et al, 2015). A similar study conducted by (Getnet, 2008) from Bahir Dar town showed that the analyzed water samples from the source of wet season had a mean total coliform count of 35.5 CFU/100ml which was above the acceptable level recommended WHO. The high amount of these coliform during the wet season because of water availability favors the movement and reproduction of the organisms especially from surface run off, sewage and waste material (Otieno et al, 2015).

Faecal coliforms (FC) of which *E.coli* is one of them, are the most commonly used bacterial indicator of faecal pollution (Chukwunenyoke et al, 2012). Water contaminated by fecal pollution is identified as being potentially dangerous by the presence of coliform bacteria Water from contaminated sources may cause numerous diseases and premature deaths. The concentration of TTC varied from 0 to 24 and 0 to 14 per 100ml in wet and dry season, respectively (Appendix 12). Mean concentrations were 8.89 per 100ml in wet season and 4.25 per 100ml in dry season. This indicates the presence of contamination in two seasons and the concentration of TTC was high in wet season except Feredowuha SW and Stedewuha SW in dry season. The high amount of these coliform during the wet season could be due to the fact that water availability favors the movement and reproduction of the organisms especially from surface run off, sewage and waste material.

4.6.2 Physico-chemical analysis in dry and wet season

The water samples were analyzed for selected physico-chemical parameters during the wet month of August and dry month of January to study drinking water quality variation with the seasonal difference.

Table 4-11 The Seasonal mean of physico-chemical parameters.

Parameter	Unite	Wet Season		Dry Season		Standard	
		Mean	Std	Mean	Std	ES	WHO
Temp.	^oC	19.16	3.69	24.81	2.08	-------	<15
pH	pH	7.425	0.555	7.687	0.514	6.5-8.5	6.5-8.5
EC	µs/cm	114.612	4.74	115.5	4.8	1500	1000
Turbidity	NTU	<5	<5	<5	<5	7	5
TDS	mg/l	55.987	8.972	59.462	9.397	1000	1000
TH (CaCO3)	mg/l	221.88	91.84	226.25	91.95	300	300
Nitrate	mg/l	3.37	1.69	1.64	.37	50	50
Chloride	mg/l	13.25	1.63	12.74	1.62	250	250
Fluoride	mg/l	.88	.19	.92	.19	3	1.5
Magnesium	mg/l	65.25	9.91	66.31	9.42	50	50
Iron	mg/l	.06	.06	.07	.06	0.4	0.3
Phosphate	mg/l	.67	.34	.44	.23	0.02	0.005

NB. Turbidity tube do not measure value below 5NTU

Temperature

The value of temperature varied from 13 to 24^oC and 21 to 27.5^oC in wet and dry season, respectively (Appendix 12). Mean concentrations were 19.16 ^oC in wet season and 24.81 ^oC in dry season. The statistical analysis showed that there was significant difference at p = 0.002 between the wet and dry seasons (Appendix 13). This significance difference was due to the influence of season**.** These results were in accordance with the results those reported by (Garg et al, 2009; Verma et al., 2011**).** The value of temperature of sample measured in this study was less compared to maximum value of 25.23 ^oC from source of water Ruiru, Kenya (Otieno et al., 2015). All of the sample result above the standard of WHO except Dulit Yegelda Kebele of Belesesayesh small spring of wet season.

Electrical conductivity (EC)

The concentration of EC varied from 109 to 124µs/cm and 110 to 125µs/cm in wet and dry season, respectively (Appendix 12). Mean concentrations were 114.61µs/cm in wet season and 115.5µs/cm in dry season. The statistical analysis showed that there was no significant difference at ($p < 0.05$) between the wet and dry seasons (Appendix 13). The lower EC values in wet season may be attributed to dilution factor as a result of high flow of water due to excessive rain. These results were in accordance with the results those reported by (Srivastava and Srivastava, 2011).

pH and Turbidity

The concentration of pH varied from 6.6 to 8.3 pH and 6.8 to 8.4 pH in wet and dry season, respectively (Appendix 12). Mean concentrations were 7.43 pH in wet season and 7.69 pH in dry season. The statistical analysis showed that there was no significant difference at $p<0.05$ between the wet and dry seasons (Appendix 13). All the pH values collected at two seasons showed that within the permissible limit of ES and WHO drinking water guideline. The lower concentration during wet season was probably due to rainwater dilution.

The concentration of turbidity highest value 26 and 20 in wet and dry season but the lowest value is not known since turbidity tube was used. The highest value was collected at Zembo Kebele of borehole due to leakage, gravel quality; rust of handle and inside part of pump (Appendix 12). Turbidity in wet season was higher than dry seasons because of soil erosion, runoff, and high flow rates**.** Lower turbidity values during the dry season are probably due to less groundwater recharge and the filtration. All the turbidity collected at two seasons were within the standard except Guadegudie borehole, Emaye Wuha small spring and Shola Wuha medium spring in dry and wet season whereas, Muzanba large spring and Belessayesh medium spring in dry season (Appendix 12).

Total dissolved solids (TDS)

The concentration of TDS varied from 47.7 to 74.2mg/l and 50.8 to 79mg/l in wet and dry season, respectively (Appendix12). Mean concentrations were 55.99mg/l in wet season and 59.46mg/l in dry season. This result is in agreement with previous study conducted in WA, Ghana by Joseph (2013). The statistical analysis showed that there was no significant difference at $p<0.05$ between the dry and wet seasons (Appendix 13). The TDS values were lower in the wet season compared to the dry season probably due to the dilution effect of rainwater**.** All the TDS values collected at different seasons showed that within the permissible limit of ES and WHO drinking water guideline.

Total hardness

The concentration of total hardness varied from 145 to 425mg/l and 150 to 431mg/l in wet and dry season, respectively (Appendix 12). Mean concentrations were 221.88mg/l in wet season and 226.25mg/l in dry season. The statistical analysis showed that there was no significant difference at $p<0.05$ between the wet and dry seasons (Appendix 13).

Lower value during wet season may due to dilution effect of calcium and magnesium ions. All the total hardness values collected at different seasons showed to be within the permissible limit of ES and WHO drinking water guideline except Guedegudie borehole.

Chloride and Magnesium

The concentration of chloride varied from 10.30 to 15.8mg/l and 10.15 to 10.30 mg/l in wet and dry season, respectively (Appendix 12). Mean concentrations of chloride were 13.25mg/l to 12.74mg/l in wet and dry season respectively. High mean value of chloride content in wet season may due to addition from human sewage, animal manure and agricultural wastes (WHO, 2008). There were no significant difference in chloride among the seasons, (Verma et al., 2012) reported similar result.

The concentration of magnesium varied from 53 to 78mg/l and 57 to 79 mg/l in wet and dry season, respectively (Appendix 12). Mean were 65.25mg/l in wet season and 66.31mg/l in dry season. The lower concentration during wet weather was probably due to dilution because of there was seepage of water to the well and recharge of wells during rain season. The statistical analysis showed that there was no significant difference $p<0.05$ between the dry and wet seasons (Appendix 13). Based on the current value obtained, the value of magnesium content of water source samples measured in this study was exceeded to the maximum permissible limit of ES and WHO guidelines.

Nitrate and Phosphate

The concentration of nitrate varied from 1.23 to 5.8 mg/l and 1.1 to 2.05 mg/l in wet and dry season, respectively (Appendix 12). Mean concentrations were 3.37mg/l in wet season and 1.64 mg/l in dry season. The statistical analysis showed that there was significant difference at $p = 0.013$ between the wet and dry seasons (Appendix 1 3). All the Nitrate values collected at different seasons showed to be within the permissible limit of ES and WHO drinking water guideline. In this study, the concentration of nitrate was increased in the wet season by 1.73mg/l. This was due to the organic wastes, surface runoff from agricultural land with fertilizer into the spring. The value of nitrate content of water source samples measured in this study is less compared to the maximum values of 6.1 mg/l from the source of two wells of Debreziet (Desta, 2009) and 10.8mg/l and 12.9mg/L from source waters of Ziway Town (Kassahun,2008).

The concentration of phosphate varied from 0.12 to 1.2mg/l and 0.1 to 0.81 mg/l in dry and wet season, respectively (Appendix 12). Mean concentrations were 0.67mg/l in wet season and 0.44 mg/l in dry season. The statistical analysis showed that there was no significant difference at $p<0.05$ between the wet and dry seasons (Appendix 13). The value increases by 0.23 mg/L in wet season. This was may be due to the use of detergents and soaps to wash their clothes and intensive agricultural activities around the source (Adimasu, 2015). Based on the current value obtained, the value of phosphate content of water source samples measured in this study was exceeded to the maximum permissible limit of ES and WHO guidelines.

Iron and Fluoride

This high concentration of metallic iron may be responsible although high iron concentrations may not pose health hazards to users, the occurrence of the yellowish-brown coloration may Cause rejection of such waters by the communities (Asante et al, 2001). The Mean concentrations of iron 0.06mg/l in wet season and 0.07mg/l in dry season. The statistical analysis showed that there was no significant difference at $p<0.05$ between the wet and dry seasons (Appendix 13). The lower concentration during wet weather was probably due to rainwater dilution. All the iron values collected at two seasons showed that within the permissible limit of ES and WHO drinking water guideline.

The concentration of fluoride varied from 0.6 to 1.1 mg/l and 0.65 to 1.16 mg/l in wet and dry season, respectively (Appendix 12). Mean concentrations were 0.88 mg/l in wet season and 0.92 mg/l in dry season. The statistical analysis showed that there was no significant difference at $p<0.05$ between the wet and dry seasons (Appendix 13). All the values of fluoride collected at different seasons showed that within the permissible limit of ES and WHO drinking water guideline.

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

A great effort was done on sustaining and improving rural water supply schemes in Ethiopia. There were 19 schemes in the study area; from these 52.63% were onspot spring. From the total improved springs, 37.5% were smi-functional and 25% were not functional due to maintenance and spring development problem. From the total shallow well 50% was non-functrional due to low penetration, break of U-seal and maintenance problem. People in the study area largely used from improved spring and shallow wells. As observed from the descriptive analysis 60% of the household use from springs and the rest 40% from shallow well, borehole and spring with distribution schemes. None of the improved water supply schemes gives the design discharge due to problem of spring development, clogging of spout, poor gravel selection, depth of excavation, low participation and lack of day-to-day follow-up of experts.

More than half of the household stated that, there was lack access of spare part and poor construction quality due shortage of supply material, poor construction activity and material selection. On the evaluation of determinant of technical and biophysical factor on sustainability of water supply schemes using multi linear regression model shows that age of schemes highly significant at ($p = 0.009$), access of spare part and construction quality were highly significant at ($p = 0.001$) which have significant influence on the sustainability of water supply schemes.

On the evaluation of determinant of socio-economic and institutional factor on sustainability of water supply schemes using logit model the Pseudo statistics (Nagelkekeis) R^2 (0.849) indicate strong relationship between dependent and independent variable. The overall prediction success of the model was 92.8%. The Wald criterion demonstrate that operation and maintenance cost and lack of training highly significant at ($p = 0.001$), participation highly significant at ($p = 0.01$), willingness to pay and acceptance were significant at ($p = 0.044$) were influence the sustainability of water supply schemes. In general, the sustainability of water supply schemes were questionable.

The data analysis of seasonal variation of drinking water ANOVA test indicate that temperature and nitrate were significant at $p<0.05$, between wet and dry season.

Bacteriological data analysis shows that all the total coliform measured were above the standard of (ES, 2002) and (WHO, 2008) except Zembo Kebele shallow well in dry season. All the Faecale measurement shows were, above the standard of ES and WHO except wet season of Zembo Kebele shallow well and dry season of Sted Wuha shallow well. The physico-chemical test of data analysis shows that (EC, PH, TDS, chloride, nitrate, iron and fluoride) were within the standard of ES and WHO but magnesium and phosphate above the standard. All the temperature measurement except (Belese Sayesh medium spring (13^0C) in wet season) were above the standard. Half of turbidity measurements were above the standard. All total hardness was within the standard except Gudegudie borehole.

5.2 Recommendations

Based on the findings discussed above, the following recommendations can be drawn to enhance the sustainability of schemes and its quality at source. The possible areas of were:

- The Woreda Water Expert /Government should have to replace aged schemes, supply spare part to replace wornout part and breakage of schemes and supervise construction quality of water supply schemes.

- The Woreda Water Expert/Government should have to do on willingness to pay, recovery methods of operation and maintenance cost, capacity building(training), acceptance of water supply schemes and participation.

- The Woreda Water Expert/Government should have to disinfect all the water supply schemes of Efrata Gidim Woreda.

REFERENCES

Abrams, L., 2013. Understanding sustainability of local water service: the African water page. Availabl at: www.africanwater.org,sustainability.htm//definingsustainability, retrieved on November, 2018.

ADF, 2005. Rural Water Supply and Sanitation report.

Adimasu Woldesenbet Worako, 2015. Physicochemical and biological water quality Assessment of Lake Hawassa for multiple designated water uses.

APHA, 1998. Standard methods for the examination of water and wastewater 20thed. Washington.

Arlsoroff S, G., Tschannerl, D. Gery, W. Journey, Karpa, O. langeneffer and R. Poche., 1987. Community water supply of hand pump, the World Bank, Washington, DC, USA.

Asante, K.A., A. Ansa, Z., Lusaka, 2001. Borehole water quality, Volat Region Ghana.Vol.27, PP.461-464.

Bhandari, B. and M. Grant, 2007. "User satisfaction and sustainability of drinking water schemes in rural communities of Nepal " Sustainability: Science Practice and Policy Vol.3, No.1, PP.12-20.

Brikke, F. and M., Bredero, 2003. Linking Technology choice with operation and maintenance in the context of community water supply and sanitation, Switzerland; World health organization and IRC water and sanitation center.

Briscoe, J and F., David, 1998. Water for rural communities: helping people help themselves, The World Bank, Washington, DC, USA.

Cairncrosses, S., 1990. “Water Supply and the Urban Poor,” The Poor Die Young, S. Cairn cross, J.E. Hardy, and D. Satterth waite, eds., Earths can Publications, Ltd., London, U.K, 1990, PP. 109-126.

Campbell, M., 2009. Study of the Sustained Effects of a Water Project.

Carter, R. C., E., Harvey, and V., Casey, 2010. User financing of rural hand pump water services: IRC Symposium; pumps, pipes and promises.

CSA, 2017. Ethiopian Population Census commission: population and housing census.

Chukwunenyoke, A., U., Igboekwe, M., Uzoma 2012. Characterization and Quality

Assessment of Groundwater. Aba Metropolis, Nigeria.

Churchill, A., 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.

Coelho-Barros E. A., Simoes P. A., Achcar J. A., Martinez, E. Z. and A. C., Shimano, 2008. Methods of Estimation in Multiple Linear Regressions: Application to Clinical Data. Revista Colombiana De Estadistica, Vol.31, No.1, PP.111-129.

Cook J.D., M., Carriage, S.G., Kahn W., Sahack, B.S., Skinkrie 1990. Gastrointestinal delivery system for iron supplementation. lancet, Vol. 76, PP.1136-1139.

Davis, J. and F., Brikke, 1995. Making your water supply work: operation and maintenance of small water supply systems, IRC, The Hague, and the Netherlands.

Diersing N., 2009. Water Quality Frequently Asked Questions. *http://floridakeys.noaa. gov/pdfs/wqfaq*. pdf (Accessed October 18, 2018).

De Saint Méloir, B., 2009. Inter Aide Support to Operation and Maintenance of Rural Water Supplies, Rural Water Supply Network , St Gallen, Switzerland,.

Desta K., 2009. Bacteriological and Physicochemical Quality assessment of Drinking Water Supply from source to taps in Debrezeit town, Ethiopia. Addis Ababa University, Addis Ababa. M.Sc. Thesis Addis Ababa University.

Efrata Gidim Woreda Agriculture and Natural Resource Office; 2018. Annual report. Ataye. North Showa Zone. Ethiopia.

Efrata Gidim Woreda Health office, 2018. Annual report.Ataye, North Showa Zone. Ethiopia.

Efrata Gidim Woreda Water Management Office, 2018. Annual report, Ataye. North Showa Zone. Ethiopia.

Ethiopian Standards (ES), 2002. "Drinking Water Specifications" Quality and Standards Authority of Ethiopia.

Evans, P., 1992. Paying the piper; an overview of community financing of water and sanitation, IRC, The Hague, the Netherlands.

FDRE, MOH, 2007. Rapid assessment of drinking water quality report. Federal Republic of Ethiopia.

Garg, R. K., R. J. Rao, D. N., Saksena, 2009. Water quality and conservation management of Ramsagar reservoir, Datia, Madhya Pradesh. J. Environ. Biol. 30: 909-916.

Gebre, A., 1997. "Water Supply Ethiopia; an Introduction to Environmental Health Practice", AAU Press, Addis Ababa.

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

Getachew A., 2002. Management aspect of rural water sustainability in Ethiopia, MSC thesis, the delft, the Netherlands.

Getnet, K, 2008. Physico-chemical and Bacteriological Drinking Water Quality Assessment of Bahir Dar town water supply from source to yard connection. (North- Western Ethiopia). M.Sc. Thesis, Addis Ababa University, Addis Ababa.

GOS, 2003. Design Manual for Rural Water Supply: Parts I and II. Rural Water Supply Branch, Ministry of Natural Resources and Energy, Mbabane.

Gujarati, 2004. Basic Econometrics, 4thEdition, Mc Graw-Hill Companies, Inc.New York.

Harvey, A., A., Read, 2007. Community-Managed Water Supplies in Africa: Sustainable or is pensable? Community Development Journal Vol 42, PP. 365–378.

Harney, P., B. Reed, 2004. Rural Water Supply in Africa: Building Blocks for Handpump Sustainability, Publications. Loughborough, Loughborough University, Washington, DC.

Haysom, A., 2006. A study of the factors affecting sustainability of rural water supplies in Tanzania. Dares Salaam, Water Aid Tanzania.

Hurst, C. J. Kundsen, M. J. Mclnerney, L.D.Stezenbach, and M.V. Walter, 2002. Manual of Environmental Microbiology. American Society for Microbiology. American Society of Microbiology Press, Washington, DC. Vol.2, PP: 265-284.

Hutton. 1996. Field water sampling techniques for developing countries.

IRC, 1987. An Approach to Sustainable Piped Water Supplies: (Technical paper series No. 28.), The Hague, the Netherlands, IRC international water and sanitation center.

Issayas, T., 1988. Evaluation of Rural water supply projects with Reference to the organizational aspects in Ethiopia, Tampere, Finland.

Jayanta.C., P, Siba, 2009. Chemical analysis of fluoride, NorthLakhimpu r, India, international journal and review in chemistry science, Vol.7, No.3, PP. 1829.

Jennifer S., Travis K., 2003. Making Rural Water supply sustainable.

JMP, 2010. Progress on sanitation and drinking-water. WHO / UNICEF, Geneva.

JMP, 2012. Progress on Drinking Water and Sanitation. UNICEF/WHO Joint Monitoring Programme.

Joseph, A.B., 2013. Latrines and household well water quality in wa. Institute for environment and sanitation studies. Environmental science program university of Ghana.

Kassahun B., 2008. Assessment of physico-chemical and Bacteriological Quality of Drinking Water in the Central Rift valley System, Ziway Town Oromia Region, Ethiopia. M.Sc Thesis, Addis Ababa University, Addis Ababa.

Kleemier, E., 2000. The impact of participation on sustainability: an analysis of the Malawi rural piped schemes program: world development Vol. 28, No. 5, PP. 929-944.

Khan M.E., A., Ahmed, 2001. Physical, Chemical and biological parameters in well waters health impacts. Karachi, Pakistan. Vol.23, pp. 263-267.

Lockwood, H., S. Smits, 2011. Supporting Rural Water Supply: Moving towards a Service Delivery Approach. Rugby, Practical Action Publishing.

Mahananda, M.R., 2010. Physico-Chemical analysis of surface water and ground water of Bargarh District, Orissa, India, International Journal of Research and Review in Applied Sciences, Vol.2, No.3, PP. 284-295.

Mebrahtu, M., 2012. Assessment of CMP approach in developing rural water supply schemes: Benishangul Gumuz, Ethiopia.

MoWR, 1999. Ethiopian water resources management policy, Berhanena Selam printing enterprise, A.A, Ethiopia.

MoWR, 2007. Ministry of water resource development: Water supply and sanitation policy of Ethiopia.

MoWE, 2013. Federal Democratic Republic of Ethiopia: National WASH Programme, Addis Ababa, Ethiopia.

Mukherjee, N., C.van., Wijk, 2003. “Sustainability Planning and Monitoring: A Guide on the Methodology for Participatory Assessment”. Water and Sanitation Program, World Bank, Washington, USA.

Musonda, K., 2004. Issues regarding sustainability of rural water supply in Zambia, master‟s dissertation, university of south Africa, departments of social works, south Africa.

NMSA., 2017. Initial National Communication of Ethiopia to the United Nations Framework Convention on Climate Change (UNFCCC). National Meteorological Service Agency, Addis Ababa, Ethiopia.

Otieno R. O., N., Ezekiel, M., Mary, 2015. Seasonal variations of physico-chemical and microbiological characteristics of groundwater quality in Ruiru, Kiambu county, Kenya.

Olson, 2004. What is on the Tap? Grading Drinking Water in the U.S. Cities. Natural Resources Defense Council.Organizations Switzerland, Geneva

Rural water supply network perspectives, 2010. Myths of rural water supply sector. November.2018. http://www.rwsn.ch/documentation/skatdocumentation.

Sara, Katz, 1997. “Making Rural Water Supply Sustainable: Report on the Impact of Project Rules”, by Jennifer Sara and Travis Katz, UNDP World Bank Water and Sanitation Program.

Seid T., L., Worku, E., Hailu, F., Kebede, 2003. Factors affecting drinking water quality from source to home in Tehuledere Woreda, northeast Ethiopia.

Smet. Jo, W., Christine, 2002. Small community water supplies, Technical paper series 40, IRC international water and sanitation center, delfit, the Netherland.

Srivastava, A., S., Srivastava, 2011. Assessment of Physico-Chemical properties and sewage pollution indicator bacteria in surface water of River Gomti in Uttar Pradesh, International Journal of Environmental Sciences, Vol.2, No.1, PP 325-336.

Thompson, J., I. T. Porras, J. K. Tumwine, M. R. Mujwahuzi, M. Katui-Katua, N. Johnstone, L. Wood, 2012. Drawers of Water II: 30 years of change in domestic water use and environmental health in east africa. London, International Institute for Environment and Development.

Trémolet, S., M. Rama, 2012. Tracking national financial flows into sanitation, hygiene and drinking-water. Working Paper. Geneva, WHO - GLAAS: UN-Water Global

Analysis and Assessment of Sanitation and Drinking Water.

UNICEF, 1999. Water Hand Book: Water, Environment and Sanitation Technical Guidelines Series - No. 2.

UNICEF, World Health Organization, 2012. Progress on Drinking Water and Sanitation: UNICEF/WHO Joint Monitoring Program for Water Supply and Sanitation. www.wssinfo.org

USAID, 2009. Environmental guidelines for small-scale activities in Africa: Chapter 16 water and sanitation.

Verma, P., Chandawat, D., Gupta, U., H. Solanki, 2012. Water quality analysis of an organically polluted lake by investigating different physical and chemical parameters. Int. J. Res. Chem. Environ. No.2: PP.105-111.

Volk, C.J., R., Hofmann, C., Chauret, G.A., Gagnon, G., Ranger, R.C. Andrews, 2002. Implementation of Chlorine Dioxide Disinfection: Effects of the Treatment Change on Drinking Water Quality in A Full-Scale Distribution System, Journal of Environmental Engineering and Science, 1:32330. *Http://Jees.Nrc.Ca/.*

WELL, 1998. DFID guidance manual on water supply and sanitation programs*,* WEDC, Loughborough University, UK.

World Bank, Water, sanitation Program, 2004. Spare part supplies for hand pumps

WHO. 2003. Water sanitation and health, Geneva.

WHO, 2008. Access to Improved Drinking Water Sources and Improved Sanitation(percentage)"Http://WWW.Who.Int/Whosis/Indicators/Compendium/2008/2wst/En/(Accessed10, April 2018)", Switzerland, Geneva.

WHO, 2011. Guidelines for drinking-water quality, fourth edition, Geneva.

Wolfe, A.H. J.A., Patz, 2002. Reactive nitrogen and human health: acute and long- ofterm implications. Ambio*:* A J. Human Environ*,* Vol.31, No.2, PP.120-125.

Yamane,T. 1967. Statistics, an introductory analysis, 2nd Ed., New York: Harper and Row.

Zemenu, A. 2012. Assessement of challenges of sustainable rural water supply. MSc thesis. School of cornell university, New York. 76p.

APPENDICES

Appendix 1 Socio-demographic characteristics of respondents

S. No	Characteristics	Frequency	Percentage
1.	Gender (N=343)		
	Male	172	48
	Female	187	52
2.	Age category		
	20	19	5
	20-29	76	21
	30-39	101	29
	40-49	78	22
	50-59	69	19
	60	16	4
3.	Marital status		
	Married	306	85
	Single	34	10
	Divorce	19	5
4.	Educational level		
	Not educated	79	22
	Non formal education	184	51
	Primary	45	13
	Secondar	35	10
	College	16	4
5.	Occupation		
	Farming	316	88
	Daily labor	22	6
	Small scale business	18	5
	Government employee	3	1
6.	Household size		
	≤ 4	57	16
	5	65	18
	6	96	27
	7	91	25
	8	31	9
	≥ 9	19	5

Appendix 2 Binary logistic regression pseudo statistics

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	131.899[a]	.634	.849

Appendix 3 Binary logistic regression Hosmer and Lemeshow Test Goodness of Fit

Step	Chi-square	Df	Sig.
1	3.012	8	.934

Appendix 4 Overall prediction of binary logistic Regression

Observed		Predicted		
		Do you think that the water supply scheme is sustainable?		Percentage Correct
		No	yes	
Do you think that the water supply scheme is sustainable?	No	183	17	91.5
	Yes	9	150	94.3
Overall Percentage				92.8

Appendix 5 Correlation estimate of binary logistic regression

Parameter	Constant	Source fund	Willingness	Trust	Operation and maintenance cost	Lack of training	Information transfer	Implementing water policies	Acceptance	Participation	Satisfaction
Constant	1.000	.391	.192	.117	-.496	-.198	.236	.089	.186	.257	.101
Source fund	.391	1.000	.015	.142	-.069	-.169	.072	.078	.079	.419	.067
Willingness	.192	.015	1.000	.106	-.283	-.225	.001	.616	.259	.330	.125
Trust	.117	.142	.106	1.000	-.039	-.083	.087	.018	.054	.170	.761
Operation and maintenance cost	-.496	-.069	-.283	-.039	1.000	.154	-.100	-.042	-.434	-.398	-.062
Lack of training	-.198	-.169	-.225	-.083	.154	1.000	-.124	-.044	-.732	-.257	-.027
Information transfer	.236	.072	.001	.087	-.100	-.124	1.000	.055	-.140	.169	.104
Implementing water policies	.089	.078	.616	.018	-.042	-.044	.055	1.000	.152	.136	.071
Acceptance	.186	.079	.259	.054	-.434	-.732	.140	.152	1.000	.210	.070
participation	.257	.419	.330	.170	-.398	-.257	.169	.136	.210	1.000	.181
Satisfaction	.101	.067	.125	.761	-.062	-.027	.104	.071	.070	.181	1.000

Appendix 6 Binary logistic Regression Result

Parameter	A	S.E.	Wald	Df	Sig.	Exp(B)	95% C.I.for EXP(B)	
							Lower	Upper
Fund	.403	.711	.322	1	.571	1.497	.371	6.034
Willingness*	1.655	.822	4.052	1	.044	5.232	1.045	26.205
Trust	.306	.889	.118	1	.731	.736	.129	4.208
Operation_maintenace**	-3.185	.641	24.716	1	.000	.041	.012	.145
Lack of trianing**	-5.785	1.045	30.660	1	.000	.003	.000	.024
Information	.315	.578	.297	1	.586	.730	.235	2.264
Implementing policies	.907	.714	1.611	1	.204	.404	.100	1.638
Acceptance*	2.148	1.066	4.059	1	.044	8.569	1.060	69.276
participation**	1.993	.770	6.698	1	.010	1.136	.030	.617
Satisfaction	.442	.904	.239	1	.625	.643	.109	3.778
Constant	4.166	.785	28.172	1	.000	64.459		

*** Highly significant at 0.01 and *significant at 0.05*

Appendix 7 Multiple linear regression adjusted R square

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.986[a]	.972	.971	.188	.972	1327.520	9	349	.000

a. Predictors: (Constant), Spare part availability, Distance of schemes, Quality of drinking water, Technician of water supply schemes, Water use per HHS, Age of scheme, Reliability of schemes, Type of technology selection, Construction quality of schemes

b. Dependent Variable: Sustainable of water supply scheme

Appendix 8 ANOVA for multiple linear regressions

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	423.166	9	47.018	1327.520	.000[b]
Residual	12.361	349	.035		
Total	435.526	358			

a. Dependent Variable: Sustainable of water supply scheme

b. Predictors: (Constant), Spare part availability, Distance of schemes, Quality of drinking water, Technician of water supply schemes, Water use per HHS, Age of scheme, Reliability of schemes, Type of technology selection, Construction quality of schemes

Appendix 9 Multiple linear regression model result

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	.103	.062		1.658	.098		
Distance of schemes	-3.912E-006	.000	-.003	-.319	.750	.968	1.033
Water use per HHS	.001	.000	.016	1.686	.093	.922	1.084
Reliability of schemes	.002	.015	.002	.124	.901	.477	2.097
Quality of drinking water	.009	.011	.008	.849	.396	.964	1.037
Age of scheme**	-.003	.001	-.026	-2.625	.009**	.840	1.191
Technician of water supply schemes	.020	.010	.019	1.937	.054	.871	1.148
Spare part availability**	.801	.025	.800	32.563	.000**	.135	7.423
Type of technology selection	.033	.017	.032	1.905	.058	.287	3.488
Construction quality of schemes**	.174	.021	.170	8.399	.000**	.199	5.022

*** Highly significant at 0.01 and *significant at 0.05*

Appendix 10 Wet season measurement

Parameters	Yemelewo		Zembo		Lay Saramba		Dulit Yegelda	
	Large spring	Medium spring	Shallow well	Borehole	Shallo well	Small spring	Medium spring	Medium spring
To	17	20.8	21	24.5	19	22	16	13
Ph	7.1	7.3	7.2	8.3	8.1	6.6	7.6	7.2
Turbidity	7	<5	<	26	<5	9	12	8
E.c	111.5	117	109	124	112.4	117.6	113.5	111.9
Tds	53	52	47.7	74.2	63.2	51	58.3	48.5
TC	16	11	3	34	9	18	17	14
TTC	10	6	0	24	3	9	11	8
TH ($CaCO_3$	145.00	165.00	165.00	425.00	165.00	235.00	265.00	210.00
Nitrate	3.50	5.80	1.75	1.23	1.71	4.70	4.90	3.40
Chlorine	12.00	13.80	14.90	10.70	12.30	13.00	15.80	13.50
Fluoride	.85	.60	.90	1.10	.70	1.05	1.10	.75
Magnesium	53.00	67.00	72.00	78.00	57.00	60.00	78.00	57.00
Iron	.07	.02	.08	.07	.02	.04	.01	.20
Phosphate	.84	1.20	.12	.42	.75	.51	.95	.58

Appendix 11 Dry season measurement

Parameters	Yemelewo		Zembo		Lay Saramba		Dulit Yegelda	
	Large spring	Medium spring	Shallow well	Borehole	Shallowell	Small spring	Medium spring	Medium spring
Temperature	24	25.5	26.5	27.5	25	26	23	21
PH	7.5	8	7.3	8.4	8.2	6.8	7.7	7.6
Turbidity	<5	<5	<5	20	<5	7	8	<5
Ec	112	119.3	110	125	113.5	117	114.2	113
TDS	59	55	50.8	79	65.9	53	61	52
TC	10	8	0	23	5	11	9	8
TTC	5	4	0	14	0	4	4	3
TH ($CaCO_3$)	150.00	169.00	171.00	431.00	170.00	238.00	267.00	214.00
Nitrate	1.10	2.05	1.40	1.23	1.60	2.03	1.95	1.77
Chlorine	11.50	13.20	14.30	10.15	11.90	12.50	15.30	13.10
Fluoride	.91	.65	.90	1.10	.70	1.09	1.16	.81
Magnesium	57.00	68.00	73.00	78.00	57.50	60.50	79.00	57.50
Iron	.07	.02	.05	.06	.01	.03	.01	.20
Phosphate	.81	.28	.10	.35	.69	.47	.29	.51

Appendix 12 Descriptive values of dry and wet seasons

Parameter		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
	Wet	8	19.1625	3.68934	1.30438	16.0781	22.2469	13.00	24.50
Temperature	Dry	8	24.8125	2.08631	.73762	23.0683	26.5567	21.00	27.50
	Total	16	21.9875	4.11045	1.02761	19.7972	24.1778	13.00	27.50
	Wet	8	7.4250	.55485	.19617	6.9611	7.8889	6.60	8.30
PH	Dry	8	7.6875	.51391	.18170	7.2579	8.1171	6.80	8.40
	Total	16	7.5563	.53413	.13353	7.2716	7.8409	6.60	8.40
	Wet	8	114.6125	4.74234	1.67667	110.6478	118.5772	109.00	124.00
E.C	Dry	8	115.5000	4.80149	1.69758	111.4859	119.5141	110.00	125.00
	Total	16	115.0563	4.63292	1.15823	112.5875	117.5250	109.00	125.00
	Wet	8	55.9875	8.97225	3.17217	48.4865	63.4885	47.70	74.20
TDS	Dry	8	59.4625	9.39710	3.32238	51.6063	67.3187	50.80	79.00
	Total	16	57.7250	9.05520	2.26380	52.8998	62.5502	47.70	79.00
	Wet	8	15.2500	9.03564	3.19458	7.6960	22.8040	3.00	34.00
TC	Dry	8	9.2500	6.541	2.3126	3.7815	14.7185	.00	23.00
	Total	16	12.2500	8.22598	2.05649	7.8667	16.6333	.00	34.00
	Wet	8	8.875	7.14018	2.52443	2.9057	14.8443	0	24
TTC	Dry	8	4.25	4.36708	1.544	.5990	7.9010	0	14
	Total	16	6.5625	6.19644	1.54911	3.2607	9.8643	0	24
	Wet	8	221.8750	91.84371	32.47166	145.0917	298.6583	145.00	425.00
TH (CaCO3)	Dry	8	226.2500	91.94680	32.50810	149.3806	303.1194	150.00	431.00
	Total	16	224.0625	88.80801	22.20200	176.7401	271.3849	145.00	431.00
	Wet	8	3.3738	1.68997	.59749	1.9609	4.7866	1.23	5.80
Nitrate	Dry	8	1.6412	.36880	.13039	1.3329	1.9496	1.10	2.05
	Total	16	2.5075	1.48212	.37053	1.7177	3.2973	1.10	5.80
	Wet	8	13.2500	1.63095	.57663	11.8865	14.6135	10.70	15.80
Chloride	Dry	8	12.7437	1.61852	.57223	11.3906	14.0969	10.15	15.30
	Total	16	12.9969	1.59128	.39782	12.1489	13.8448	10.15	15.80
	Wet	8	.8813	.19075	.06744	.7218	1.0407	.60	1.10
Fluoride	Dry	8	.9150	.18996	.06716	.7562	1.0738	.65	1.16
	Total	16	.8981	.18472	.04618	.7997	.9966	.60	1.16
	Wet	8	65.2500	9.91031	3.50382	56.9648	73.5352	53.00	78.00
Magnesium	Dry	8	66.3125	9.41859	3.32997	58.4384	74.1866	57.00	79.00
	Total	16	65.7813	9.35587	2.33897	60.7959	70.7666	53.00	79.00
	Wet	8	.0638	.06116	.02162	.0126	.1149	.01	.20
Iron	Dry	8	.0563	.06232	.02203	.0041	.1084	.01	.20
	Total	16	.0600	.05978	.01494	.0281	.0919	.01	.20
	Wet	8	.6713	.33664	.11902	.3898	.9527	.12	1.20
Phosphate	Dry	8	.4375	.23206	.08204	.2435	.6315	.10	.81
	Total	16	.5544	.30428	.07607	.3922	.7165	.10	1.20

Appendix 13 ANOVA results for dry and wet seasons

Parameter		Sum of Squares	Df	Mean Square	F	Sig.
	Between Groups	127.690	1	127.690	14.216	.002
Temprature	Within Groups	125.748	14	8.982		
	Total	253.437	15			
	Between Groups	.276	1	.276	.964	.343
PH	Within Groups	4.004	14	.286		
	Total	4.279	15			
	Between Groups	3.151	1	3.151	.138	.715
E.C	Within Groups	318.809	14	22.772		
	Total	321.959	15			
	Between Groups	48.303	1	48.303	.572	.462
TDS	Within Groups	1181.648	14	84.403		
	Total	1229.950	15			
	Between Groups	144.00	1	144	2.315	0.150
TC	Within Groups	871.000	14	62.214		
	Total	1015.000	15			
TTC	Between Groups	85.563	1	85.563	2.443	0.14
	Within Groups	490.375	14	37.027		
	Total	575.938	15			
	Between Groups	76.563	1	76.563	.009	.925
TH (CaCO3)	Within Groups	118226.375	14	8444.741		
	Total	118302.938	15			
	Between Groups	12.006	1	12.006	8.026	.013
Nitrate	Within Groups	20.944	14	1.496		
	Total	32.950	15			
	Between Groups	1.025	1	1.025	.388	.543
Chloride	Within Groups	36.957	14	2.640		
	Total	37.982	15			
	Between Groups	.005	1	.005	.126	.728
Fluoride	Within Groups	.507	14	.036		
	Total	.512	15			
	Between Groups	4.516	1	4.516	.048	.829
Magnesium	Within Groups	1308.469	14	93.462		
	Total	1312.984	15			
	Between Groups	.000	1	.000	.059	.812
Iron	Within Groups	.053	14	.004		
	Total	.054	15			
	Between Groups	.219	1	.219	2.615	.128
Phosphate	Within Groups	1.170	14	.084		
	Total	1.389	15			

BIOGRAPHICAL SKETCH

Mekete Agizew was born in Ataye Woreda, North Showa Zone, Nouthern Ethiopia. He attended higschool education at Ataye Secondary and Preparatory S chool. He then joined Hawassa University, College of Forestry and Natural Resources and graduated with Bachelor of Science Degree in Soil Resources and Watershed Management 2010. After enormous commitment and hard work, he continued his studies in a Master"s program at school of Biosystems and Environmental Engineering, specialization in Water Resource Engineering and Management, Institute of Technology of Hawassa University in mid of 2015.