



ASSESSEMENT OF COVERAGE AND QUALITY OF POTABLE WATER
AND SANITATION IN RURAL AREAS OF KUCHA WOREDRA, GAMO
ZONE, SOUTHERN ETHIOPIA

MASTER OF SCIENCE THESIS

BY

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HAWASSA UNIVERSITY, HAWASSA, ETHIOPIA

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DECLARATION

I hereby declare that this MSc thesis is my original work and that has not been presented for a degree in any other university and all sources of material used for this thesis have been duly acknowledged.

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Table of Contents

DECLARATION	iii
ACKNOWLEDGEMENT	iv
LIST OF ACRONMYS & /ABBREVIATIONS	ix
LIST OF TABLES.....	xi
LIST OF FIGURES	xii
LIST OF APPENDICES	xiii
1. INTRODUCTION	1
1.1. Background.....	1
1.2. Statement of the problem	3
1.3. Objectives	4
1.3.1. General objectives.....	4
1.3.2. Specific objectives	4
1.4. Research questions.....	4
1.5. Significances of the study	4
1.6. Scope of the study	5
2. LITERATURE REVIEW.....	6
2.1 Water supply and sanitation worldwide and in Africa	6
2.2 Water Supply and Sanitation in Ethiopia.....	7
2.3 Existing estimates of per capita water requirements.	8
2.4 Water demand analysis	9
2.4.1 Population Growth.....	10
2.4.2 Socio-economic Changes	11
2.4.3. Population forecasting.....	11
2.5. Sanitation and hygiene promotion	11
2.5.1. Domestic rural water supply and sanitation in socio- economic development	12

2.5.2. Causes for Poor Sanitation Coverage	13
2.5.3. Economic Causes	13
2.5.4. Socio-Cultural Causes	14
2.6. Water Quality	14
2.6.1. Physicochemical Water Quality Aspects	15
2.6.2. Bacteriological Water Quality Aspects.....	17
2.6.3. Water quality standards and guidelines.	18
3. MATERIAL AND METHOD	19
3.1. Description of the study area.....	20
3.1.1 Topography and Climate	21
3.1.2 Population.....	21
3.1.3 Economic and Infrastructure	21
3.1.4 Drainage and Water Sources of the Rural	22
3.2 Data source and collection instruments	22
3.2.1 Households water use pattern and sanitation status	22
3.2.2 Data Collection Methods.....	25
3.2.2.1 Primary Data Collection.....	25
3.2.2.2. Secondary Data Collection.....	26
3.2.5. Document Review.....	26
3.2.6. Statistical Data	27
3.3. Multiple linear regression	27
3.3.1. Dependent variable for household water coverage	28
3.3.2. Independent variables for household water coverage	28
3.4. Present and future population projection	30
3.4.1 Domestic Water Demand (DWD)	30
3.4.2. Commercial and institutional water demand (CIWD).....	31
3.4.3 Industrial water demand (IWD).....	31

3.4.4. Livestock water demand (LWD)	31
3.4.5. System losses (SL)	33
3.4.6 Institutional Demand (ID)	33
3.4.7. Total average daily demand (ADD)	34
3.5. Assessment of sanitation condition of the Woreda	34
3.6. Water quality parameters	34
3.6. Water quality assessment	35
3.6.1. Sample points and parameters determination for water quality analysis	35
3.6.3. Analysis of Physicochemical Parameters	37
3.6.4. Analysis of Bacteriological Parameters	38
3.7. Statistical Data Analysis	39
3.8. Ethical consideration	39
4. Results and Discussions	40
4.1 General information of the respondents	40
4.2. Household water use and collection	41
4.3 Waiting time for fetch water	44
4.3.1. Distance /spatial distribution of water points in the woreda	45
4.3.2. Container Volume (Liter per capita per day)	45
4.1.4. Habit of household water use	47
4.1.5. Water supply system and consumers satisfaction	47
4.1.6. Water points characterization, their current status and coverage	48
4.1.7 Population and water demand projections	51
4.2. FACTORS ANALYSIS	52
4.2.1. Evaluating of household water coverage in the study area	53
4.3. Sanitary and Hygienic practices	55
4.3.1. Existence of latrines	55
4.3.2. Types of latrines constructed	56

4.3.3. Disposing of liquid and solid wastes.	57
4.3.4. The habits of using pit latrines	58
4.3.5. Materials used for washing hands after defecation	59
4.4. Water quality at the source, storage and point of use.....	60
4.4.1. Physicochemical analysis for the source, storage and point of use	60
4.4.2. Bacteriological analysis for the source, storage and point of use	64
5. Conclusion and Recommendation	67
5.1. Conclusion	67
5.2. Recommendation	69
6. Reference	71

LIST OF ACRONMYS & /ABBREVIATIONS

ADF	Africa Development Fund
ADD	Total average daily demand
BOD	Biochemical oxygen demand
BOH	Bureau of Health
BOWI	Bureau of Water and Irrigation
CFU	Colony Forming Unit
CSA	Central Statistical Agency
COD	Chemical oxygen demand
CIWD	Commercial and institutional water demand
DWD	Domestic water demand
DOC	Dissolved organic carbon
EC	Electrical conductivity
EPA	Environmental Protection Agency
ES	Ethiopian Standards
FDRE	Federal Democratic Republic of Ethiopia
GIS	Geographic Information System
GPS	Global Positioning System
GTP	Growth and Transformation plan
GZWME	Gamo zone water mine and energy Department
IWD	Industrial water demand
ID	Institutional Demand
JMP	Joint Monitoring Programmed
KWRADO	Kucha woreda rural agricultural deve
KWMEO	Kucha woreda water mine and energy office
KWHO	Kucha woreda health office
LWD	Livestock water demand
MDG	Millennium Development Goals
MoH	Ministry Of Health
MoWRD	Ministry of water resource development
NGOs	Non-Governmental Organizations

NTU	Nephelometric Turbidity Unity Southern
SL	System losses
SS	Spot Spring
SER	South, Ethiopia Regional
SPSS	Statistical Program for Social Science
SW	Shallow Well
TC	Total Coliform
TDS	Total Dissolved Solid
TOC	Total organic carbon
TON	Threshold odor number
UN	United Nations
UNDP	United Nation Development Programmers
UNICEF	United Nations Children's Fund
USEPA	United States Environmental Protection Agency
VIF	Variance Inflation Factors
WHO	Word Health Organization office
WSS	Water Supply and Sanitation

LIST OF TABLE

Table 1. Water and sanitation coverage by region.....	8
Table 2. Existing water supply schemes in Gamo zone (GZWMED, 2020)	8
Table 3. Existing water supply schemes in Kucha Woreda (KWMED, 2021).	8
Table 4. Improved and Not Improved Water Supply and Sanitation Technologies	13
Table 5. Maximum allowable concentrations of water quality parameters for drinking	18
Table 6. Chemical Parameters (WHO, 2011 and ES, 2013	18
Table 7. Bacteriological Parameters (WHO, 2011 and ES, 2013)	19
Table 8. Summary of livestock population.....	22
Table 9. Sample respondent taken from different targeted kebele	25
<i>Table 10. Population projection for livestock water demand of kucha woreda rural area (2015-2035).</i>	33
Table 11. Water quality parameters (WHO 2012).....	34
Table 12. Major Physiochemical and bacteriological parameters for the analyzed water sample	36
Table 13. Sampled water supply schemes for quality analysis	37
Table 14. Age distribution of respondents	40
Table 15. Occupation, education level of respondents and house hold members responsibility of fetch water	41
Table 16. Different purposes for which respondents use water.....	42
Table 17. The average water demands of respondents in liters per household per day.....	42
Table 18. The average time to fetch drinking water (minutes per household)	44
Table 19. Water consumption in liters per capita per day.....	46
Table 20. the results of sanitation and hygiene practices of the consumers at the households, Sanitation and hygiene practice of consumers.....	47
Table 21. Evaluates of household water coverage model result.....	54
Table 22. Type of pit latrine in the study area	57
Table 23. Reasons of the respondents who have latrine for not using it regularly	58
Table 24. the hand washing materials after defecation.	59
Table 25. Mean values of physicochemical parameters for the source, storage and point of-use.	61
Table 26. the value of bacteriological parameter for the source, storage and point of use.	64

LIST OF FIGURES

Figure 1. Geographical location of the study area	20
Figure 2. Schematic Presentation of Sampling Design	23
Figure 3. Cattle troughs in the study area.....	32
Figure 4. Water Source/point mapping of the study area.....	36
Figure 5. Spatial distribution of the schemes.	45
Figure 6 . Some of existing water supply schemes in the study area.....	49
Figure 7 Schematic representations of types of schemes in the Woreda and their status	50
Figure 9 the value of temperature at the source, storage and point of-use.....	62
Figure 11. the value of phosphate at the source, storage and point of-use.....	63
Figure 12.the value of Iron at the source, storage and point of-use.....	64
Appendices 13. Different sources of water used by the communities in each kebeles.....	97

LIST OF APPENDICES

Appendix 1 Socio-Demographic Characteristics of Respondents	74
Appendix 2 Multiple linear regression adjusted R square	79
Appendix 3 ANOVA for multiple linear regressions	80
Appendix 4 multiple linear regression model result	80
Appendix 5 Sampled water supply schemes for coverage and quality analysis	82
Appendix 6 Descriptive Values for the Source, Storage and Point of Use	83
Appendix 7 Results for the Source, Storage and Point of Use	89
Appendix 8 Mean value of Physicochemical and Bacteriological analysis of sample points of source, storage and point of use from kuto kebele.....	92
Appendix 9 Mean value of Physicochemical and Bacteriological analysis of sample points of source, storage and point of use from delewoyza kebele.	93
Appendix 10 Mean value of Physicochemical and Bacteriological analysis of sample points of source, storage and point of use from basso kebele.	94
Appendix 11 Mean value of Physicochemical and Bacteriological analysis of sample points of source, storage and point of use from fango kebele.....	96
Appendix 12 Mean value of Physicochemical and Bacteriological analysis of sample points of source, storage and point of use from kullo kebele.....	96
Appendices 14. Projected Water Demand (m3/day) for the year 2015 - 2035.....	91
Appendices 15. Respondent's satisfaction of water supply.....	91
Appendices 16. Respondents satisfaction of water supply.....	92

ABSTRACT

Safe water supply and sanitation services are basic requirements for a society. Limited access associated with poor water supply, sanitation and hygiene make the community to depend on unsafe and improvement of basic water supply and sanitation services to give proper and timely response. Thus, this study was conducted to evaluate coverage and quality of potable water supply and sanitation services and forecast the future demand by 2035 for Kucha Woreda. Five Kebele administrations were selected by purposive sampling technique. Totally 110 households (HHs) were selected as a sample population for primary data sources are then distributed to each Kebeles proportionally by using purposive sampling technique. The data sources for the study were both primary and secondary. For secondary data collection document review was used as a tool to collect valuable information. Household surveys, personal observations and key-informants interview were used for primary data collection. The data from households were analyzed using descriptive statistical techniques and explanation building. The inferential statistics one way ANOVA and were descriptive statistical employed to see the statistical significances and associations of the variables respectively. The major finding showed that there are low coverage (21.9%), inadequate spatial distribution of water points (58.4%), low per capita consumption (an average of 7.36 liters), with almost all residents consuming less than 25 liters of safe water, and waiting water-fetching times (an average of 52. 5 minutes). Likewise, sanitation situation was not so healthy and encouraging. Many factors were responsible for poor sanitation. Some of them were lack of proper disposal of garbage and toilet waste and lack of knowledge of rural people about personal hygiene and health. The survey result showed that more than 51.4% of the households were disposing baby faces and solid wastes in the open field, majorities of them (26.5.%) using water only, water use and ash 14.1% of respondents in the study area don't use water at all for hand washing after defecating. The result of water quality test of the study area obtained overall water quality indicates that most parameters are within standard except parameters like Temperature, Iron and phosphate that do not fulfill the WHO and Ethiopian drinking water standards. Bacteriological results show that the presence pathogens i.e. total coliform four water sample sites contaminated exceeding the WHO and Ethiopian standards which do not allow any fecal or total colonies in drinking water.

Key words: Coverage, Quality of Potable Water, Sanitation, in the kucha woreda

1. INTRODUCTION

1.1. Background

Sustaining natural resource is critical for the survival of all living Organisms, food production and economic development. Problems in providing satisfactory water supply to the rapidly growing population especially that of the developing countries is increasing from time to time. The sustainable provision of adequate and safe drinking water is the most important of all Public services (Dassalew, 2017). In Ethiopia, due to lack of access to improved water supply and sanitation, people are suffering from water communicable diseases that are associated with unsafe and inadequate water supply.

Provision of quality rural infrastructure system has become a major concern in many developed and developing countries. Contrary to this, the quality aspect of providing water has been downplayed by the focus put on access provision to this infrastructure. This is mostly the case of water supply provision and other basic infrastructure. The low quality of rural infrastructure such as water supply and sanitation may be detrimental to the environment leading unhealthy living conditions. The performance of one infrastructure may affect the other due to their interconnection such as water supply and sanitation are highly interrelated. Hence, understanding this integration and interrelation provide a better consideration on the importance of providing quality infrastructure (Bekele, 2010).

SDG 6 focuses on ensuring a clean and stable water supply and effective water sanitation for all people by the year 2030. The goal is a reaction to the fact that many people throughout the world lack these basic services. About 40 percent of the world's population is affected by a lack of water. As global temperatures rise, that total is expected to increase. Already, some of the poorest countries in the world are affected by drought, resulting in famine and malnutrition. Throughout the world, about 1.7 billion people live in a watershed where water is used faster than the watershed can be replenished. According to some estimates, if such trends continue, one in four people, or more, might experience water shortages on a regular basis by the year 2035.

Today's awareness and concern of safe drinking water in developing country is increased from ever. In sustainable world, sufficient and safe water is made available to meet every person's basic needs (WWAP, 2015). Ethiopia is becoming a challenge for most water utilities. Problems in providing satisfactory water supply to the rapidly growing population especially that of the developing countries is increasing from time to time (Asmelash, 2014). Water is the primary need to sustain life every citizen in the country has the right to have access to potable water. Access to safe drinking water supplies and sanitation services in Ethiopia are among the lowest in Sub-Saharan Africa (Seifu, 2012).

Access to clean and safe drinking water is a fundamental human requirement. However, in many areas of the world natural water sources have been impacted by a variety of biological and chemical contaminants. The ingestion of these contaminants may cause acute or chronic health problems. To prevent such illnesses, many technologies have been developed to treat, disinfect and supply safe drinking water quality (Dewitt, 2015). Provision of safe and adequate water supply services is necessary components for sustainable development. A water supply system is a collection of water transport structures, pumping stations, and water treatment and storage facilities that are managed to supply the desired amount of water with the desired quality to consumers. The estimated water supply service level of Ethiopia in terms of coverage, quantity, quality and reliability is very low.

Ethiopia is very well known for its enormous potential all of which is generated in its own tertiary and it is still known the water towers in Africa. However, access to sufficient and potable water sources and sanitation facilities is a challenge in the majority of Ethiopian rural. Similar issues with water supply and sanitation coverage have plagued Kucha woreda in recent years.

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 (KWMEQ, 2018).

This study is conducted in Kucha Woreda, Gamo zone, south Regional State, the water supply and sanitation challenges are still untouched and unsolved problems. The Institutional, health officers considered from their observation and experience that the problem of water in kucha woreda is growing from time to time. Improving the water supply coverage and evaluating from

source to point of use and seasonal variation of water quality 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

Ethiopia ranks among the lowest countries in the world in levels of safe water and sanitation coverage 66% of Ethiopia's 83 million citizens do not have access to an improved water supply and 79% lack access to basic sanitation. The majority of Ethiopia's citizens live in rural areas where rates of coverage are even worse. Among rural Ethiopians, only 34% have access to an improved water supply (Bekele, 2013). Kucha is one of the Woreda found in rural Ethiopia, where the community does not have access to potable water and basic sanitation. Thus, the communities are forced to use water from unprotected water sources, which they may share with their animals. Access and coverage of potable water supply and sanitation services are supposedly very sounding problem in study area. It is observed that there are several factors in the community that were likely resulting in water contamination at sources or during collection, storage and point of-use in household level.

The other major problems related to water, sanitation and hygiene in the study area are lack of awareness for sanitation and hygiene practice managements of water supply schemes. Moreover, pesticides used in agricultural fields impose additional burden in the study area. Diarrhea, gastroenteritis, malaria, typhoid, and hepatitis are the most prevalent water associated communicable diseases in the study area that varies from season to season Kucha Woreda Health office (KWHO, 2020).

Despite various efforts made by government and non-governmental organizations on the development of water supply schemes of the study area there is still a critical information gap on the water consumption pattern of households, water supply coverage, accessibility, future water demand forecasting, and sanitation coverage. This research work therefore, specifically investigated the coverage and sanitation, water demand; quality of potable water: the gap associated with water scarcity to initiate intervention measures in order to address the aforementioned problems in study area.

1.3. Objectives

1.3.1. General objectives

The main objective of this research is to assess coverage and quality of potable water and sanitation in the study area.

1.3.2. Specific objectives

1. To assess the current status of water service coverage in the study area and project future water demand by 2035.
2. To evaluate the current sanitation and hygiene condition in the study area.
3. To evaluate the drinking water quality in rural areas using established standards.

1.4. Research questions

1. How do users evaluate the existing water supply and sanitation against their satisfaction?
2. Why demand for water exceeds the supply of water?
3. How can the sanitation coverage in the study area be evaluated?
4. Does the water quality in the study area meet the standards set for drinking?

1.5. Significances of the study

This study is expected to increase the knowledge and up to date information for individuals who are interested to study further on the coverage, demand, quality of drinking water and sanitation status in the study area. It was serving as a working document to policy makers in the water sector and the nongovernmental organizations. Furthermore, it will help to draw possible suggestions and recommendations in order to improve status of water supply and sanitation and also quality of drinking water in the study area. Farming, raising animals, and small-scale industry all depend on having access to water. More hygienic and clean surroundings encourage investment, tourism, and other economic activity. This is made possible by improved sanitation facilities. Lack of access to clean water and sanitation services disproportionately affects women and girls. Water collection, which can be labor-intensive and physically taxing, is typically their task. By providing them with the time they need for education, earning activities, and personal growth, access to clean water and hygienic facilities may empower women and girls. The local environment is taken into consideration when researching sanitation and the availability of water

in rural locations. For the purpose of maintaining long-term environmental sustainability, to promote public health, improve quality of life, foster economic development, ensure gender equality, protect the environment, and increase disaster resilience in these communities, it is imperative to conduct research on the coverage of water supplies, sanitation, and the potability of water for drinking purposes in rural or remote areas.

1.6. Scope of the study

The focus of this study is on water supply and sanitation constructed in the rural part of Kucha woreda. This study specifically emphasizes on evaluation of rural coverage, sanitation and hygiene and potable water quality. The study area was limited to rural Kebeles in the Woreda. The study covers selected five Kebeles of water supply and sanitation where data generated from selected water supply schemes and household beneficiaries. Only rural Kebeles in the Woreda had a subject of the investigation.

2. LITERATURE REVIEW

2.1 Water supply and sanitation worldwide and in Africa

Water and sanitation are about much more than health (Cairncross et al., 2008). Access to safe drinking water is important as a health and development issue at national, regional and local levels. In some regions, it has been shown that investments in water supply and sanitation can yield a net economic benefit, since the reductions in adverse health effects and health care costs outweigh the costs of undertaking the interventions. This is true for major water supply infrastructure investments through water treatment in the home. Experience has also shown that interventions in improving access to safe water favor the poor in particular, whether in rural or urban areas, and can be an effective part of poverty alleviation strategies (WHO, 2004). According to UNESCO (2006), every person needs 20 to 50 liter of potable water a day for their basic needs: drinking, cooking and cleaning, but more than one in six does not have access to such amount of potable water. Africa has the lowest total water supply coverage of any region, with only 62 percent of the population having access to improved water supply. The situation is worst in rural areas, where coverage is only 47 percent. According to the WHO/UNICEF (2010), around 2.6 billion people do not have access to basic sanitation; and as a result of poor access to basic sanitation 1.5 million peoples die each year. Many of these people live in south East Asia and sub-Saharan Africa. Sanitation coverage in Africa also is poor, only 60 percent of the total population in Africa has sanitation coverage, with coverage varying from 84 percent in urban areas to 45 percent in rural areas as shown in the Table 1. Water and sanitation coverage by region (WHO/UNICEF, 2010).

Region	Water supply (%)	Sanitation (%)
Africa	62	60
Asia	81	48
Latin America and Caribbean	85	78
Oceania	88	93
Europe	96	92
North America	100	100

2.2 Water Supply and Sanitation in Ethiopia

Provision of safe and sufficient water supply and adequate sanitation services are indispensable components in the sustainable development of Ethiopia's urban and rural socioeconomic wellbeing. At present, most of the population does not have adequate and safe access to water supply and sanitation (WSS) facilities. As a result, over 70% of the contagious diseases in the country are water borne/based diseases. Source of most of these diseases could be traced back to inadequate WSS facilities (MoWR, 2006).

Ethiopia has been trying to supply potable water to its population, without great success, for more than a century. While water for agricultural use has attracted high levels of investment, water resource management for domestic supply has been relatively neglected, especially before the post imperial period. Even today, rural water supply programs, which affect the majority of the country's population, have not been given sufficient attention (Rahmato, 2012).

However, it has been noted that about 27% of the water supply schemes are non-functional at any given time. The causes for non-functionality are; technical break down (45%), low yield (21%), management/financial problem (20%) and others like water quality (14%). However, lack of sustainability of project aggravated the existing poor coverage of water and sanitation implying negative impacts on coverage and on the attainment of the plan. However, due to the efforts made by governmental and non-governmental organization, the number of people with access to potable water supply increases from 38.7% to 58.7%, at the end of 2014(Bekele, 2017).

Gamo zone is located in the area of southwest corner. In towns, kebele water coverage is up to 59% within per consumption rate of 40 liter/capital/day with in 0.5km, and coverage rate for access to safe water is 37% for rural areas up to 49% with per consumption rate of 25 liter/capital/day within 1km. The non-functionality rate in rural areas is 37.46%. (GZWMED 2020). Different groups, such as governmental and non-governmental organizations, develop these supply systems at various times. Totally available water supply schemes in the Zone are; -

Table 1. Existing water supply schemes in Gamo zone (GZWMED, 2020)

Water supply schemes	Hand dug well	Rope pump	Shallow well	On spot spring	Borehole	Spring with distribution
No	114	65	208	689	32	457

The Zonal and Woreda Water Office has noted that the Woreda has enormous ground and surface water potential. Despite the Woreda's ability to supply groundwater, not all Kebeles can afford to have adequate water systems built. Even in Kebeles, where there are upgraded water schemes, the water supply is insufficient for everyone, and the operating schemes themselves are unable to offer adequate and reliable services to respective populations for a variety of reasons. About 34.8% of the Woreda is covered by water. Only 10,783 beneficiaries have access to safe water, and the remaining 143,781 people acquire their water from rivers and springs that are not protected kucha woreda water mine and energy offices (KWMEO., 2021).

It has been noted that there has been no coordination, cooperation, or collaborations among. Due to this reason; 46% of water schemes are non-functional, 45% of schemes cannot cover operation and maintenance costs, 56% of the scheme catchments are poorly managed and water scheme committees are not well equipped to effectively manage water schemes (KWMED, 2021). These supply systems are constructed by different organizations such as governmental and non-governmental organizations at different times. Totally available water supply schemes in the Woreda are; -

Table 2. Existing water supply schemes in Kucha Woreda (KWMED, 2021).

Water supply schemes	Hand dug well	Rope pump	Shallow well	On spot spring	Borehole	Spring with distribution
No	13	18	41	33	5	55

2.3 Existing estimates of per capita water requirements.

Water requirements have been developed. The WHO and in their global assessment of water supply adopted the figure of 20 l/c/d for domestic hygiene purposes from a source located within one kilometer of a person's dwelling and coming from one of a range of technologies generally

considered capable of supplying safe water. No clarification was given, however, about how their estimate of 20 l/c/d was derived. Gleick argues that at least 50 l/c/d are required to meet human and ecological needs, namely 5 l/c/d for drinking in tropical climates, 20 l/c/d for sanitation, 15 l/c/d for bathing and 10 l/c/d for food preparation (Gleick, 1996). Howard and Bartram argue that 7.5 l/c/d can be calculated as the basic minimum water requirement to meet direct human consumptive needs, of which 12 l/c/d is required for food preparation. When water required for maintaining human hygiene is considered also, calculating a minimum water requirement becomes less precise as the effective use of water for hygiene purposes is more important than the quantity used, with only a very small quantity of water required to prevent water acting as an absolute constraint on hygiene). With basic access of approximately 20 l/c/d (7.3 m³/c/y) it is unlikely that all water requirements for hygiene will be met; at 50 l/c/d (18.3 m³/c/y) (intermediate access) most requirements can be met, and at 100 l/c/d (36.5 m³/c/y) (optimum access) all requirements can be met (Howard and Bartram, 2003).

2.4 Water demand analysis

Evaluation of the amount of water available and the amount of water demanded by the public are primary tasks in designing any water supply system. Demand of water is the amount of water required to meet all the needs of the people, which the system serves. It is expressed as per capital per day (l/c/d). Water resource planning requires reliable forecasts of population and water demand. Increasing populations translate into increased water demand for municipal, residential and commercial uses. Community growth, the growth of local commerce and industry and the development of new industries all increase demand for water. In planning the water system it is necessary to find out not only the total yearly water requirement but also to assess the required average rate of flow and the variation in these rates (Kaika, 2003).

System water demand is the quantity of water that the treatment plant must produce in order to meet all water needs in the community (Willem, 2009). Water demand includes water delivered to the system to meet the needs of consumers, water supply for firefighting and system flushing, and water required to properly operate the treatment facilities (Santosh, 2012). Additionally, virtually all systems have a certain amount of leakage that cannot be economically removed and thus total demand typically includes some leakage. The difference between the amount of water sold and the amount delivered to the system is referred to as unaccounted water. Unaccounted water can result from system flushing, leakage, firefighting, meter inaccuracies, and other non-

metered usage. Different literature likes Santosh (2012); Willem (2009) states that in assessment of quantity of water demand for the public in the town, the demand were broken down in to the following class. Domestic water demand, Institutional water demand, Industrial water demand, Fire demand, Losses and waste (Unaccounted water).

Domestic water demand : It includes the quantity of water required for various domestic usage such as bathing, drinking, cooking, flushing toilets, washing clothes, tooth-cleaning, food preparation, cleaning cooking and eating utensils, etc. (Santosh, 2012). The total domestic water consumption shall be equal to the total design population multiplied by per capital domestic consumption.

Institutional water demand: This includes the quantity of water required for various public utility purposes. Parks, playground, gardening sprinkling on road street foundation, banks; Churches were come under this demand (Santosh, 2012). Estimates that the total Institutional water consumption usually about to 10 % of the total water consumption.

2.4.1 Population Growth

The design of the water supply projects is done on the basis of projected population since it is the main factor which affects the water supply project. Future population growth can be influenced by affecting birth, death, or migration rates due to social, economic, political, technological, and scientific developments (Lee and Tuljapurkar, 2010; O'Neill et al., 2012). The two approaches commonly used for characterizing uncertainty in demographic forecasting are scenario and probabilistic. Scenario uses to describe its projections in consistent story in which fertility, mortality, and migration assumptions are embedded to provide a comprehensive picture of what the future might be. Probability distribution explicitly accounts for uncertainty in projected trends of fertility, mortality, and migration; and derives the resulting probability distributions for projected population size and age structure (Khatri and Vairavamoorthy, 2013). The knowledge of population forecasting is very important for the design of any water supply scheme. The design is done on the basis of projected population at the end of the design period. Otherwise a present scheme will be inadequate in the near future (Chatterjee, 2009).

Unaccounted water: This includes the quantity of water losses in leakage due to bad plumbing or damaged meters, stolen water due to unauthorized connection, and other loss and wastage.

Normally, this quantity should not exceed 20% of total water supply for a well-managed water work (Santosh, 2012). However, it cannot be less than 15%

2.4.2 Socio-economic Changes

There is a strong correlation between water consumption and socio-economic changes. Examples are changing life style, changing housing type and household size, acceptability, and market penetration of water efficient appliances alternative sources of water, economic development, employment opportunities, education level, and water pricing (Bradley, 2010; Clarke et al., 1997; Scheider 1991). Forecasting and describing these parameters are subjected to uncertainties

2.4.3. Population forecasting

After the design period has been fixed, the population of the area in various periods has to be determined. As population of the area increases in the future, the correct present and past population data have to be taken form census office to determine design population the area by considering growth rate of the town (Santosh, 2012). There are various methods adopted by engineers to estimate the future population's growth. Those are: Arithmetic increase method, Geometric increase method, Incremental increase method, Simple graphical method and Master plan method.

Arithmetic increase method: This method is based on the assumption that the population is increasing at a constant rate. The rate of change of population with time is constant

Geometric (Uniform) increase method: This method assumed that the percentage increase in population from decade to decade remains constant. The average percentage of growth of last few decades is determined; the population forecasting is done on the basis that percentage increase per decade was the same (Santosh, 2012).

Were P_0 = Initial population; i.e. the population at the end of last known census P_n = Future population after n decades r = Assumed growth rate (%) Santosh (2012) states that this method gives somewhat larger value as compared to arithmetic method and can be used for new cities with rapid growth.

2.5. Sanitation and hygiene promotion

Adequate sanitation and good hygiene knowledge and practice are more important for protecting water supplies than any other factor. Removing faeces safely from the environment eliminates

the main source of water pollution. The proper use and maintenance of water facilities and the hygienic transport and storage of water protects the water supply chain from faecal contamination. But the importance of sanitation and hygiene goes far beyond protecting water quality because water is not the only transmission route in the faecal oral cycle. Improving the quality of water in sources, systems and homes can result in significant health benefits. However, one of the most important lessons learned from water supply programmes worldwide is that maximum health benefits are achieved if water interventions are accompanied by sanitation and hygiene promotion. (MOWR, 2006).

2.5.1. Domestic rural water supply and sanitation in socio- economic development

Water supply and sanitation are among two of the most important sectors of development (Bendahmane, 1993). As water demand grows, water stress increases, and the poor find it more difficult to meet their water needs. Water sources are often distant, polluted or intermittent. The burden falls especially heavily on women who typically end up doing most of the water collection and children who typically suffer most from the diseases associated with inadequate water supplies (Briscoe and Garn, 1995).

The provision of safe drinking water and basic sanitation contributes to sustainable improvements in peoples' lives regarding their health and education situation, the preconditions for productive employment as well as for the eradication of extreme hunger and the empowerment of women. Development of community water supplies and sanitation results in improved social, economic and health conditions (Davis, et al., 1993). The Global Water Supply and Sanitation Assessment 2000 Report by WHO/UNICEF differentiates between the term "improved" and the terms "safe" and "adequate" because of the lack of information on the safety and adequacy of water supplies and sanitation facilities.

Table 3. Improved and Not Improved Water Supply and Sanitation Technologies

Type of Technology	Water Supply	Sanitation
Improved Technologies	Household connection Public standpipe Borehole Protected dug well Protected spring Rainwater collection	Connection to a public sewer Connection to a septic system Pour- flush latrine Simple pit latrine Ventilated improved pit latrine
Not Improved Technologies	Unprotected well Unprotected spring Vendor-provided water Tanker truck provision of water	Service or bucket latrines Public Latrines Open Latrine

2.5.2. Causes for Poor Sanitation Coverage

Sanitation is an aspect that goes hand in hand with a steady and safe water supply. The world health organization states that sanitation refers to “the provision of facilities and services for the safe management of human excreta from the toilet to containment and storage and treatment onsite or conveyance, treatment and eventual safe end use or disposal” (2020). The organization goes on to explain that sanitation also includes the management and containment of solid waste and animal waste (WHO, 2020).

2.5.3. Economic Causes

According to Ethiopian Ministry of Health (2005), the well-known negative synergy of Diarrhea disease, malnutrition and opportunistic infections are known to have short-term health impacts and long term debilitating effects. Thus, it is clear that human waste is potentially dangerous material which needs to be managed properly. But there are some factors which may prohibit people from adopting latrine services, of which economic reason is to be listed as the main and the first. Poor people rely on subsistence income, of their income they prefer to spend on food and goods, than spending it on latrine construction (Betel hem, 2011). Of course it could be expensive to build a latrine for someone who doesn’t secure his food. Even if people understand having latrine is beneficial, they may not be able and willing to spend high cost on it Though economic status inhibits people to build their own latrines, on the other hand this shows that,

people do not realize the costs they spend on treating diseases cause of unsanitary environment, which the costs for curing might be higher than preventing. Thus, if people had aware of the consequences of unhealthy environment, the costs to prevent its consequences like diarrheal diseases would be the easiest than treating the diseases. So investing on latrine is also a means of minimizing expenses of medication comes after unhealthy living environment because of poor sanitation

2.5.4. Socio-Cultural Causes

There are also socio-cultural reasons why people do not adopt latrine use; ‘what is dirty and clean can vary from culture to culture’. Many people view latrines as evil and dirty places. As a result people may prefer to defecate away from their houses in the fields which are considered more sanitary. Of course, it might be difficult to change long ingrained behavior dictating defecation practices; without proper support people will revert to old habits. The practice of open defecation is ritualized and bound in tradition. Both the economic and socio-cultural reasons for unimproved sanitation do not outweigh the costs of the consequences because of unimproved water and sanitation. In addition to the above reasons the study conducted in three African countries: Zambia, South Africa, and Zimbabwe; illiteracy, lack of strong linkages between sanitation service providing agencies and communities, supply-led approach in providing sanitation service, and lack of effective communication between the local authorities and the communities are found to be some of the causes for poor sanitation (WHO, 2020).

2.6. Water Quality

Additionally, water quality problems are booming in water sources of the country that demand effective monitoring and evaluation for the proper protection of water sources from contamination.

To provide safe water, there is a need to ensure that the quality of drinking water assessed and monitored. Even a personal preference such as taste is a simple evaluation of acceptability. Drinking water qualities assessed by comparisons of water samples to drinking water quality guidelines or standards. These guidelines and standards provide for the protection of human health by ensuring that clean and safe water is available for human consumption (WHO, 2008, Bekele, 2017).

2.6.1. Physicochemical Water Quality Aspects

Physicochemical parameters are the physical and chemical parameters associated with water which have an influence on its quality and also affect the biological constituents of the water. Temperature, microorganisms. Thus, turbid conditions may increase the possibility for waterborne disease. Turbidity can have a significant effect on the microbiological quality of water. Microbial growth in water is most extensive on the surface of particulates and inside loose, naturally- occurring flocks. River silt also readily adsorbs viruses Temperature in analysis of the physicochemical quality of water samples, temperature considered as a critical parameter. 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 15°C 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, and odor and color problems. Temperature also affects water treatment.(Semaria, 2017). Turbidity may also be associated with the presence of inorganic ions such as manganese (II). For example, when water containing manganese(II) ions is treated with chlorine and left to stand, slow reaction kinetics indicate that colloidal manganese(IV) oxide is formed, leading eventually to the formation of a fine precipitate (SAWQD, 1996).

PH is one important water quality parameter, the pH of water, affects the biochemical processing water. Most drinking water have a pH from 4 to 9 and the majority are slightly alkaline due to carbonates and bicarbonates of calcium and magnesium dissolved in water with variable pH are most likely contaminated and indicating the introduction of industrial wastes (Hutton, 1996).

Electrical Conductivity (EC) is a measure of how well water can conduct an electrical current, Conductivity increases with increasing amount and mobility of ions (Selamawit, 2012).

Total dissolved solids is the term applied to the residue remaining in a weighed dish after the sample has been passed through a standard fiber glass filter and dried to constant mass at 103 – 105°C (Jürgen, 2004). The total dissolved solids (TDS) in water consist of inorganic salts and dissolved materials. In natural waters, salts are chemical compounds comprised of anions such as carbonates, chlorides, sulphates, and nitrates (primarily in ground water), and cations such as

potassium (K^{\pm}), magnesium (Mg^{\pm}), calcium (Ca^{\pm}), and sodium (Na^{\pm}). In ambient conditions, these compounds are present in proportions that create a balanced solution (WHO, 2008). Dissolved minerals, gases and organic constituents may produce aesthetically displeasing color, taste and odor. Some dissolved organic chemicals may deplete the dissolved oxygen in the receiving waters and some may be inert to biological oxidation, yet others have been identified as carcinogens. Water with higher solids content often has a laxative and sometimes the reverse effect upon people whose bodies are not adjusted to them (Jürgen, 2004).

Hardness is a measure of both the magnesium and calcium contained in the water and it relates to how the water can mix with soap. Too little hardness makes the water more corrosive while too much reduces the effectiveness of soap. Water that has a higher hardness inhibits soap from lathering and more soap is consumed than normal. This is quite disappointing to users in rural Ethiopia where soap is actually a luxury when it is available, WHO (2011) suggests levels between 150 and 300mg/L. Hardness levels greater than 200 are considered poor, but tolerable, while hardness levels greater than 500 are generally considered unacceptable (Stantec, 2009).

Fluoride is found naturally in much water; it is also added in many water systems to reduce tooth decay. Excessive fluoride concentration can cause stained or mottled teeth. This is true where the natural fluoride content is above 2.4mg/l the concentration of fluoride in drinking water is critical when considering the strength of growing teeth and bones (Dagnew et al., 2007).

Chloride is the anion of the element chlorine. Chlorine is the major constituent in water and wastewater with a wide range of concentration from few mg/l in clean rain to 10 of mg/l in super saturated, hot saline ground water. Chloride may be increased in surface water since it is concentrated in human and animal urine reaching watercourses. Human urine may contain 1-1.5% of NaCl. A related health problem of chlorine contamination in drinking water includes Eye/nose irritation; Anemia; Infants and young children: nervous system effects (WHO, 2008.)

Nitrates are the most oxidized forms of nitrogen and the product of the aerobic decomposition of organic nitrogenous matter. 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 levels in water can cause methemoglobinemia or blue baby syndrome, a condition found

especially in infants less than six months. The health effects of nitrate in drinking water are shortness of breath and blue-baby syndrome and other disorders.

Iron is one of the most abundant metals in the earth's crust. Iron contamination is a particular problem for anaerobic groundwater supplies, but 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. Iron also promotes the growth of iron bacteria, which oxidize ferrous iron to ferric iron and in the process, corrode the piping and deposit a slimy coating on its surface some surface waters also have iron problems, particularly related to colloidal iron.

Total chlorine or residual chlorine in areas where there is little risk of a water borne outbreak, residual free chlorine of 0.2 to 0.5 mg/l at all points in the supply is recommended. General system failures, inefficiency in disinfection, poor maintenance are some of factors that affect the quality of water in Ethiopia (Danger et al., 2007). Therefore, when water leaves the treatment plant residual free chlorine of about 1mg/l is needed for health reasons and it is recommended that such level be maintained at points of consumption (Moomba et al., 2006).

2.6.2. Bacteriological Water Quality Aspects

The most common bacteriological water quality indicators include TC, FC and E.coli. An indicator organism may not necessarily pose a health risk but it can be easily isolated and enumerated, is present in large numbers, is more resistant to disinfection than pathogens, and does not multiply in water and distribution systems (WHO, 2008). Indicator bacteria are used to evaluate the portability of drinking water because it would be impossible to accurately enumerate all pathogenic organisms that are transmitted by water. Coliforms are a group of bacteria with common characteristics used to indicate unacceptable water quality. The presence of any coliform organism in drinking water is used as an indicator of faecal contamination since they are the most sensitive indicator bacteria for demonstrating excretal contamination. Within the total coliforms group, E.Coli bacteria specifically used to indicate faecal contamination *Escherichia coli* (E.coli), a thermo tolerant coliform, is found to be the most numerous in animal or human faces of the total coliform group, rarely grows in the environment and is considered the most specific indicator of faecal contamination in drinking water. The presence of *Escherichia coli* provides strong evidence of recent faecal contamination (Era et al., 2002). System failures, inefficiency in disinfection, poor maintenance are some of factors that affect the quality of water

in Ethiopia (Danger et al., 2007). Therefore, when water leaves the treatment plant residual free chlorine of about (0.2-0.51mg/l) is needed for health reasons and it is recommended that such level be maintained at points of consumption (Moomba et al., 2006).

2.6.3. Water quality standards and guidelines.

Physical indicators of water include Turbidity, Color, Odor, Temperature, Electrical Conductivity WHO, 2008 *purposes*

Table 4. Maximum allowable concentrations of water quality parameters for drinking

S.No	Description	Unit	WHO Standard	Ethiopia Standard
1	Turbidity	FTU	5	5
2	Temperature	°C	15	15
3	Electrical Conductivity	µs/cm	2500	2500

Chemical parameters indicators of water include:

Table 5. Chemical Parameters (WHO, 2011 and ES, 2013)

S.No	Description	Unit	WHO Standard	Ethiopia Standard
1	pH	Mg/l	6.5-8.5	6.5-8.5
2	TH (CaCO ₃)	Mg/l	300	300
3	Chloride	Mg/l	250	250
4	Fluoride	Mg/l	1.5	1.5
5	Iron	Mg/l	0.3	0.3
6	Magnesium	Mg/l	30	30
7	Potassium	Mg/l	1.5	1.5
8	Total chlorine	Mg/l	5	5
9	Phosphate	Mg/l	0.1	0.1
10	Calcium hardness	Mg/l	300	300
11	Total alkalify	Mg/l	500	500
12	Bicarbonate alkalify	Mg/l	500	500
13	Carbonate (Co)	Mg/l	-	-
14	Sulfate (So ₄)	Mg/l	250	250

15	Dissolved Ammonia	Mg/l	1.5	1.5
16	Ammonium (NH ₄)	Mg/l	1.5	1.5
17	Sodium (Na)	Mg/l	200	200
18	Calcium (Ca)	Mg/l	100	100
19	Copper (Cu)	Mg/l	2	2
20	Nitrite (No ₂)	Mg/l	3	3
21	Sulfate (So ₄)	Mg/l	250	250
22	Carbonate (Co ₃)	Mg/l	-	-
23	Nitrate (No ₃)	Mg/l	50	50
24	Chromium (Cr)	Mg/l	0.05	0.05

Table 6. Bacteriological Parameters (WHO, 2011 and ES, 2013)

S.No	Description	Unit	WHO Standard	Ethiopia Standard	Incubation Temperature
1	Total coliform	(CFU/100ml)	0	0	
2	E.Coli(fecal coliform	(CFU/100ml)	0	0	

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.

3. MATERIAL AND METHOD

3.1. Description of the study area

Kucha woreda is found in Gamo Zone and located 182km far from the capital zone 62 km far from wolayta sodo. Kucha Woreda is sharing borders on the south by Dita and Deramalo, on the southwest by Gofa Zone, on the northwest by the South West Ethiopia Region, on the north by the Wolayita Zone, on the east by Boreda, and on the southeast by Kogota Woreda. Geographically, it is located between $6^{\circ}20'30''$ N to $6^{\circ}32'30''$ N, and $37^{\circ}22'30''$ E to $37^{\circ}30'0''$ E, and the elevation of the site is 1315 m.a.s.l. and the mean annual Minimum and maximum temperatures are 21°C and 25°C respectively. The averages mean annual temperature of Kucha woreda 22°C . The highest temperature occurs at February, March and April seasons. The river Deme passes near to Kucha woreda. The Deme River drains to Omo River. Kucha woreda is fall in kola eco-climatic zone characterized by hot climate. The average annual rain falls of 900mm-1200mm. The rural are composed of five administrative Kebeles namely kuto, Dele-woyza, baso, kulo and fango a was the total area of about 7,000 hectares with an average altitude of 1315 meters above sea level.

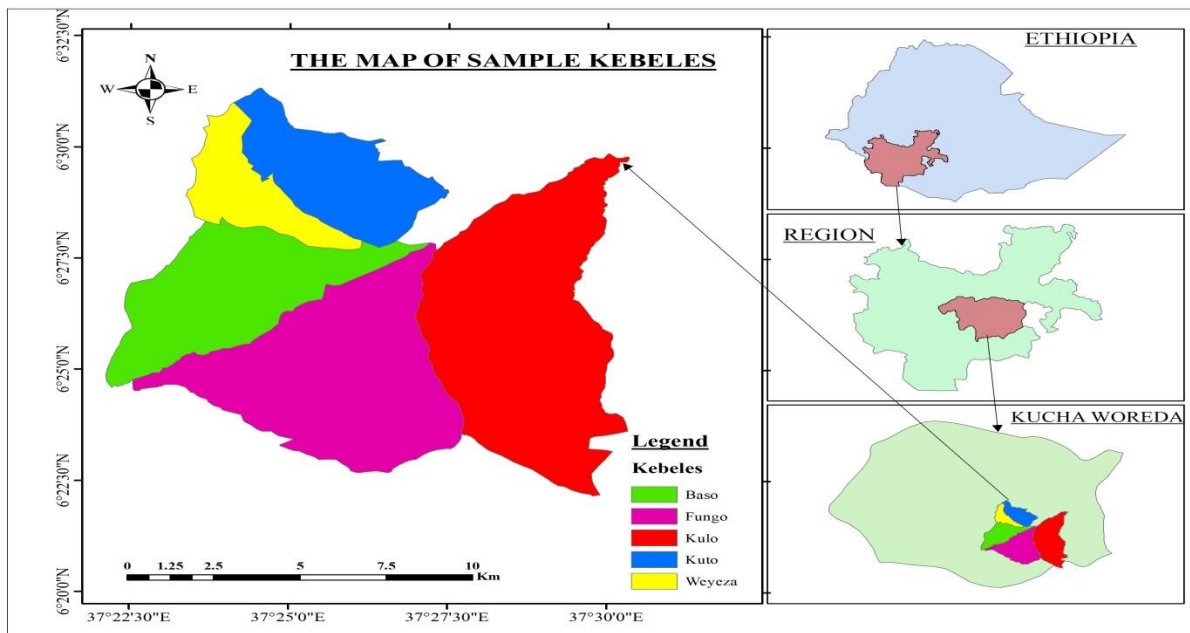


Figure 1. Geographical location of the study area

3.1.2 Topography and Climate

The rural kebele are located at an elevation of within the ranges between 900-1200m.a.s.l above sea level, with the kucha woreda's elevation ranging from 1315meters above sea level. The elevation of the rural often rises in the direction of the gofa sawula gravel road and declines in the direction of the wolaita sodd. Kucha woreda and its surrounding areas are located in the kola Agro-climate zone, which is known for its hot and sub humid environment. In Kucha Woreda, rainfall varies widely both annually and monthly. The months with the most rain are April, July, and August, whereas the months with the least rain are November and December. 900mm to 1200mm of rain falls on average each year.

3.1.3 Population

The central statistics authority estimates that there are 154,564 people living in the woreda as a whole. There are 76,595 men and 77969 women among them, or 47.9% of the total (CSA, 2007). According to the woreda population data created by the Kucha woreda, there are 154,564 people living there in total (CSA, 2007). Males make up 47.9% of the rural population overall, while females make up 52.1%.

3.1.4 Economic and Infrastructure

The Kucha woreda's primary economic activity is agriculture. According to the agricultural of the rural, various small-scale agricultural practices, such as garden crop production, are also prevalent in the rural. There are seven senior secondary and preparatory schools and fifty three elementary and primary schools in Kucha woreda.

There are seven health centers and one hospital is currently under construction in terms of the health care infrastructure. Moreover, data was also collected needed for analyzing the potential project beneficiaries, their preferences for a specific level of service and their willingness to pay for the level of service to be provided under the thesis.

Agriculture is the major source of income with major production of maize, haricot bean, sweat potato, teff and inset. As indicated in the following table the total population of livestock in the Woreda is 102,776 (KWRADO, 2014):-

Table 7. Summary of livestock population.

S. No	Name of livestock	Livestock population
1	Oxen and cows	65,344
2	Sheep and goats	28,754
3	Horses, mules and donkeys	8678
Total		102,776

3.1.4 Drainage and Water Sources of the Rural

Kucha woreda has located in the catchments of Deme Rivers. The flow of surface water originating from the surrounding areas joins these rivers; Deme River is found approximately 1kms north of the kucha woreda. There are ephemeral streams and natural springs, within the woreda, in addition to river which is found at the lower part of the woreda that flows through the year. The potable water sources of woreda are four natural springs namely kuto spring, Baso spring, delewoyza spring and kulo spring. From out of four spring, two (kuto and baso springs) are near the Selamber town. Though they found inside the town, they have served as tape water (Bono) on the point where it flows.

3.2 Data source and collection instruments

A combination of both primary and secondary data sources were used for the study. In any type of study, it is noted to assess the availability of secondary data before embarking upon the collection of primary data. The data related to sanitation of the study area was gathered from both primary sources. Coverage and demand analysis related issues were carried out using primary sources via questionnaire and secondary sources by referring different data sources published and unpublished and reports of various organizations for the whole study area. The water sources/points of the study area were located by GPS and the spatial distribution of water source/point of the whole study area and the study area were carried out using ArcGIS software.

3.2.1 Households water use pattern and sanitation status

To assess the water use pattern and sanitation status of the households, an interview was conducted with structured questionnaire. The questionnaires were both close and open ended questions. The 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.

3.2.1.1 Sampling techniques

For this study, from the total of 24 rural kebele administrations in kucha woreda, due to budget and time constraint 20% of the total kebeles of the woreda were selected by using purposive sampling techniques for household water use pattern and sanitation status as shown below. kucha woreda has two agro-climatic zones from which 70% was “Kolla” and 30% was “Woinadega”. Three sample kebeles were selected proportionally from “kola” agro-climatic Zone whilst the remaining two sample kebeles were selected proportionally from “woinadega” agro-climatic zone in order to have representative sample. To select respective kebeles from “kola” and “Woinadega” agro-climatic zonation the availability of water supplies, the representativeness of their water supplies to the kebeles and accessibility of the kebeles were taken in to consideration on top of the agro-climatic zonation. Accordingly five kebeles selected for this purpose were: Basso, Fango, and Delewoyza, from “kola” agro-climatic zonation and Kullo and Kuto from “woinadega” agro -climatic zonation.

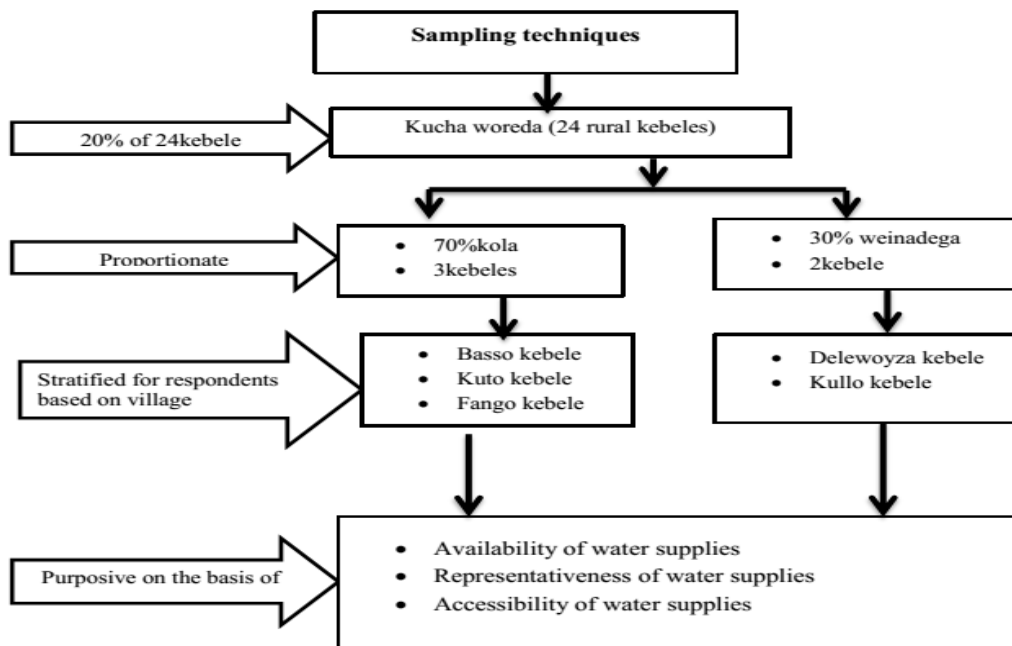


Figure 2. Schematic Presentation of Sampling Design

3.2.1.2 Sample size determination

Beneficiaries are the main primary data sources in this study. In order to ensure the generalization of the findings to larger population, the study was considered adequate sample respondents for selection through appropriate techniques.

The study is conducted by evaluated appropriate representative sample using simplified formulae for proportions by Yamane (1967).

$$n = \frac{N}{1+N(e)^2} \text{-----Equ. 3.1}$$

Where

n is the sample size for the study

N is the total population size of kebele which is 7160 HHS

e is the level of precision which is 0.1 and 93 confidence level in this study. Based on the above formula 110 sample respondent was selected.

Finally total sample size 110 household heads was selected from the coverage and sanitation potable of water for drinking in rural areas of study area.

$$n = \frac{N}{1+N(e)^2} = \frac{7160}{(1+7160(0.1^2))} = 98 \approx 100$$

As an outcome, the study's sample size (n) was 110, and the researcher took a 10% non-response rate into consideration for convenience. Five Kebeles were utilized as sample populations by Yamane (1967) for the major data source, and a total of 110 houses (HH) were dispersed proportionally to each Kebele. Since each research method has positive and negative aspects of its own, it is customary to use the method of integration to fill in the gaps left by other research methods in use while attempting to minimize the downsides as much as possible.

Table 8. Sample respondent taken from different targeted kebele

NO	Kebeles	Village	Total HHs	Sampled HHs
1	Delewoyza	ocholo	1410	21
2	Fango	zazira	1428	22
3	Baso	dosha	1540	23
4	Kuto	aginichare	1250	20
5	Kulo	tawaye	1532	24
	Total		7160	110

3.2.2 Data Collection Methods

To collect everything necessary to accomplish the study's objectives, primary as well as secondary data collection methodologies were employed. Household surveys, key informant interviews, focus groups, personal observations, and research investigations of water quality are the main methods of data collection. Document evaluations on rural water supply and sanitation in the woreda and zone, as well as additional related journals, articles, newspapers, magazines, and the internet, are examples of secondary strategies for data gathering.

3.2.2.1 Primary Data Collection

A household survey, key informant interviews, and in-person observations (structured and unstructured interviews) of the water supply and sanitary conditions in the study location were utilized to collect primary data from the respondents.

I. Household survey

According to the recommendations of WHO (2008), five indicators have been taken into account for the evaluation of rural water delivery systems. These indicators were primarily concentrated on the quantity and quality of water given to customers, the system's accessibility for ongoing supply, and the convenience of the water sources. The questionnaires also covered community involvement, operation and maintenance, hygiene and sanitation, and access to water supply. Pretesting was done prior to data collection, and the author personally administered the questionnaires to the interview subjects with the assistance of assistants. Five research assistants in all, one for each kebele, were chosen to interview members of the public. The research

assistants were selected based on three criteria a) previous involvement in administering interview, b) Understanding of the local language and c) College/university graduates.

II. Key informant interview

Key informants interviews were carried out to collect background information on institutional set up, operation and maintenance, causes of non-functionality of the schemes, coverage of water supply and sanitation situation of the Woreda. The interviews were held with selected individuals Health offices and sanitation and hygiene practice of the Woreda and one Zone water office experts who were believed to have good knowledge about the sanitation and hygiene coverage and experience.

III. 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 interview 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 protection mechanism like presence of fence, guard, appropriate and fixed time of fetching, problems related with service structures, presence of latrine and its situation.

3.2.2.2. 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 coverage, demand forecasting, quality and sanitation was made. This includes various published and unpublished documents, annual reports, design documents and kucha wereda. They were collected at different levels and from different sources. The purpose of the literature study is to see Health offices, Institutional reports regarding with sanitation and hygiene practices in the study areas. Before and what the gaps were hither *//to so that the researcher able to come up with theories, which used to make analytical generalizations of the empirical data to be collected.

3.2.5. Document Review

In addition to the original data, written records from the Kebele, the Woreda administrative office and district, reports, and publications on potable water and basic sanitation were analyzed.

3.2.6. Statistical Data

Descriptive models in SPSS aim to summarize and describe the characteristics of the data without making predictions or inferences. Overall, SPSS models provide researchers and data analysts with a comprehensive toolkit for exploring, analyzing, and modeling data. By leveraging these models, users can gain insights, test hypotheses, make predictions, and support evidence-based decision-making in various disciplines. Frequency tables, cross-tabulations, and charts/graphs are also common descriptive techniques in SPSS for exploring relationships between variables and visualizing data patterns. Data were recorded organized and summarized in sample descriptive statistics methods using SPSS-PC statistical package (SPSS 25 for windows version) and MS excel. Results has been done analyzed using this statistical software analyses, and these results were presented in a descriptive statistic such as frequencies, correlations measures, ANOVAs, T-tests such as tables, Multilinear regression and graphs. Moreover, to compare variation in water systems was applied to all physicochemical parameters and the bacterial counts. The data were interpreted by their frequencies and magnitudes such as concentration of the organisms in a liter of water sample

3.3. Multiple linear regression

Multiple Linear Regression (MLR) analysis is a statistical procedure that was used to evaluate 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 n observations, given by:

$$y_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \dots + \beta_k x_{ki} + \epsilon_i \text{ ----- } \text{---equ(3.2)}$$

- a. Dependent Variable: container volume
- b. Predictors: (Constant), what is the causes, sex, age, no restroom, water during interruption, present, water losses, bathroom, How much water, How long, family size, monthly income, source of drinking water, use facility, restroom, levels of education, water is colored, your water safer to drink, have issues with water & sanitations, why use at home treatment.

Where, y is the dependent variable (container volume). X₁, x₂, x_k are the Predictors: (Constant), (what is the causes, sex, age, no restroom, water during interruption, present, water losses, bathroom, How much water, How long, family size, monthly income, source of drinking water,

use facility, restroom, levels of education, water is colored, your water safer to drink, have issues with water & sanitations, why use at home treatment, Meter and size of household in number). 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, \dots, x_k are equal to zero). $\beta_1, \beta_2, \dots, \beta_k$ 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 multicollinearity problems were 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 multicollinearity affects seriously the parameters estimated.

3.3.1. Dependent variable for household water coverage

The dependent variables, container volume, were obtained by asking the total daily water consumption of the HH for different uses and dividing it by the number of people currently living in the family. HHs in rural area use bucket, clay jars (clay called „Ensira“ /„Madigan“) or plastic jars „Jerikan“ to take water in to the house. It hypothesized to be a function of the following variables.

3.3.2. Independent variables for household water coverage

How long /waiting time: - It is the time it took/waiting time at the water source to fetch water. This implies that the more waiting time at the source and the longer one must queue, the less water from that source was used (Gazzinelli et al., 2019). I was work the method as taken from average time, total fetch time and Number of individual (or household).

How much of water supply schemes: - Used to estimate how the water points/sources are spatially distributed in the Woreda. This means that those households located nearer to the water source are likely to use water more than others located farther away are. In a review conducted by Howard & Bartram (2003), it was revealed that distance is a crucial factor in evaluating access to water facilities. The further away the source of water is to a household, the less water consumed. To using method were works to the mean, deviation, square deviation, variance and standard deviation are importance's to get water coverage in the study area.

Water Supply Coverage = (Population with access to safe water / Total population) x 100

Standard Deviation = $\sqrt{(\sum [(X - \mu)^2]/N)}$

Where:

X =represents each coverage value

μ = represents the mean coverage value

Σ = represents the sum of the squared deviations

N =represents the total number of data points

Household size: - The household size increase, the amount of water used per person per day significantly decrease. This implies that there was a negative relationship between household size and water consumption per capita (Aschalew, 2013).

Habit of household water use: - Household's water use perception and attitude about water supply schemes and quality treatment. Adequate protection of the water sources improves the quantity and quality of water from the sources.

Your water safer to drink:-Is the satisfaction of service takers using different indicators. Satisfaction with the quantity and quality of water namely; color of water, taste of water, smell, hardness of water, amount of water, time given for water service a day and general service of water points could be the main ones to mention.

Water point characterization: - is the character of water supply schemes namely either its micro schemes or macro schemes, catchment character of the scheme, source/points get prediction during wet season.

Income:-The literature has shown a positive relation between wealth and water use. The wealthier families use more water per day. It assumed that poverty negatively affects water use because poor people cook less and often have less clothing to wash (Rashim and Suntan, 2013).

Purpose of using potable water:-Water for multiple uses seems to depend on the capacity /quantity of water supply schemes. Some of the multiple uses are Drinking and cooking, washing clothes and bathing, animal watering and small irrigation.

Functionality of the schemes:-Technical preferences are likely to have effects on the sustainability of water facilities. Water source protection and maintenance taking into account both the operational status of water services and structural conditions as a whole. Together with construction of new drinking water and sanitation schemes to cover additional people deprived of the facilities, it requires maintaining functionality of the existing schemes for ensuring they serve the designed populations for the design period and possibly beyond.

Education: -It expected that, as the level of education increases among household members, the level of household awareness about the health benefits of water use (quantity and quality) also increases and water consumption per capita decrease (Rashim and Suntan, 2013). Thus hypothesized those education levels were affecting negatively water consumption per capita.

3.4. Present and future population projection

The Central Statistical Authority (CSA) is the recognized Ethiopian organization to determine the official population figures and growth rates that should be taken for any development activity throughout the country. Population data of Kucha Woreda were collected from central static authority with four purposes. Firstly to know the present population that is served by the existing coverage, Secondly to forecast the future population, third sanitation and potable water quality of the study area to be served from water supply system. Several models are used but it should be pointed out that the judgment was made based on the trend of population growth and to minimize uncertainties that may occur due to improper estimation of the population. Therefore, the constant population growth rate of 2.8 (%) was used and method used by Ethiopia statistic Authority was adopted for this scenario for the purpose of future population forecast of the rural areas of the woreda. The baseline population figure of rural areas of the Woreda as per CSA was 154, 564 for the year 2023. It can be written as:

The geometric growth method is given by Al-Sawalha (2019) as

$$P = P_0 \left(1 + \frac{r}{100}\right)^n \text{ ----- Equ. 3.3}$$

Where, P = population projection

P₀ = base population

n = number of years (annual rate of growth rate)

r = annual growth rate in percent=2.8%

3.4.1 Domestic Water Demand (DWD)

Water is utilized in the houses for different uses. The residential or domestic use includes water requirements for drinking, cooking, bathing, washing of clothes, utensils and house, and flushing of water closets. The quantity required for domestic demand mainly depends on climatic conditions, the social and customs of the people. Per capita water consumption of the study area was only determined by house hold survey result (was 1.11l/c/d) due to failure of technical efforts to get secondary data from the Woreda office besides inability to generate primary data

due to the difficulty to get layout and complexity to measure the discharge that belongs to the specific area as this study area gets much of its water supply from Kuto =0.07l/c/d kebele agin charesource. Therefore, the daily domestic water demand (DWD) is projected by adopting the per capita water consumption recommended for rural communities by ministry of water resource of Ethiopia. The ministry of water resource has adopted the general design standards of 30 to 50 liters per capita daily (lpcd) for urban centers and 15–25 lpcd for rural areas. For rural water supply, the daily DWD is projected as being: 15 lpcd for short term (2002-2006), 20 lpcd for medium term (2007-2011) and 25 lpcd for long term (2012-2016) (MoWR, 2006).

Therefore, there is a rational ground to adopt the per capita consumption of 25 liter to make the demand forecast for the coming 20 years.

$$DWD = P_n AWD$$

Where,

DWD = Domestic water demand

P_n = Population at the target year

AWD = Average per capita domestic water demand

3.4.2. Commercial and institutional water demand (CIWD)

In addition to those of household consumers, the water requirements of public utilities include the needs of such commercial and institutional consumers as public schools, clinics, hospitals, offices, shops, bars, restaurants, and hotels. For small- and medium-sized towns, it was estimated at 5% of the DWD. For larger towns, the CIWD estimate was 10% of DWD but no allowances were made for CIWD for rural communities (MOWR, 2006).

3.4.3 Industrial water demand (IWD)

For planning purposes, a reliable IWD indicator was assumed to be the following percentages of DWD: 30% of DWD in large and medium towns; and 10% of DWD in small towns. As far as possible, large- and medium-sized industries are assumed to provide water supply from own sources. No IWD allowance was made for rural communities.

3.4.4. Livestock water demand (LWD)

The custody of livestock is an integral part of rural community life, and water is an essential commodity for animals just as it is for humans. However, the use of improved domestic water sources for livestock is not encouraged. It is assumed that most of the animals will be watered from such natural sources as rivers, streams, lakes, ponds, and springs in the vicinity. If no such

sources are available nearby for the livestock, the animals should be watered from cattle troughs sited below water sources for human consumption. In case potable water supply schemes are to be used for livestock watering, an allowance of 3 lpcd is made (MoWR, 2002). Since in some part of the study area households use the cattle troughs at water sources to water their livestock as acquired during personal observations and site visit. Moreover, 63.2 % of respondents indicated their using the same water sources for animal watering. Livestock water demand is therefore incorporated in this study area water supply demand analysis. Hence water 24 sources designed considering the needs for the rural livelihood in addition to the domestic water demands by the household.



Figure 3. Cattle troughs in the study area

While estimating LWD, relationship with size of population was captured as follows: (a) 60% of the population in rural communities; (b) 30% of the population of towns with fewer than 10,000 inhabitants; (c) 9% of the population of towns with 10,000 – 50,000 inhabitants; and (d) 1% of the population of towns exceeding 50,000 inhabitants (MoWR, 2006). By adopting 60% of the population in the rural communities population projection for livestock water demand was estimated (Table 10).

Table 9. Population projection for livestock water demand of kucha woreda rural area (2015-2035).

Description	Year					
	Unit	2015	2020	2025	2030	2035
Forecasted population	In person	92738	106470	122234	184965	321330

3.4.5. System losses (SL)

It is obvious that all the water which goes in distribution pipes does not reach the consumers. Some portion of this is wasted in the pipe lines due to defective pipe joints, cracked and 38 broken pipes, loose valves and fittings. Sometimes consumers keep open their taps even when they are not using the water and allow continuous wastage of water. The water loss in the distribution system was considered to be a function of the ages of the distribution system. But due to unavailability of sufficient data associated with unreliable metering, the volume of water loss could not be assessed in rural areas. While estimating the total requirement of water of the Woreda, allowance of 10% of the total water demand for the losses is adopted (MOWR, 2006). Therefore, $SL = 10\%(DWD + LWD)$

Where:

SL = System losses

LWD = Livestock water demand

DWD = Domestic water demand

3.4.6 Institutional Demand (ID)

This refers to the water demand of facilities such as schools, hospitals, hotels, etc. and small commercial enterprises, and also public demand where appropriate.

The review was assessing the extent and development of the institutional assess in each rural and vary the likely daily demand, if necessary, based on the following consumptions:

Day schools 5 l/pupil

Cinema house 4 l/seat currently, there are 52-government primary, 8 private primary and 7 government secondary schools in the Woreda. In the woreda, total enrolment population is 52,594 in primary school (male 26,297 and 26, 00 female). In the primary school, there are 745

teachers (male 476, female 269) of which 498 are diplomas and above (Woreda Annual Report, 2013/14).

3.4.7. Total average daily demand (ADD)

Rural TADD for water supply is the combined total of domestic demand, livestock demand and system losses.

$$TADD = DWD + LWD + SL + ID$$

3.5. Assessment of sanitation condition of the Woreda

In order to assess the sanitation condition of the study area, an interview was conducted with structured questionnaire. Accordingly, data related to sanitation and hygienic condition like toilet availability, its type, habit of using toilet, hand washing facility and disposal of waste were collected from the households. The questionnaire was supported by household survey, key informant interview and personal observation. Statistical correlation was employed and significant positive correlations were seen between sanitation and hygiene evaluating factors.

3.6. Water quality parameters

The following parameters are intended to evaluate the water's Physicochemical and Bacteriological properties.

Table 10. Water quality parameters (WHO 2012)

No	Water quality parameter	Instruments of elements
1	Physical parameters:	Turbidity, TDS (Total Dissolved Solid) Electrical Conductivity (EC) and Temperature.
2	Chemical parameters:	Total Dissolved Solid (TDS), Power of Hydrogen (pH), Total hardness (TH), Fluorine, Nitrate and Nitrite, Dissolved metals and salts (Sodium, Chloride, Potassium and Manganese).
3	Bacteriological parameters:	Total coliform, thermo tolerant coliform / Escherichia coli (E.coli) bacteria.

Samples need to be taken from locations that are representative of the water source, treatment plant, storage facilities, distribution network, points at which water comes to the consumer, and

points of use, as recommended by the Drinking Water Program (2013), Denel Analytical Laboratory (2011), and WHO (2008). Based on this, samples for this study were taken from all sources, reservoirs, and water taps that were under study. As a result, three samples from the first, third, and fifth taps of the reservoir's water supply—Bono—were taken for this investigation. Two samples have been collected from the source and reservoir in addition to the tap water. Five samples were collected and evaluated.

3.6. Water quality assessment

3.6.1. Sample points and parameters determination for water quality analysis

Temporal and spatial variation of water quality analysis is very important for the water sampling points to evaluate the water quality changes at different seasons and one sampling point to the next sampling points respectively. However, due to time and budget restrictions the required samples for quality test were only collected from eleven sample water points of the study area. Eleven major sampling points were selected based on the public complaint on the water quality and one sampling point from each kebeles. Accordingly, Kuto spring from aginichare, Delewoyza kebele, ocholo village spring, from Basso kebele, dosha villege on-spot, from Kullo kebele, Tawaye shallowell, from Fango zazira spring kebele and shallowell from Fango sola village. Samples were collected in 1000ml polyethylene plastic bottles for different parameters from eleven sampling points. Triplicate water samples from each sampling sites were taken and analyzed for selected physiochemical and bacteriological parameters. 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. The water samples were handled aseptically in sterile glass bottles, labeled and kept in an ice-box during transportation to the laboratory of Arba Minch Town Water Sewerage Supply Enterprise for physicochemical quality analysis and for bacteriological quality analysis. Bottles were preserved using icebox and a total of 33 water samples from five sample sites of the study area were taken and studied for the selected physicochemical and bacteriological parameters.

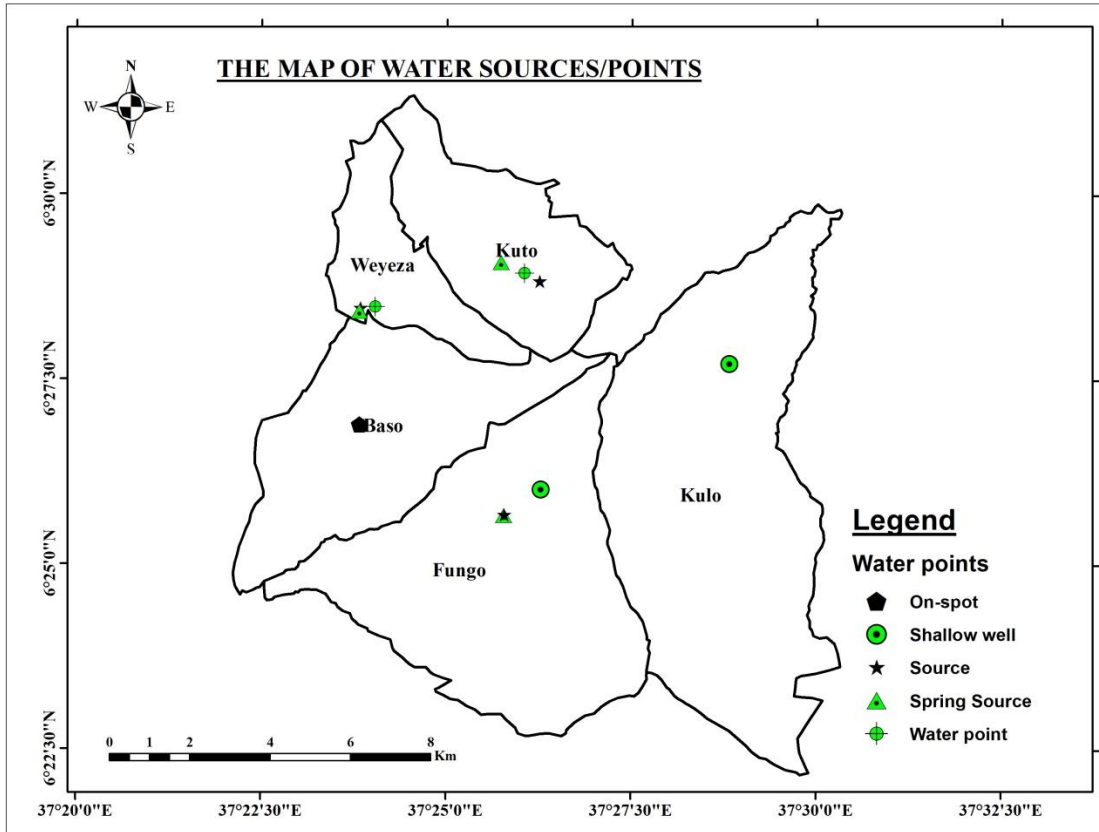


Figure 4. Water Source/point mapping of the study area.

Table 11. Major Physicochemical and bacteriological parameters for the analyzed water sample

S. No	Physicochemical parameters	Bacteriological parameters
1	Temperature	E.coli/Thermo tolerant coliform bacteria Total coliform bacteria
2	Electrical conductivity	
3	Turbidity	
4	Total hardness	
5	Nitrate	
6	Chloride	
7	Fluoride	
8	Iron	
9	Manganese	
10	Total /residual/free chlorine	
11	Total dissolved solids	

12	pH	
13	Phosphate	

Table 12. Sampled water supply schemes for quality analysis

S. No	Sample kebele	Existing water supply schemes	Sampled Water supply schemes	Total water supply schemes	Current discharge(l/sec)
1	Delewoyz a	1 on-spot spring 1 large spring 1 medium spring	1 large spring 1 medium spring	2	Kuto (0.062)
2	Fango	1 large spring 2 shallow well	1 shallow well 1 large spring	2	Kullo (0.25)
3	Baso	1 on-spot spring 2 large spring	2 large spring 1 on-spot spring	3	Fango (1.64)
4	Kuto	1 on-spot spring 1 large spring 1 medium spring	1 large spring 1 medium spring	2	d/woyza (0.27)
5	Kulo	2 shallow well 2 large spring	2 shallow well	2	Basso (0.15)
Total			11 water supply schemes were taken	11	Average (0.47)

3.6.3. Analysis of Physicochemical Parameters

In-situ measurements were used to evaluate sensitive water quality parameters, which include; temperature, pH, turbidity, EC and TDS. Temperature and pH were analyzed by using thermometer and portable digital pH meter (pH meter ELE international), respectively. The pH meters were calibrated just before analysis using pH 4.0 and pH 7. Total solids and total

dissolved solids (TDS) were determined by putting 50ml water sample to the crucible and put on the oven to vaporize the collected water and measuring the remaining solids on the crucible. With regard to turbidity, it were analyzed using portable Wagtech International turbidity meter (Weg-WT 3020 Wagtech international), whereas electrical conductivity and total dissolved solids (TDS) were analyzed using portable digital conductivity meter. Their measurements were taken immediately after the samples were collected on each site.

Magnesium, total hardness, chloride and Fluoride were evaluated by photometric measurements using paqualab photometer by adjusting the wavelength (580 m) and keeping their reaction periods and analytical reagents analyzed by using their respective standards. Iron was evaluated. Iron was evaluated by using paqualab photometer by 520 m of the wavelength. The nutrients like nitrate and phosphate were measured by photometric measurements using paqualab photometer by adjusting the wavelength(560 m), keeping their reaction periods and analytical reagents were analyzed 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.

3.6.4. Analysis of Bacteriological Parameters

With regard to bacteriological parameters, samples were analyzed using membrane filtration method for water quality to evaluate the degree of contamination (WHO, 2008; APHA, 1998). All samples were analyzed for the presence of total coliforms (TC). The procedures include membrane filtration followed by incubation of the membranes on selective media. Composite samples were used to improve the precision of the estimated average contaminant concentrations. In the laboratory, the three samples from each site were mixed into one and a composite sample was subjected for membrane filter analysis of total coliform.

The composite samples were mixed thoroughly by shaking and filtered under laboratory hood, using WagTech membrane filtration apparatus and membranes, pore size 0.45 μ m, 47mm diameter, sterile and gridded. It were shaking properly to get red color. The membranes then transferred aseptically to m-FC agar with rosolic acid in glass Petri dishes. Prepared cultural 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 source for optimal viewing sheen.

3.7. Statistical 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 were employed to identify the statistically significant water coverage evaluate variables in the study area and associations of the variables respectively. Results of water quality analysis from the source, storage containers, point of-use (consumption) wet season variation were compared against standards set by WHO (2008). Moreover, ANOVA was used to evaluate the significant differences in the mean values of the water quality parameters at the various sampled sites at $p < 0.05$ significant level and also correlation was employed to see statistical significance relation between physicochemical and bacteriological parameters and sanitation and hygiene influencing factors. Deduction made from these measures and compared with the existing literature to arrive at the conclusion of the study.

3.8. 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 Discussions

4.1 General information of the respondents

This section provides a general overview of the respondents' background and how it affects water use, collection, allocation and gender relations in rural households in the study area. The key issues identified are; age, education, occupation and household size. These highly determine the water use and demand in the households and the extent to which the households get involved in sanitation and hygienic issues. An understanding of these can help the researcher to see which areas are critical for enhancing water supply and sanitation schemes. About 96.5% of respondents were in the economical productive or 25-64 age bracket. That means data was gathered from the productive age group and indeed people of this age group are those expected to take actions in the development processes of rural water supply and sanitation. The average age of respondents was about 43.6 with a standard deviation of 10 having significant age difference among the respondents (Table 14). The mean household size is about six persons which are greater than the average Ethiopian family size of 4.7 persons (CSA, 2007).

Table 13. Age distribution of respondents

Age of respondents by sex							
Age	Total	Male	Female	%	Mean	Standard deviation	Average household size
<24	26	12	14	9.1	41.27	11	6.1
25-31	28	13	15	21.2			
32-38	27	12	15	30.3			
>38	29	13	16	39.4			
Total	110	50	60	100			

The sample households have different occupations. These include government employees, Merchants', daily laborers and farmers. Out of the total of 110 sample households 8.2% are government employees, since farmers constitute 60% of sample households they are the dominant section of the population. Nearly all of the households make a living out of subsistence agriculture and animal farming. Merchants' men constitute 2.4 whereas 4.7% of the sample households are students (Table 15). The same table also describes education level of the respondents' in the study area. The majority of respondents' 50.6 % had primary education

meaning they could write or read or did attend formal education. About 12.9 % of the respondents can write and read without having formal education in schools and 2.4% of the respondents were not educated and they couldn't write or read or didn't attend formal education. The remaining 34.1% included those attending or interrupted education at secondary and tertiary/university or college level.

Table 14. Occupation, education level of respondents and house hold members responsibility of fetch water

Occupation	Percentages (n=110)
Farming	84.7(72)
Merchants'	2.4(2)
Government employee	8.2(7)
students	4.7 (4)
Education level	Percentages (n=110)
Non-formal education	12.9(11)
Primary	50.6(43)
Secondary	20(17)
Diploma	14.1(12)
Degree	2.4(2)
Household members responsible to fetch water	Percentage (n=110)
Daughter	45.9
Son	12.9
Mother	43.5
Father	1.19

4.2. Household water use and collection

Domestic water use patterns are generally similar in the study area regardless of the type of the water supply schemes and the distances covered to reach it. The main uses of water in the households in the study area are drinking, cooking, and washing clothes and other activities like watering animals among others. All respondent households were using the water supply for

drinking and cooking, 71 % for washing, 66% for livestock as to Kucha woreda water mine and Energy office. While the fundamental priority of water use from the improved water sources is for human consumption. At many of the protected springs, the taps are used not only for domestic water needs but also for animal watering and small irrigation. These findings agreed with previous research in Tehuledere Woreda, northeast Ethiopia by Seid et al (2013) and in WA, Ghana by Joseph (2019).

Table 15. Different purposes for which respondents use water

S.no	Purpose of using water	Frequency	Percentage
1	Drinking and cooking	83	100
2	Washing clothes and bathing	59	71
3	Animal watering /livestock	55	66

Households' reported that the individuals who were responsible for fetching water, mostly women, travel on average two times in a day to the water sources/ points on normal condition.

The maximum amount of water used per household per day is 60 liters/day and the average household water use per day in study area is 21.95 liters/day and the standard deviation was 8.21. However, this varied per household depending on the household size, the distance to the water point and the waiting time at the water sources/points. ANOVA test showed significant differences ($P < 0.001$) for the total volume of water consumption among the households(Appendix 3 and Appendix 7).

The average household water use in Basso is 24.6 liters/day, Kuto is 18.48 liters/day, kulo is 35.2 liters/day, Fango 19.3 liters/day and Delewoyza is 10.3 liters/day as to kucha woreda water mine and energy offices. The difficulty in collecting sufficient amount of water due to few water supply facilities, anomalies of the schemes and long distance between the water points and beneficiaries made the water use to be inadequate. According to Ethiopian water sector (strategy, 2015) "As per the GTP-2 water supply service level standard, it was required to provide safe water in minimum 25 l/c/day within a distance of 1km for study areas . However, this varied per household depending on the household size, the distance to the water point and the waiting time at the water sources/points. This finding was much lower than previously reported research in Kucha Woreda, South Ethiopia.

Table 16. The average water demands of respondents in liters per household per day.

S.No	Statistical parameters	Basso N=23	Kuto N=22	Kulo N=24	Fango N=20	Delewoyza N=21	Total 110
1	Minimum	15	30	40	20	20	25
2	Maximum	60	60	40	40	40	48
3	Average	24.6	18.48	35.2	19.3	10.3	21.95
4	Standard deviation	12.3	9.24	17.6	9.65	5.15	8.21

The result in table 15 showed that women and daughters are responsible to fetch water in most of the households, as indicated by 42.5 % and 43.8 % respectively. Only 13.7 % of the husbands and sons are responsible for collecting water. Most of the responsibility to fetch water from distance sources for household use lies on females (women and girls). Women and girls were the bearers of responsibilities with regard to water collection and other domestic works and hence there is a big workload and a long walk in search of water for household use.

The considerable labor involved in ensuring the availability of water for about 6 people in a household is almost exclusively done by women and daughters. This clearly shows that gender plays a significant role in domestic water management.

As the amount of time spent on water collection increases, women's involvement in other economically beneficial activities significantly decreases. Thus daughters and mothers, who are the common water entourages, spend much time on water collection in the rural areas.

The impact of spending of a lot of time for collecting water and carrying other household activities on her education can be judge. As WHO (2008) pointed out this believed to affect spare times required for other household affairs that may impact the health of the family as a whole.

4.3 Waiting time for fetch water

The respondents expressed, was surveyed 110 households and the total fetch time for all households combined was 1500 minutes, the average time to fetch drinking water .Therefore, the standard deviation of the average times to fetch drinking water: for this study is approximately 35.9minute. The respondents in the study area was asked to give information on the time it took them to fetch water from water supply schemes. Although the values obtained were not based on accurate measurement it is roughly used to estimate the time taken from rural water supply services. The researcher was so careful about overestimation and underestimation. The minimum and maximum time to fetch water from the supplied services including waiting time varies from 15 to 30 minutes and 75 to 120 minutes, respectively, with a mean duration varies from 41 to 64 minutes and standard deviation of 35.9 minutes. The mean duration to fetch water from the supplied services includes the time required for round trip from beneficiaries and waiting time at the water supply schemes. The standard deviation indicates there is great difference among the households for water fetching time. The time taken to fetch water from protected facilities in this study exceeded the guide line value recommended by WHO (2008), which is set at 15 minutes of walking distance, equivalent to a distance of about one kilometer.

Table 17. The average time to fetch drinking water (minutes per household)

S. No	Statistical parameters	Basso N=23	Kuto N=22	Kulo N=24	Fango N=20	Delewoyza N=21	Total 110
1	Minimum for the scheme	15	18	23	15	25	19
2	Maximum for the scheme	85	95	98	75	78	86
3	Average for the scheme	50	56	60.5	45	51	52.5
4	Standard deviation	7	7.4	7.8	6.7	7.14	35.9

4.3.1. Distance /spatial distribution of water points in the woreda.

The mean duration from home to the source of water for round trip is (average 52.5 minutes) above the recommended value of WHO, 2008. The coverage of water sources/points within 1km is only 9,567.15ha, out of the total area of the Woreda, 16,091.34ha; hence, the coverage of overall Woreda including the non-functional water sources/ points was only 48.35%. This was used to estimate how the water points or sources are spatially distributed in the study area.

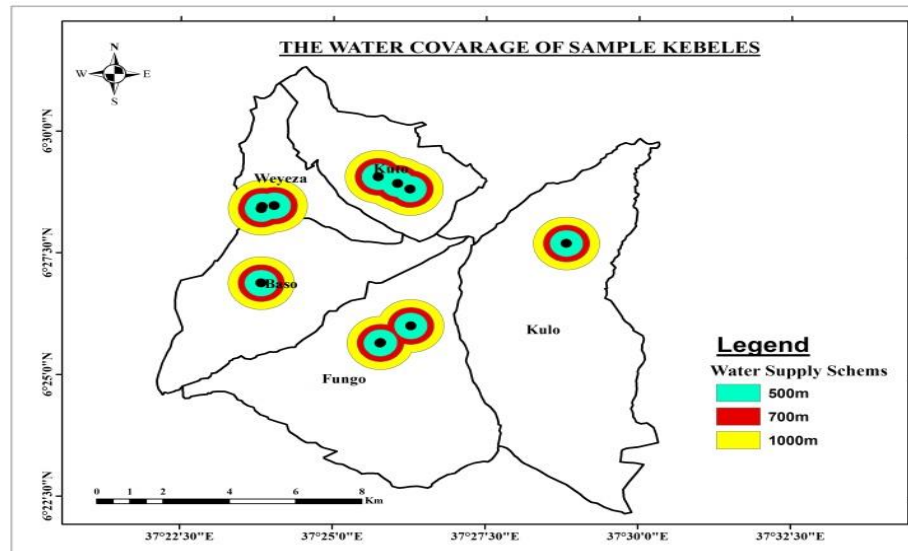


Figure 5. Spatial distribution of the schemes.

4.3.2. Container Volume (Liter per capita per day)

All the households use „jerry cans“ to collect water; these jerry cans typically hold 20 liters. Children also use smaller jerry cans, 5 liters up to 10 liters. The respondents were asked to tell the average number of liters in terms of “jerry can” that their family used per day due to unfamiliarity of measuring in liters besides their inability to tell the amount in liters. The consumption per capita of water in a respondent’s household were then calculated by multiplying the number of “jerry can” used per day with the amount of liters it contains and then dividing the result by the household’s family size was 6. According to table 19, the average volume of water used by liters per person per day ranged from 1 to 18 liters and the average water consumption per capita ranges from 7.36 liters and less used by the majority. This was significantly different from WHO guideline value set at least 25 liters per capita per day (MoWR, 2006 and Webster et al., 1999). Inadequate drinking water adversely affects personal hygiene, clean food preparation and housing sanitation, hence favoring the transmission of water borne and water washed

communicable diseases. Around 99.2% of residents consume less than 25 liters of water in a day, as indicated in the table 19. The standard deviation was found to be 2.9 liters implying there is great variation in the pattern of water consumption per person per day among different households in the study area. Highest average values were recorded in kulo and the lowest average value was recorded in dele-woyza kebele. According to Ethiopian water sector (strategy, 2015) “As per the GTP-2 water supply service level standard, it was required to provide safe water in minimum 25 l/c/day within a distance of 1km for study areas . With regard to this value, the current average domestic water consumption of Kucha Woreda not satisfies basic level of service to the people.

Table 18. Water consumption in liters per capita per day.

S. No	Statistical parameters	Amount in liters per person per day (in l/c/d)					
		Basso N=23	Kuto N=22	Kulo N=24	Fango N=20	Delewoyza N=21	Total 110
1	Minimum volume	1.5	2.8	1.8	1	2.5	1.92
2	Maximum volume	11	18	15	10	11	13
3	Average volume	6.5	9	7.3	5	9	7.36
4	Standard variation	2.5	3.5	2.8	3	2.8	2.92
5	%above 25 liters	0	0	9	0	0	1.8
6	%below 25 liters	100	100	95.8	100	100	99.2

4.1.4. Habit of household water use

Water treatment is essential to improving water quality, which reduces risks of water borne diseases (WHO, 2008). According to the consumers' responses (38.5%) collect water which is in contact with their hands and majority of them (53%) have no separate water containers in their home to store it from the water used for other purposes. Most of them (71%) did not use any particular treatment at home before use. Although some people use water treatment in their home, general water treatment for all household basic needs is still limited in study area. Poor sanitation and poor hygiene were the main effects of the contaminated water during transportation and after storage in household. This finding was in agreement to the studies conducted elsewhere in Ethiopia (Dagneu et al., 2013 and Mengesha et al., 2012).

Table 19. the results of sanitation and hygiene practices of the consumers at the households, Sanitation and hygiene practice of consumers.

S. No	Questions reflected to the consumers	Yes		No	
		Frequency	%	Frequency	%
1	Separate container for storage of drinking water	45	40	48	43
2	Have no contact with your hand	55	50	42	38.2
3	Particular treatment for your drinking water	34	30.1	69	62.7

4.1.5. Water supply system and consumers satisfaction

It is a known fact that the water period is available to the customers in a day is an indicator of reliability of the water supply system, which in turn has a significant bearing on consumer attitudes. Consumer satisfaction can be accessed from service takers in different ways using different indicators. Satisfaction with the quality of water namely: color of water, taste of water, smell, hardness of water, amount of the water, time given for water service a day, general services of water points, whether they stand in line for long period of time to collect water could be the main ones to mention. The four principal dimensions on domestic water supply and availability are; Quantity, quality, spatial variability and temporal variability (Lenton et al., 2008). Good water quality is important to women; however, most of the improved sources are seasonally unreliable.

As UNDP (2010) noted control of water variability is important because poverty stricken and vulnerable households can have devastating effects in case of water related events like droughts and floods. With this regard, the survey found that only (28%) of respondents are satisfied with the provided amount of water, (69%) are satisfied with the quality of water namely taste, color, smell and hardness of water (Appendix 16). This community satisfaction is a tool for the overall water supply services and projects. When the respondents were asked to tell the period through which the quantity of water supplied was not adequate to fulfill their demand, they specified the period i.e. during mid-day (2-4pm o'clock) through which low quantity of water was obtained and This somehow affected the satisfaction of community due to the fact that the sources/points get unpredictable during dry season (Jan – March) in a year as indicated by 47.6% of the respondents and 36% of them also complained the inconvenience of the water quality. The former problems most pronounced in three kebeles of the study area namely Fango, Delewoyza and Kullo kebeles. A study carried out by Gulyani et al (2013) indicated that service availability, apart from easy access, strongly influences household water satisfaction. However, in the study area, water is available for limited time intervals. As a result, consumers were not satisfied with the duration of water availability in a day.

4.1.6. Water points characterization, their current status and coverage

There are two types of rural water supply schemes in the study area. The micro schemes are defined as those rural water schemes comprising point source supplies such as hand dug well equipped with hand-pumps, collection tanks, stand posts and protected springs whilst macro schemes are those schemes such as, gravity schemes or point sources with collection tanks supplying more than four communal standpipes (GOS, 2010). Springs, shallow wells and hand-dug wells were the main source of water for household used in the study area where the schemes are functional. When the protected springs, shallow wells were functional: unprotected springs and rivers were mentioned as alternative sources of water used by the respondents, as 10(30.3%) of the respondents in the study area were using rivers. This is the main problem in kebeles where the sources/water points were functional or when the sources/ points get unpredictable in (March–June) 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 Fango and Delewoyza kebeles. The normal maintenance period for a water facility as recommended by MoWR (2007) is 2 to 3 days.

The long maintenance period observed to be in excess of 4 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 3(27%) of the water points and 6(55%) have animal troughs.

An illustration of sampled water points in the study area are shown in the following Figure.



Kuto kebele large spring



Delewoyza kebele medium spring

Figure 6 . Some of existing water supply schemes in the study area.

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 scheme are characterized by very low service 20.8 Coverage, limited service over the day from public distribution points, poor operation and maintenance as specified by key personnel and site observation. In relation to this, the following adverse conditions were identified as problems related to operation and maintenance functions of Woreda Water Resource Development Office.

Lack of awareness of beneficiaries, lack of spare parts, design problem, poor financial management, inadequate planning, lack of preventive maintenance and lack of trained personnel who fully understand how to operate the systems and low capacity of the schemes to satisfy the demand are the main ones. As per the official data of Woreda Water Resource Office, 6 hands dug well, 13 shallow well, 11 on-spot spring, 5 bore hole and 4 other water supply schemes are non-functional. Hence, in the Woreda 69% of the water sources/points are functional, 38.1% of them are not and 3% of them were abandoned. The Ministry of Water Resources estimates that 33% of water supply schemes in Ethiopia are non-functional at any time, with negative impacts on coverage and universal access due to lack of funds for operation and maintenance, inadequate community mobilization and commitment and a lack of spare parts (MoWR, 2007 and Moriarty et al., 2009). From existing water supply schemes in the Woreda, 7 hand dug wells are estimated to serve 10575 people, 22 on-spot springs are estimated to serve 7613 people, 48 spring with distribution 12,507 people, 36 shallow wells are estimated to serve 17,700, 5 borehole estimated to serve 4100 and 8 other schemes are estimated to serve 1420 people. Since the population served by the schemes in the study area are 1571 out of the total population of 7160 hence; the total coverage is 21.9%. The remaining 78.1% not covered with the reasonable population load per a single water source/point. This showed that, the water supply coverage of Kucha Woreda is low.

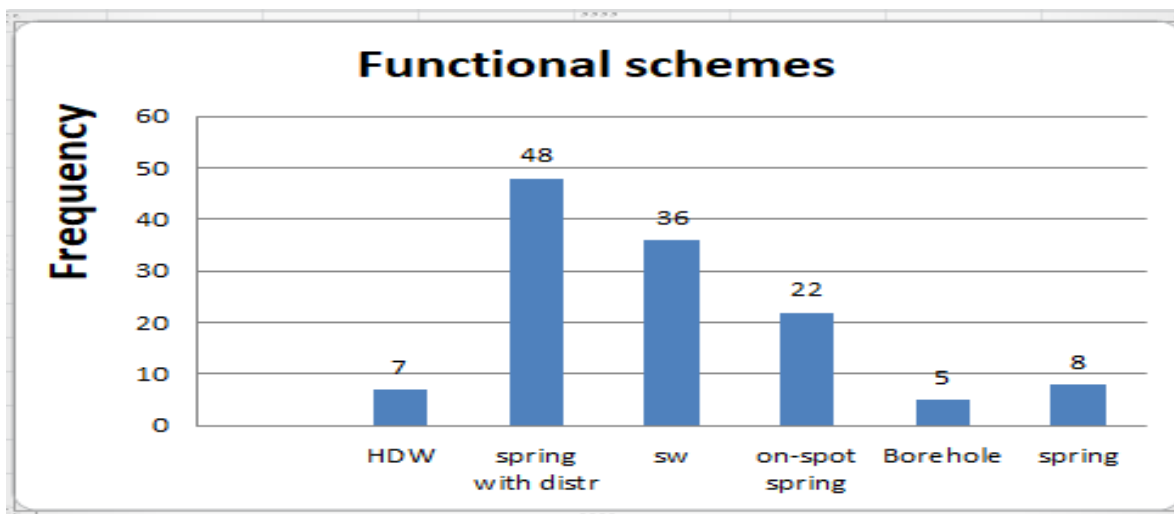


Figure 7 Schematic representations of types of schemes in the Woreda and their status

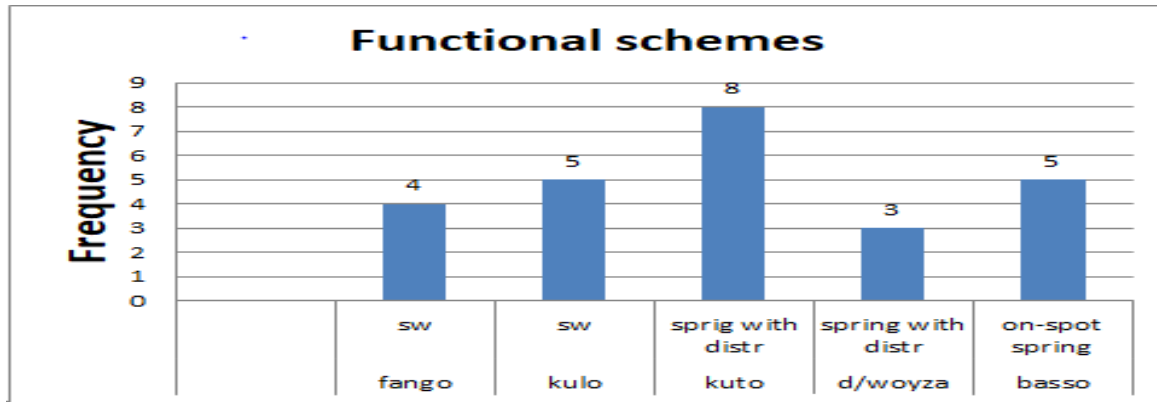


Figure 9 Schematic representations of types of schemes in the study area and their statu

4.1.7 Population and water demand projections

The study area population has been increasing at the course of time. The population projection was developed From National Statistical Report of the Population and Housing Census of 2007 were utilizing year 2015 population data as a starting point (base year) with growth rate of 2.8%. Figure 4.4 below presents the 2015 to 2035 population projections of the rural areas of the study area.

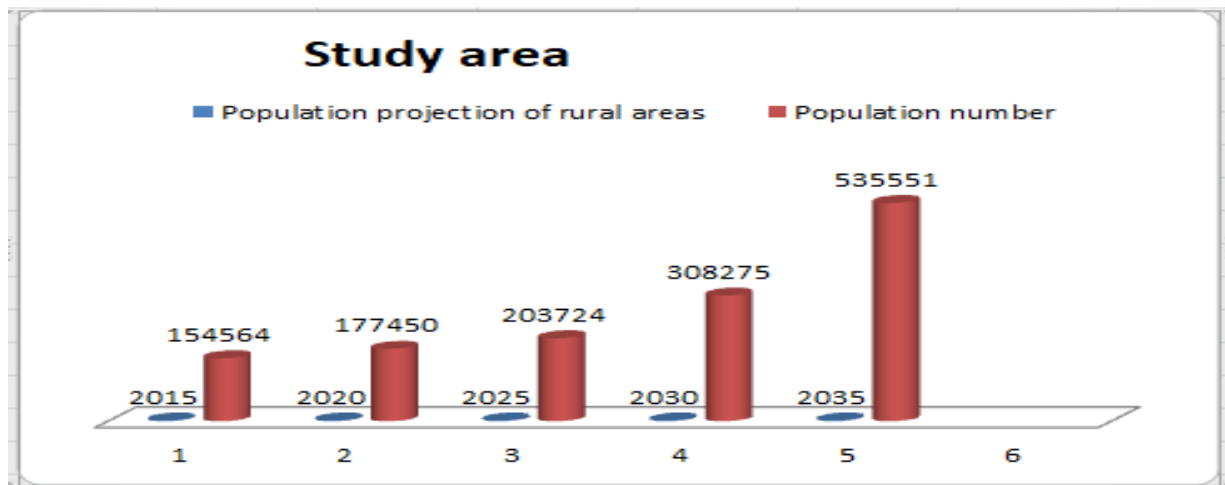


Figure 10. Population projection of rural areas of Kucha Woreda

Evaluation of the amount of water available and the amount of water demanded by the public are primary tasks in designing any water supply system. Water resource planning requires reliable forecasts of population and water demand. Increasing populations translate into increased water demand for different uses. The projected increase in population is the principal force triggering the projected increase in total water demand. Water demand increases with time due mainly to

population growth and economic development. Figure 10 shows water demand projections by category for the year 2015-2035.

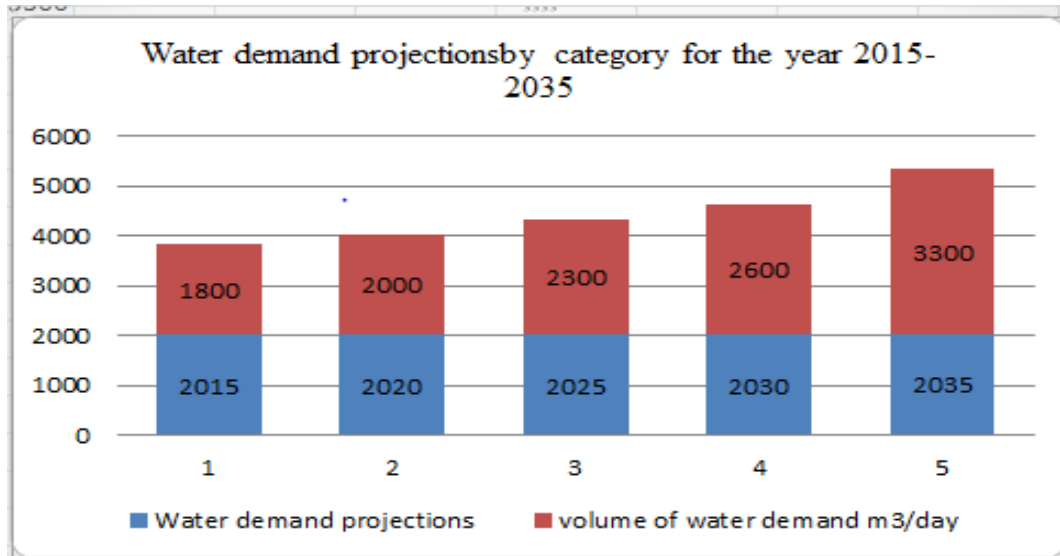


Figure 11. Water demand projections by category for the year 2015-2035

The projected total water demand for the Woreda was increased by nearly 1500m³/day over 20 years period. Since the current total domestic consumption is 1146m³/day as indicated in the survey result, it shows the amount of water that reaches the inhabitants is not adequate, as the government hoped in its universal access program (UAP) for water supply and sanitation services. Since the existing water coverage is estimated about 20.8 % and should be increased by 6 times or needs the annual growth rate of 0.6 to reach 6225.3m³/day for the duration of the coming 20 years. Therefore, exploration of new water sources and increasing the water supply efficiency seem to be inevitable activities of the stakeholders of the sector.

4.2. FACTORS ANALYSIS

Attempts were made to identify factors responsible for the evaluation of rural household water coverage among the sampled households. Occurrence of strong multicollinearity 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 multicollinearity problems among the explanatory variables included in the model (Appendix 4).

The MLR model result showed that the coefficient of evaluation i.e. the adjusted R-values was 1.000. This implies that about 100% 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 4). Appendix 5 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 2).

4.2.1. Evaluating of household water coverage in the study area

The result indicated that, out of the 20 hypothesized variables which were included in the multiple linear regression models four variables were found to be statistically significant to influence the household water coverage (Appendix 4). These are functionality of water supply schemes, distance to the schemes, time required to fetch water and size of the household.

Family size:- Family size was statistically significant at 1% probability level and had a negative coefficient of 4.488, which implies that for every increase in an individual in a household, water coverage decreases by 4.488 water consumption liters per capita (Table 21). Larger family size has a negative impact on household water availability. A study by Ashalew (2009) also found a strong negative relationship between family size and household water coverage respect to water consumption liters per capita. Another study by Samaria (2017). For every one-unit increase in the household size there is a decrease in the water consumption per capita by 1.9 times in urban and 1.7 times in rural areas.

Functionality of the schemes: - The study result showed that functionality of the schemes is positively related with water coverage and statistically significant at 5% probability level. The coefficient of the variable implies that increasing the number of function of the schemes, increases water coverage availability of the households by a factor of 0.295 (Table 21). Aschalew (2009) pointed out that one of the daunting challenges in the water supply sector is securing resources to manage and maintain frequently breaking water facilities and keeping the water sources operating in a sustainable manner, which determines rural water supply systems.

Waiting time: - Time was statistically significant at 1% probability level and had a negative coefficient of 5.360, which implies that for every increase of time in minute for a household, water coverage decreases by 5.360 water consumption liter per capita per day (Table 21). More water fetching time has a negative impact on household water availability. That means when the time required to fetch water increase the household was less likely to be water coverage. A study by Aschalew (2009) also found a strong negative relationship between fetching time and

household water consumption per liter. The waiting time at the sources varies from 0 to 120 minutes, with a mean duration of 25 minutes and standard deviation of 23 minutes.

Distance to the schemes: - Distance was statistically significant at 5 % probability level and had a negative coefficient of 0.001, which implies that for every increase of distance in meter for a household, water coverage decreases by 0.001 liter per capita per day (Table 21). Larger distance to the water supply schemes has a negative impact on household water availability. That means when the distance required reaching water points the household was less likely to be water coverage. A study by Ashalew (2009) clearly observed that the per capita water use is negatively and significantly evaluated by the distance of water source from household (i.e., keeping other factors constant, as the distance of a water source from the household increases by a kilometer, the per capita water use significantly decreases by 21.9 liters)

Table 20. Evaluates of household water coverage model result

Variables	Coefficient	Std. Err	T	P
Education	11.883	.000	.	.
Income level (birr/ month)	7.548	.000	.	.
Functionality of the water supply scheme	.295	.117	2.519	.014**
Consumer satisfaction	.260	.201	1.292	.200
How much water	8.307	.000	.	.
Distance to the scheme in meter	-.001	.0003	2.651	.010**
Point characterization	.046	.180	.257	.798
your water safer to drink	25.496	.000	.	.
family size	-4.4883	.000	.	.
How long	5.360	.000	.	.

why use at home treatment	9.082	.000	.	.
no restroom	2.496	.000	.	.
use facility	23.292	.000	.	.
restroom	2.974	.000	.	.
have issues with water & sanitations	2.185	.000	.	.
water is colored	9.691	.000	.	.000*
present water losses	16.68	.000	.	.000*
what is the causes	4.460	.000	.	.000*
bathroom	11.82	.000	.	.000*
water during interruption	2.185	.000	.	.000*

* Significant at less than 1% probability and** significant at less than 5 % probability.

4.3. Sanitary and Hygienic practices

In addition to the analysis of physical, chemical and biological aspect, sanitary inspections carried out at all supply points visited during the study. Sanitary inspections are visual assessments of the infrastructure and environment surrounding a water supply, taking into account the condition, devices and practices in the water supply system that pose an actual or potential danger to drinking-water quality and thus to the health and well-being of the consumer

4.3.1. Existence of latrines

The results presented in this section based on household survey and personal observation. The results revealed that 90% of the respondents that are included in this survey reported the existence of latrine in the household compound. However, this does not mean that the sanitation coverage mostly and successfully achieved. Although the latrine coverage is 90% (6450HHS),

sanitation problems like poor awareness on sanitary and hygienic practices, lack of using hand-washing facility after defecation and poor disposal method of wastes are still there. The results of household survey and personal observation revealed that the public toilets available in different parts of stud area are dirty and filled with farces.

4.3.2. Types of latrines constructed

In the study area, three types of latrine commonly constructed; pit latrine with walls but without roof, pit latrine with closed wall and roof and open pit latrine without house. On the average, 37.54% (2680) of the households had latrines with a wall and roof; 45.2% (3238) of the respondents had pit latrines with closed walls but without roof, 13.85 % (992) of the households had open pit latrines. Usually bowls used to avoid bad smell around the latrines. Moreover, covering might prevent bad smells from spreading beyond the latrine. However, bowls not covered in most latrines observed in the study area. Latrine with bowls covered is only 20.5 % (1470). The sanitation technologies said to improve if those sanitation facilities prevent humans, animals and insects from coming in contact with human excreta (MoWR, 2008). However, such improved technologies not mostly been observed in the study area. The sanitation condition is not pleasing as some of the toilets are simply made of local materials without any facilities. As sanitation is highly linked to water supply, people in the community are suffering from sanitation problems. Therefore, lack of proper access to sanitation is the major cause of potable water quality problem and spreading of diseases in Kucha Woreda, which are harmful to human life.

According to the above figure the latrine coverage in the study area seems encouraging as traditional latrines, which do not meet official standards, are taken in to consideration in the arithmetic. The sanitation technologies said to be improved if those sanitation facilities prevent humans, animals and insects from coming in contact with human excreta (UNICEF, 2008). However, such improved technologies have never been observed in the study area, therefore; the condition is not so healthy and enjoyable as the toilets are simply made of local materials without any facilities. As it is applied to water sources, people in the community can also be classified as people with improved/unimproved sanitation. Accordingly people in the study area can be categorized under unimproved sanitation. Therefore, lack of proper sanitation is the major cause of spreading diseases which are harmful to human life in the study area as they do not have access to improved sanitation.

Table 21. Type of pit latrine in the study area

S. No	Types of pit latrine	Basso N=23	Kuto N=22	Kulo N=24	Fango N=20	Delewoyza N=21	Total 110
1	Pit latrine with walls but without roof	34 %	49.5 %	39 %	55.5%	48 %	45.2
2	Pit latrine with walls and roofs	36 %	46 %	51.7 %	26.5 %	27.5 %	37.54
3	Open pit latrine without house	10.5 %	26.5 %	10.7 %	9.3 %	12.25	13.85

4.3.3. Disposing of liquid and solid wastes.

Good hygiene practices (especially hand washing with soap after defecating and before preparing food, and safe disposal of children's faeces) prevent diarrhea (UNICEF, 2006). It has been reported that baby faeces that is not properly disposed might put household members at risk of diarrhea (Tumwine et al., 2003). Disposal of solid and liquid wastes in open field is a usual activity in the study area. During his stay in the study area, the researcher observed the people that were disposing wastes of different type in open field outside their houses. Of the total respondents, 33 % (36.3) used private sanitary pit to dispose waste generated from their house. The remaining 84.7% (73.7) of the respondents did not have private sanitary pit; as a result, they disposed the waste generated from their house including the baby feces anywhere else. Households that used the private sanitary pit for disposing wastes did not worry about the dimension of the pit and the frequency of disposing the compost from the pit. They said that they have enough space to construct another pit in their compound. As a result, they constructed pits of small dimension. This situation results in a continuous transmission of communicable diseases. This enabled to indicate the condition of environmental sanitation in Kucha Woreda mainly in relation to water supply and sanitation. The situation in most cases was very poor. Hence, there is a need to educate the people on how to handle the wastes properly and dispose of

the waste in proper ways and places. This finding agreed with previous study by Tegegn (2009) in twenty villages of Ethiopia. The correlation result of the association of the disposing of liquid and solid wastes with other sanitation influencing factors showed that there is positive relationship between them (Appendix 11).

4.3.4. The habits of using pit latrines

The survey showed that if latrine was constructed, it did not mean it used regularly. Only 20% or less of those who constructed a latrine used it regularly. On average, about 35% of the respondents who had constructed a latrine used it rarely or not at all. The reasons for not using the latrine regularly were in order of importance: bad smell around the compound, feeling uncomfortable in using the latrine, and the large distance between agricultural fields and their home and latrine (Table 23). The correlation result of the association of the habit of using pit 70 latrine with other sanitation influencing factors showed that there is positive relationship between them (Appendix 11).

Table 22. Reasons of the respondents who have latrine for not using it regularly

		Habit of using house pit latrine					
S. No	Questions reflected to respondents	Basso N=23	Kuto N=22	Kulo N=24	Fango N=20	Delewoyza N=21	Total 110
1	Feel uncomfortable using latrine	35 %	30 %	33.5%	29 %	31.2%	31.74%
2	Farther distance between farming place and home	8.5 %	12 %	13 %	23.5%	14.7 %	14.34%
3	Bad smell developed around the compound	55.4 %	61 %	52.3%	51.5%	50.8 %	54.2 %

4.3.5. Materials used for washing hands after defecation

More than 51.4 % of respondents in all the study area don't use water at all for hand washing after defecating (Table 24). 26.54% of the respondents were using water only, and the remaining were used water and ash (14.1%) or water and soap (11.1%) for hand washing after attending toilet. The number of respondents who do not use water at all after attending toilet was the smallest in Kullo and higher in Fango kebele. There may be socio-economic, cultural, and related knowledge barriers inherent in the study area which strictly hampering this practice. Poor health awareness and poor level of personal hygiene might explain lesser amount of water 57 consumption. Hand-washing with soap can result in major health improvements: one review of studies worldwide documented a 45% reduction in diarrheal morbidity from improved hand-washing (Curtis and Cairncross, 2003) and another documented over 50% reductions in the incidence of both diarrhea and pneumonia when children washed their hands with soap (Luby et al., 2004). This finding was higher than the studies conducted in Ghana, Peru and Kyrgyzstan (Scott et al., 2005). Table 23. the hand washing materials after defecation.

S. No	Washing material used after defecation	Basso N=23	Kuto N=22	Kulo N=24	Fango N=20	Delewoyza N=21	Total 110
1	Water only	21.8%	32.5%	33%	19.8%	25.6%	26.54%
2	Water and ash	11.5%	16%	12%	18%	13%	14.1%
3	Water and soap	12%	9%	16%	8%	10.5%	11.1%
4	Don't use water at all	54%	42%	33%	64%	61%	51.4%

The number of households who were using water and soap after attending the toilet was small due to use of soap was limited because soap was reportedly expensive and was only used for laundry purposes. For those who used it for hand washing after attending toilet, soap was not kept at the toilet because of the fear that someone might visit the toilet and decide to take it.

Majority of the households who did not use water for washing their hands after defecation were illiterate. Besides, they have poor awareness on hygienic practices. Therefore, awareness creation and educating the community about hygiene and sanitation with their combined impact on health at household level is of great importance.

Hygiene improvement is a comprehensive approach to prevent diarrheal disease by promoting improvements in hand washing, treatment and safe storage of water, sanitation, improved access to water and sanitation technologies and products, and fostering an enabling environment. Studies have documented that hand washing at critical times with soap reduce the risk of diarrheal diseases (Curtis and Cain cross, 2003).

Thus, encouraging people to frequently wash their hands is not accomplished solely through teaching. To support and strengthen such actions, regular follow-up is needed, as well as the provision of soap, especially for people with little income. In order to effectively wash your hands, you must use soap. Therefore, consideration should give to provide soap particularly to those who lack income. Furthermore, follow up evaluations are important to assess the degree to which hygienic behaviors are adopted and continued.

4.4. Water quality at the source, storage and point of use

4.4.1. Physicochemical analysis for the source, storage and point of use

Water quality criteria, standards and the related legislation are used to interpret water quality characterization. The most common national requirements are suitability of water quality for drinking and domestic purpose. Many countries base their own standards on the standards of world health organization (WHO) guidelines for drinking water quality (WHO, 2004).

The World Health Organization (WHO), drinking water quality guidelines provide international norms on water quality and human health be used as the basis for regulation and standard setting in developing and developed countries worldwide. These guidelines 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. The analyzed laboratory result were taken eleven samples from the source, eleven samples from storage(household containers) and eleven samples from point of-use(drinking cup). Totally, samples were taken to evaluate the average mean values for selected physicochemical and bacteriological parameters during wet season of January, then compared with the Ethiopia

and WHO drinking water quality standards and interpreted in accordance with the result obtained. Table 24. Mean values of physicochemical parameters for the source, storage and point of-use.

Parameters	Units	Source		Storage		Point of-use		Standards	
		Mean	Std	Mean	Std	Mean	Std	ES	WHO
Temp.	°C	25.22	.0957	25.13	.057	26	-	--	<15
Turbidity	NTU	.2525	.500	.800	.806	2.63	15.75	7	5
EC	µs/cm	218.4	5.59	208	9.16	147	-	1500	1000
PH	PH	8.2	.1500	8.133	.305	8.0	-	6.5-8.5	6.5-8.5
TDS	Mg/l	138.2	66.22	164.3	127.	119	-	1000	1000
		5	8		81				
THas CaCO3	Mg/l	168.3	28.78	126.6	25.6	160	25.6	300	300
			6						
Nitrate	Mg/l	0.875	.525	1	.556	0.500	-	50	50
			2		8				
Chloride	Mg/l	31.75	11.79	29.3	7.09	30	1.02	250	250
Fluoride	Mg/l	1.75	0.84	0.43	0.28	0.3	0.28	3	1.5
Iron	Mg/l	0.4	0.336	0.33	0.15	0.1	0.28	0.4	0.3
Potassium	Mg/l	4.375	2.241	2.833	1.46	3.500	-	50	50
Phosphat e	Mg/l	2.9	0.316	2.4	1.15	4.0	-	0.02	0.005

The laboratory result shows that overall water quality indicates that most parameters are within standard, except parameter like, Temperature, Iron and phosphate are above the ES and WHO guidelines, so the treatment recommend.

Temperature

It was one of physical parameters used to evaluate quality of drinking water. The mean values of temperature for the source, storage and point of-use were $25.22 \pm 0.0957^\circ\text{C}$, $25.13 \pm 0.057^\circ\text{C}$ and $26 \pm 0^\circ\text{C}$, respectively. Minimum is 25.1°C from the source of fango kebele shallow well and

maximum is 25.2°C from the spring with Distribution of fango kebele zazira spring (Appendix 6 and 11). After storage, it has varied between 25 °C and 26 °C (Appendix 6 and 11).

It is desirable that the temperature of drinking water should not exceed 15°C 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, and odor and color problems. Temperature also affects water treatment.(Semaria, 2017).

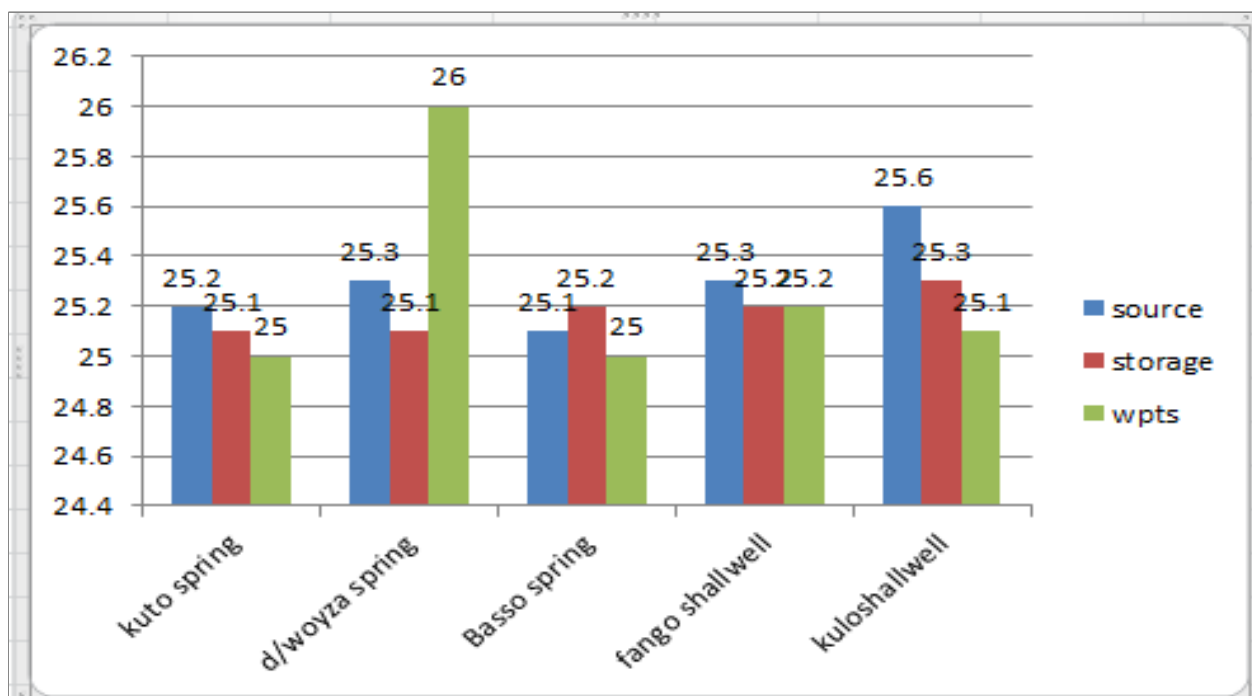


Figure 8 the value of temperature at the source, storage and point of-use

It was exceeded safe levels in drinking water, it has several effects. Here are some of the main impacts Regarding water quality, the study found that, on average, all selected physicochemical parameters sample was selected point kuto it indicate that water point, delewoyza in the source, basso water point, fango storage and kulo source it was affects in drinking water,so,that Consequences of Bacterial growth, altered change taste and Oder, reduced dissolved oxygen and increase chemical reactions.

Phosphate

The result of laboratory analysis revealed that the mean values of phosphate for the source, storage and point of-use were 2.9±.316mg/l, 2.4±1.154mg/l and 4.00±0.18mg/l respectively. The

minimum and maximum values for phosphate were 2.5mg/l kulo kebele shall well to 3.2mg/l Fango kebele large spring, respectively (Appendix 6 and 11). The finding of this study was in agreement to previous research by Douhri et al (2015). The laboratory result showed that above the acceptable limits of ES and WHO for potable water quality. Statistical analysis showed that, the differences in the mean from source, storage and point of use value of phosphate from sampled sites were not significant at p 0.05 significant levels (Appendix 11).

The result shows that sample indicates excesses Phosphate was expressed that funding out of Phosphate were indicated study area kuto spring in the source, basso spring in the source, kullo sw in the source are exceeded limited standard of WHO guidelines.it were affects based on environmental concerns, health risk, change taste and Oder, Corrosion of and Pipes and Plumbing.

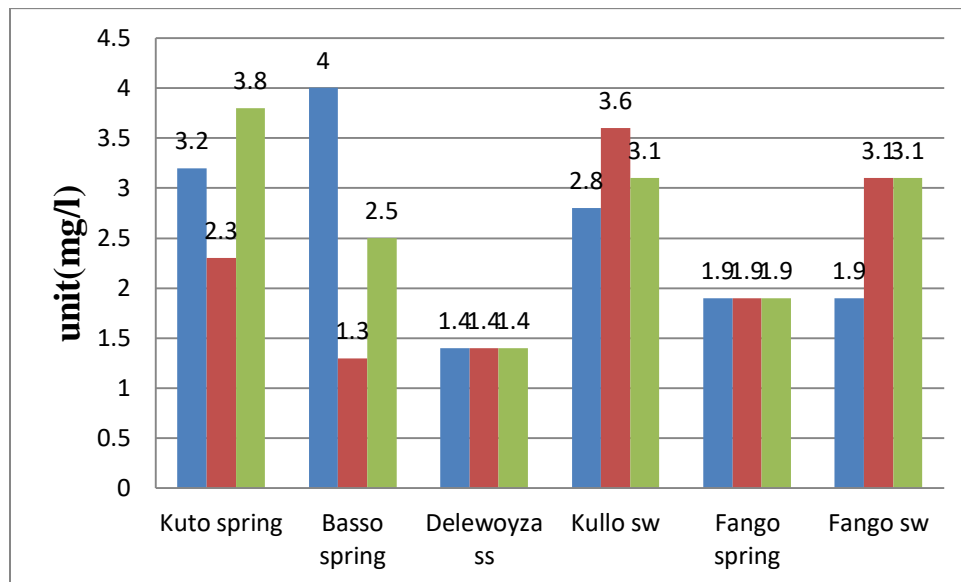


Figure 9. the value of phosphate at the source, storage and point-of-use.

Iron

The registered mean concentration values of iron for source to storage were $(0.300 \pm 0.336 \text{ mg/l})$ and $(0.333 \pm 0.156 \text{ mg/l})$, respectively. The statistical analysis showed that the mean difference from the source, storage and point of-use for iron of the sampled sites were not significant at p 0.05 significant level (Appendix 11). The analyzed laboratory result of iron concentration obtained from the sampled sites was above the maximum permissible limit of ES and WHO standards.

The result of laboratory analysis revealed that the mean values of phosphate for the source, storage and point of-use were the indicate that sample site for founding out of iron were indicated study area are kuto spring, Water point in the kullo shallwell, water point, fango spring water pont and fango sw in the source are exceeded limited standards, of WHO guidelines. This results quncequnces the impacts of discoloration and staining, altered taste and odor, Health Risks, Plumbing and Appliance Damage.

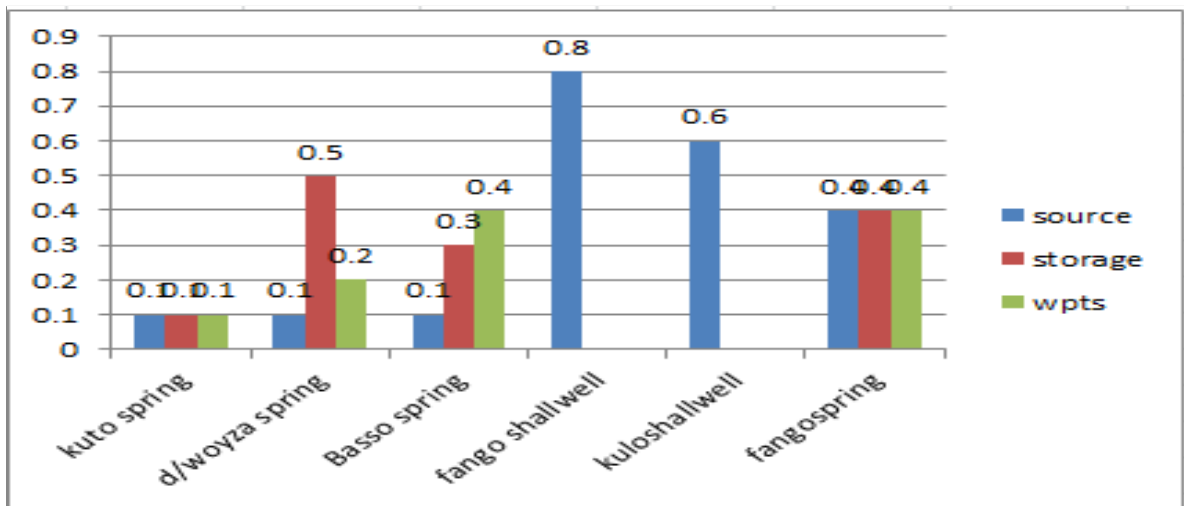


Figure 10.the value of Iron at the source, storage and point of-use.

4.4.2. Bacteriological analysis for the source, storage and point of use

Table 25. the value of bacteriological parameter for the source, storage and point of use.

Parameters	Units	Dry season				Standards	
		Mean	Std	Mean	Std	ES	WHO
TC	CFU	8.9	6.4	13	6.7	0	0

It is the critical issue in the quality of water in the study area and any areas of Ethiopia. Bacteriological analysis of water samples showed that all samples of water sources were positive for total coliforms in two rounds of triplicate sampling. The concentration of TC varied from 2 to 15 and 5 to 25 per 100ml in dry and wet season, respectively (Appendix 9,11 and 12). Mean

concentrations were 8.9 per 100ml in 13 per 100ml in wet season. This indicates the presence of contamination in one seasons and the concentration of TC increase from wet season. However, the statistical analysis showed that there was no significant difference $P > 0.05$ between the dry and wet seasons (Appendix 12). In one different seasons the value was beyond the recommended maximum permissible limits of ES and WHO (ES, 2002 and WHO, 2008), zero/100 mL for the drinking.

In Kucha Woreda, the contamination of water source with excreta from people or animals introduces a great variety of bacteria, viruses, protozoan worms. Insufficient protection of water sources or inadequate treatment, handling and storage, thus puts the community risk of contracting infectious diseases. An important problem is that the communities not perceive the risk of bacteriological contamination as the pollution is often not visible. Local people may value the taste and appearance of the water but not its bacteriological quality unless they understand the risk. Water quality parameter are very many in type and dependent on natural factors (geological, topographical, meteorological, hydrological and biological) and human intervention. Testing at households' storage water was done to characterize the quality of water coming out of the source and analysis at point-of-use i.e. drinking bono done to characterize the quality of water coming out of household containers. For all of sites inspected, there was change in the total coliforms counts from source to household storage containers and from household storage containers to point-of-use. The result obtained for the microbial analysis indicated that all the water samples contaminated with E.coli/thermo tolerant coliform. The least total coliform registered at Fango kebele spring were source there was contaminants CFU/100ml from the source, from the storage contaminant CFU/100ml (Appendix 11). The maximum total coliform registered at kullo kebele shallow well were the result showed that contaminants CFU/100ml at delewoyza spring, in the source indicates contaminates and fango spring in the storage are contaminate with bacteria it were not acceptable limits of the standard of WHO guidelines (Appendix 6).

The medical officers in charge of the health centers in the Woreda confirmed frequent occurrence of water-borne diseases especially dysentery and diarrhea. They treat an average of thirty-four cases of these diseases every week and the children are majorly affected (KWWHO, 2016).

These cases showed that there is problem of potable water quality in the study area of the eleven samples analyzed in this study, 100% complied with the Ethiopia standard and WHO guideline value for total coliforms. Compliance was significantly higher for source and household containers than for the point of use (100%).

In conclusion, the result of the laboratory analysis showed that all the physicochemical water quality parameters considered in this study from all sampled sites varies from the source to household storage and showed the same value from household storage to point of use. However, the differences in the mean values of the sampled sites were not significant at $p < 0.05$ significant level except temperature (Appendix 11). All bacteriological water quality analysis showed significant deterioration of water quality from source to household storage and from household storage to point of use. Although the Woreda's water supplies service office did not apply any kind of water treatment method on regular basis.

5. Conclusion and Recommendation

On the basis of the findings and outcomes of the previous components, this chapter aims to give broad conclusions and recommendations.

5.1. Conclusion

Water supply adequate in quantity and acceptable in quality is the basic need of human beings. The state of water supply in terms of coverage both in spatial and population, accessibility is not at the required standard. Water consumption is affected in the study area due to population growth, household size and distance to the water point. These problems imposed different challenge on inhabitants especially on women and girls such as wait of time and exposure to water borne and related diseases which penalizes the poor. The study was supported to understand the nature of rural water supply and sanitation issues such as water use practices, hygienic practices, sanitation practices, the technical quality of water from improved water schemes, the current status of improved water facilities, coverage of water supply and sanitation. As found out, Kucha Woreda rural water supply service could not enough to water demands of the population with existing capacity. The problems in rural areas of developing countries are of particular concern as still large sections of the community are living without safe water supply and basic sanitation services. At present the coverage of water supply is only 21.9 %.Only 21.9% of the total population is currently covered by a single water supply point. Only 20.8% of Woreda's total area was covered within a 1 km radius, according to the water source/point mapping. Only 21.9% and 78.1% of respondents were satisfied with the quantity and quality of the water provided by the existing water delivery schemes, respectively. Additionally, 28% of the water supply systems were found to be in poor operating and maintenance conditions. The supply services are not operating. The data analysis indicated that family size ($p = 1\%$), waiting time at the schemes ($p = 1\%$), distance to the schemes ($p = 5\%$), and functionality of the schemes ($p = 5\%$) had an important effect on Woreda water use at the household level. In Woreda, the state of sanitation and hygiene was neither good nor encouraging. The results showed that poor hand washing habits, improper waste handling and disposal, and a lack of drainage facilities near water points were identified as the main causes of poor sanitation and hygiene and contributing to the decline in the portability of drinking water in the Woreda. This circumstance showed that Kucha woreda was not given access to a sufficient supply of drinking water or basic sanitation.

The quality of the water from the source, in addition to household storage, transport, and handling procedures, all affect how safe the water is in a community. The physicochemical characteristics demonstrated that the quality of drinking water decreases from the source to domestic storage and from domestic containers to the place of usage. The variability analysis (ANOVA) test revealed that there were no apparent variations in the mean values of the physicochemical parameters for the source, storage, and point of use at the several measured points. With the exception of temperature ($p = 0.010$), the variability analysis (ANOVA) test indicated no significant differences for mean values of all physicochemical parameters among the various sampled points for the source, storage, and point of use at $p 0.05$ significant levels; however, total coliform increased in all sampled points from the source to storage and from storage to point of use.

In addition, the results of seasonal analysis showed that most of the parameters have higher mean values during the, for temperature, Iron, phosphate, which had Higher mean values during the wet season and overall water quality indicates that most of parameters are within standards. The variability analysis (ANOVA) test indicated that there were no significant differences for mean values of all physicochemical and bacteriological parameters of wet season among various sampled sites at $p 0.05$ significant levels. Most of the physical and chemical parameters measured were within the recommended range of WHO standards. Except temperature (at all samples $^{\circ}\text{C}$), Iron (shallow ell $=0.6\text{mg/l}$, spring $=0.4\text{mg/l}$ and shallow ell $=0.5\text{mg/l}$ at Fango, Delewoyza and Kullo kebeles, respectively), phosphate (at all samples 0.8mg/l) and phosphate (spring $=2.8\text{mg/l}$ at Fango kebele), which were found to be unacceptably high in case of temperature, iron and phosphate and unacceptably. Unlike the physicochemical parameters, bacteriological analysis showed that the studied source, storage, point of use, wet season's drinking water were found to be contaminated as it was indicated by high total coliform (all samples $0 \text{ CFU}/100\text{mg}$). This study demonstrated that supply of water alone could not guarantee that the water at the source, storage and in the household for drinking purpose is safe as well.

5.2. Recommendation

To recommend the study of water supply and sanitation coverage, as well as the potable of water for drinking purposes in rural or remote areas, the following steps can be taken

- Provide sustainable access to safe drinking and updates existing water coverage in the study area.
- The addition of new water source and expansion of the existing sources should take place in order to improve low water coverage and consumption of the Woreda.
- Equitable distribution: water points and pipes ought to be evenly distributed to all beneficiaries in order to address the problem of the fringe inhabitants in the study area. Moreover, installation of additional facilities/ public water points to reduce the waiting time to better satisfy daily domestic water requirements by taking into consideration the number of people, density and distance between water points are indispensable.
- The accuracy of a population model forecast is essential prerequisite for effective water supply planning. An under estimation increases the likelihood that planners will not meet the future need for water supply infrastructure. Therefore, the actual population growth rate should be adjusted periodically based on revised population estimates and trends.
- The governmental and non-governmental organizations chiefly focus on construction of new water supply schemes currently but the operation and maintenance of rural water supply are in the lowest performance margin. There should be preventive and regular maintenance program by local institutions and communities in order to keep water supply system sustainable,
- Many awareness creation activities should be done on sanitation and hygiene through all concerned bodies and extension workers for not only preparing latrines but also regular use of the latrines and hand washing practices.
- The Woreda WMEO, health office and other concerned bodies should work by integrating water supply and sanitation as they are interdependent on each other instead of treating them disjointedly;
- More private sanitary pit and communal landfills have to be established to ensure proper waste collection.

- Attempts are necessary to improve the safety of all water supply schemes from the source. This can be made by source disinfection mechanisms like chlorination, point of use disinfection mechanisms such as boiling and other household water treatment measures to decrease the bacteriological health hazards and regular cleaning of water containers and drinking cup system may improve the conditions significantly.

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APPENDICES

Appendix 1 Socio-Demographic Characteristics of Respondents

Variable	Characteristics	Frequency	Percentage
marital status	Married	21	63.6
	Single	11	33.3
	divorced	1	3.0
	Total	33	100.0
Age category	<24	3	9.1
	25-31	7	21.2
	32-38	10	30.3
	>38	13	39.4
	Total	33	100.0
sex	female	15	45.5
	male	18	54.5
	Total	33	100.0
Family size	4	3	9.1
	5	9	27.3
	6	9	27.3
	7	3	9.1
	8	8	24.2
	9	1	3.0
	Total	33	100.0
House	house head	12	36.4
	house wife	11	33.3
	children	10	30.3
	Total	33	100.0
	primary	21	63.6
	secondary	5	15.2
	diploma	5	15.2

Level of education	degree	2	6.1
	Total	33	100.0
occupation status	student	7	21.2
	farmer	15	45.5
	merchant	6	18.2
	gov.t.employer	5	15.2
	Total	33	100.0
monthly income	No	25	75.8
	yes	8	24.2
	Total	33	100.0
source of drinking water	pipe water to yard/plot	3	9.1
	public tap/standpipe	7	21.2
	borehole	3	9.1
	dug well	4	12.1
	river	3	9.1
	spring	12	36.4
	Other	1	3.0
	Total	33	100.0
How long	<5	1	3.0
	5-10	2	6.1
	10-15	9	27.3
	15-30	14	42.4
	>30	7	21.2
	Total	33	100.0
How much water	Number of container	20	60.6
	Don,t know	13	39.4
	Total	33	100.0
supply interruption	yes	33	100.0
	5	1	3.0
	6	1	3.0

container volume	8	2	6.1
	10	3	9.1
	15	3	9.1
	20	5	15.2
	25	9	27.3
	40	7	21.2
	80	2	6.1
	Total	33	100.0
water during interruption	from river	10	30.3
	from pond	11	33.3
	from unprotected spring	9	27.3
	other, specify	3	9.1
	Total	33	100.0
bathroom	No	26	78.8
	yes	7	21.2
	Total	33	100.0
restroom	Bucket	3	9.1
	pit latrine	11	33.3
	NO facility	19	57.6
	Total	33	100.0
pour flush	septic tank	3	9.1
	unknown place	23	69.7
	pit latrine	7	21.2
	Total	33	100.0
use facility	No	12	36.4
	yes	21	63.6
	Total	33	100.0
	4	1	3.0
	5	2	6.1
	8	1	3.0

how many people use	10	3	9.1
	14	1	3.0
	15	1	3.0
	16	1	3.0
	18	2	6.1
	20	2	6.1
	25	2	6.1
	30	3	9.1
	53	1	3.0
	55	1	3.0
	60	1	3.0
	63	1	3.0
	69	1	3.0
	Total	24	72.7
	System	9	27.3
	Total	33	100.0
how to dispose feces	children used toilet/latrine	4	12.1
	Thrown into garbage	13	39.4
	other, specify	16	48.5
	Total	33	100.0
no restroom	lack of money	14	42.4
	lack of permission for construction	5	15.2
	lack of space	6	18.2
	The house is rented	2	6.1
	others , specify	6	18.2
	Total	33	100.0
	Bad	6	18.2
	good	3	9.1

you think water source	very bad	5	15.2
	satisfactory	14	42.4
	Don't know	5	15.2
	Total	33	100.0
your water safer to drink	No	6	18.2
	yes	26	78.8
	I don't know	1	3.0
	Total	33	100.0
what alterations	use a water filter	2	6.1
	Add Agar	15	45.5
	Filter it through cloth	1	3.0
	Let it stand and settle	14	42.4
	5	1	3.0
	Total	33	100.0
why use at home treatment	lack of money	3	9.1
	lack of knowledge	20	60.6
	lack of treatment mechanisms	7	21.2
	others, specify	3	9.1
	Total	33	100.0
have issues with water & sanitations	No	5	15.2
	yes	19	57.6
	2	2	6.1
	3	3	9.1
	4	3	9.1
	5	1	3.0
	Total	33	100.0
	diarrhea	14	42.4
	water borne diseases	11	33.3
	bacteria	1	3.0

what are they	viruses	3	9.1
	others, specify	1	3.0
	Total	30	90.9
	System	3	9.1
	Total	33	100.0
water is colored	No	12	36.4
	yes	20	60.6
	Total	32	97.0
	System	1	3.0
	Total	33	100.0
present water losses	No	2	6.1
	yes	31	93.9
	Total	33	100.0
what is the causes	broken pipe line	10	30.3
	defective pipe joints	13	39.4
	cracking	5	15.2
	consumers open their tapes	5	15.2
	Total	33	100.0

Appendix 2 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	df 1	df 2	Sig. F Change
1	1.000 ^a	1.000	.	.	1.000	.	19	0	.

Appendix 3 ANOVA for multiple linear regressions

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1646.950	19	86.682	.	. ^b
	Residual	.000	0	.		
	Total	1646.950	19			

a. Dependent Variable: container volume

b. Predictors: (Constant), what is the causes, sex, age, no restroom, water during interruption, present, water losses, bathroom, How much water, How long, family size, monthly income, source of drinking water, use facility, restroom, levels of education, water is colored, your water safer to drink, have issues with water & sanitations, why use at home treatment.

Appendix 4 multiple linear regression model result

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	-8.827	.000		.	.	-8.827	-8.827		
	Age	.830	.000	.596	.	.	.830	.830	.124	8.063
	Sex	-30.552	.000	-1.683	.	.	-30.552	-30.552	.110	9.115
	levels of education	11.883	.000	1.126	.	.	11.883	11.883	.053	18.742
	family size	-4.488	.000	-.718	.	.	-4.488	-4.488	.299	3.347
	monthly income	7.548	.000	.381	.	.	7.548	7.548	.094	10.597
	source of drinking water	-.839	.000	-.186	.	.	-.839	-.839	.062	16.027
	How long	-5.360	.000	-.537	.	.	-5.360	-5.360	.093	10.711

How much water	-8.307	.000	-.455	.	.	-8.307	-8.307	.164	6.084
water during interruption	2.185	.000	.262	.	.	2.185	2.185	.049	20.361
bathroom	11.821	.000	.391	.	.	11.821	11.821	.065	15.438
restroom	2.974	.000	.219	.	.	2.974	2.974	.149	6.729
use facility	23.292	.000	.917	.	.	23.292	23.292	.102	9.785
no restroom	-2.296	.000	-.362	.	.	-2.296	-2.296	.138	7.268
your water safer to drink	25.970	.000	.624	.	.	25.970	25.970	.115	8.692
why use at home treatment	-9.082	.000	-.910	.	.	-9.082	-9.082	.039	25.899
have issues with water & sanitations	2.185	.000	.279	.	.	2.185	2.185	.089	11.175
water is colored	-9.691	.000	-.509	.	.	-9.691	-9.691	.113	8.839
present water losses	16.680	.000	.401	.	.	16.680	16.680	.541	1.847
what is the causes	4.460	.000	.428	.	.	4.460	4.460	.213	4.699

Appendix 5 Sampled water supply schemes for coverage and quality analysis

Kebeles Name	Village Name	Type of water supply	GPS x	GPS y	GPS z	Current status	Yield (L/ s)
Kuto	Agni chare	Medium spring	0326852	0716783	1616	Functional	0.062
Delewoyza	ocholo	Large spring	0323131	0715948	2150	Functional	0.27
Basso	dosha	On spot spring	0322734	0713015	1654	Functional	0.15
Fango	zazira	Medium spring	0326340	0710761	1626	Functional	0.14
	Sola kutir -2	Shallow well	0327248	0711393	1528	Functional	1.5
Kullo	tawaye	Shallow well	0331946	0714518	1435	Functional	0.25

Appendix 6 Descriptive Values for the Source, Storage and Point of Use

Parameter	Source	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
PH	spring	4	8.225	.1500	.0750	7.986	8.464	8.1	8.4
	reservoir	3	8.133	.3055	.1764	7.374	8.892	7.8	8.4
	water point	1	8.000	.	.	.	.	8.0	8.0
	source	1	8.500	.	.	.	.	8.5	8.5
	shallow well	2	8.100	.2828	.2000	5.559	10.641	7.9	8.3
	Total	11	8.182	.2228	.0672	8.032	8.331	7.8	8.5
Cond	spring	4	218.00	5.598	2.799	209.09	226.91	213	225
	reservoir	3	208.00	9.165	5.292	185.23	230.77	198	216
	water point	1	147.00	.	.	.	.	147	147
	source	1	223.00	.	.	.	.	223	223
	shallow	2	210.00	11.31	8.000	108.3	311.6	202	218

	well		00	4		5	5		
	Total	1	207.	21.78	6.567	193.1	222.4	147	225
		1	82	0		9	5		
TEM	spring	4	25.2	.0957	.0479	25.07	25.37	25.1	25.3
			25			3	7		
	reservi or	3	25.1	.0577	.0333	24.99	25.27	25.1	25.2
			33			0	7		
	water point	1	26.0	.	.	.	.	26.0	26.0
			00						
	source	1	25.0	.	.	.	.	25.0	25.0
			00						
	shollo well	2	25.4	.2828	.2000	22.85	27.94	25.2	25.6
			00			9	1		
	Total	1	25.2	.2857	.0861	25.09	25.47	25.0	26.0
		1	82			0	4		
Turbidity	spring	4	.252	.5050	.2525	-	1.056	.00	1.01
			5	0	0	.5511	1		
	reservi or	3	.830	.8061	.4654	-	2.832	.00	1.61
			0	6	4	1.172	6		
						6			
	water point	1	2.63	.	.	.	.	2.63	2.63
			00						
	source	1	.000	.	.	.	.	.00	.00
			0						
	shollo well	2	66.0	91.83	64.94	-	891.2	1.12	131.00
			600	903	000	759.0	009		
						809			
	Total	1	12.5	39.28	11.84	-	38.96	.00	131.00
		1	682	868	598	13.82	27		
						63			

TDS	spring	4	138. 250	66.22 88	33.11 44	32.86 5	243.6 35	65.0	223.0
	reservoir	3	164. 333	127.8 137	73.79 33	- 153.1 73	481.8 40	42.0	297.0
	water point	1	119. 000	.	.	.	.	119.0	119.0
	source	1	154. 000	.	.	.	.	154.0	154.0
	shallow well	2	37.3 00	16.54 63	11.70 00	- 111.3 63	185.9 63	25.6	49.0
	Total	1 1	126. 691	82.26 60	24.80 41	71.42 4	181.9 58	25.6	297.0
CL	spring	4	.00	.000	.000	.00	.00	0	0
	reservoir	3	.00	.000	.000	.00	.00	0	0
	water point	1	.00	.	.	.	.	0	0
	source	1	.00	.	.	.	.	0	0
	shallow well	2	.00	.000	.000	.00	.00	0	0
	Total	1 1	.00	.000	.000	.00	.00	0	0
Chlorine(total)	spring	4	.00	.000	.000	.00	.00	0	0
	reservoir	3	.00	.000	.000	.00	.00	0	0
	water point	1	.00	.	.	.	.	0	0
	source	1	.00	.	.	.	.	0	0

	shollo well	2	.00	.000	.000	.00	.00	0	0
	Total	1 1	.00	.000	.000	.00	.00	0	0
Fluoride	spring	4	1.75 0	.8426	.4213	.409	3.091	1.2	3.0
	reservoir	3	.433	.4933	.2848	-.792	1.659	.1	1.0
	water point	1	.300	.	.	.	.	.3	.3
	source	1	.500	.	.	.	.	.5	.5
	shollo well	2	.350	.3536	.2500	- 2.827	3.527	.1	.6
	Total	1 1	.891	.8608	.2595	.313	1.469	.1	3.0
Iron	spring	4	.300	.3367	.1683	-.236	.836	.1	.8
	reservoir	3	.333	.1528	.0882	-.046	.713	.2	.5
	water point	1	.100	.	.	.	.	.1	.1
	source	1	.400	.	.	.	.	.4	.4
	shollo well	2	.500	.1414	.1000	-.771	1.771	.4	.6
	Total	1 1	.336	.2292	.0691	.182	.490	.1	.8
potassium	spring	4	4.37 5	2.241 1	1.120 5	.809	7.941	1.2	6.3
	reservoir	3	2.83 3	1.464 0	.8452	-.803	6.470	1.5	4.4
	water	1	3.50	.	.	.	.	3.5	3.5

	point		0						
	source	1	2.40 0	.	.	.	.	2.4	2.4
	shollo well	2	2.80 0	.4243	.3000	- 1.012	6.612	2.5	3.1
	Total	1 1	3.40 9	1.613 4	.4864	2.325	4.493	1.2	6.3
Hardness	spring	4	158. 50	44.93 3	22.46 7	87.00	230.0 0	120	205
	reservi or	3	126. 67	25.54 1	14.74 6	63.22	190.1 1	98	147
	water point	1	160. 00	.	.	.	.	160	160
	source	1	155. 00	.	.	.	.	155	155
	shollo well	2	194. 50	7.778	5.500	124.6 2	264.3 8	189	200
	Total	1 1	156. 18	36.06 9	10.87 5	131.9 5	180.4 1	98	205
Nitrate	spring	4	.875	.5252	.2626	.039	1.711	.1	1.2
	reservi or	3	1.00 0	.5568	.3215	-.383	2.383	.4	1.5
	water point	1	.500	.	.	.	.	.5	.5
	source	1	1.40 0	.	.	.	.	1.4	1.4
	shollo well	2	.500	.2828	.2000	- 2.041	3.041	.3	.7
	Total	1 1	.855	.4762	.1436	.535	1.174	.1	1.5

phosphate	spring	4	2.90 0	.3162	.1581	2.397	3.403	2.5	3.2
	reservoir	3	2.40 0	1.153 3	.6658	-.465	5.265	1.3	3.6
	water point	1	4.00 0	.	.	.	.	4.0	4.0
	source	1	3.80 0	.	.	.	.	3.8	3.8
	shallow well	2	1.65 0	.3536	.2500	- 1.527	4.827	1.4	1.9
	Total	1 1	2.71 8	.9282	.2799	2.095	3.342	1.3	4.0
Chloride	spring	4	31.7 5	11.58 7	5.793	13.31	50.19	15	40
	reservoir	3	29.3 3	7.095	4.096	11.71	46.96	23	37
	water point	1	30.0 0	.	.	.	.	30	30
	source	1	20.0 0	.	.	.	.	20	20
	shallow well	2	22.5 0	12.02 1	8.500	- 85.50	130.5 0	14	31
	Total	1 1	28.1 8	9.152	2.760	22.03	34.33	14	40
fecal	spring	2	.00	.000	.000	.00	.00	0	0
	reservoir	2	.00	.000	.000	.00	.00	0	0
	water point	1	.00	.	.	.	.	0	0
	source	1	.00	.	.	.	.	0	0

	shollo well	1	.00	.	.	.	.	0	0
	Total	7	.00	.000	.000	.00	.00	0	0
T.coliform	spring	2	.00	.000	.000	.00	.00	0	0
	reservoir	2	.00	.000	.000	.00	.00	0	0
	water point	1	.00	.	.	.	.	0	0
	source	1	.00	.	.	.	.	0	0
	shollo well	1	.00	.	.	.	.	0	0
	Total	7	9.36	5.12	14.27	6.85	17.72	8.02	0

Appendix 7 Results for the Source, Storage and Point of Use

ANOVA results

Parameter	Between and within Groups	Sum of Squares	Df	Mean Square	F	Sig.
PH	Between Groups	.162	4	.041	.728	.604
	Within Groups	.334	6	.056		
	Total	.496	10			
Cond	Between Groups	4353.636	4	1088.409	16.745	.002
	Within Groups	390.000	6	65.000		
	Total	4743.636	10			
TEM	Between	.702	4	.176		

	Groups				9.226	.010
	Within Groups	.114	6	.019		
	Total	.816	10			
Turb	Between Groups	6999.535	4	1749.884	1.245	.385
	Within Groups	8436.472	6	1406.079		
	Total	15436.007	10			
TDS	Between Groups	21571.712	4	5392.928	.702	.619
	Within Groups	46105.197	6	7684.199		
	Total	67676.909	10			
CL	Between Groups	.000	4	.000	.	.
	Within Groups	.000	6	.000		
	Total	.000	10			
Chlorine(total)	Between Groups	.000	4	.000	.	.
	Within Groups	.000	6	.000		
	Total	.000	10			
Fluoride	Between Groups	4.667	4	1.167	2.554	.146
	Within Groups	2.742	6	.457		
	Total	7.409	10			
Iron	Between	.119	4	.030		

	Groups				.438	.778
	Within Groups	.407	6	.068		
	Total	.525	10			
Potassium	Between Groups	6.495	4	1.624	.499	.739
	Within Groups	19.534	6	3.256		
	Total	26.029	10			
Hardness	Between Groups	5587.470	4	1396.867	1.129	.425
	Within Groups	7422.167	6	1237.028		
	Total	13009.636	10			
Nitrate	Between Groups	.740	4	.185	.726	.605
	Within Groups	1.528	6	.255		
	Total	2.267	10			
Phosphate	Between Groups	5.531	4	1.383	2.689	.134
	Within Groups	3.085	6	.514		
	Total	8.616	10			
Chloride	Between Groups	189.720	4	47.430	.439	.777
	Within Groups	647.917	6	107.986		
	Total	837.636	10			
Fecal	Between	.000	4	.000	.	.

	Groups					
	Within Groups	.000	2	.000		
	Total	.000	6			
Coliform	Between Groups	.000	4	.000		
	Within Groups	.000	2	.000		
	Total	8.02	6			

Appendix 8 Mean value of Physicochemical and Bacteriological analysis of sample points of source, storage and point of use from kuto kebele.

		Spring			ES	WHO
Parameters	Units	Source	Storage	Point of use		
Physical						
Temp.	(⁰ c)	25.2	25.1	25	-	12-30 ⁰ c
EC	(mv)	213	216	223	-	10-1000mv
PH	PH	8.4	8.4	8.5	-	6.5-8.5
Turbidity	(NTU)	0.00	0.00	0.00	-	<5NTU
Chemical						
TDS	Mg/l	149	154	154	-	10-1000 NTU
TH (CaCO ₃)	Mg/l	120	98	155	-	300
Nitrate	Mg/l	1.2	1.1	1.4	-	50
Chloride	Mg/l	40	37	20	-	50
Fluoride	Mg/l	1.2	1.0	0.5	-	250

Iron	Mg/l	0.1	0.3	0.4	-	0.3
Magnesium	Mg/l	9.3	7	7	-	30
Phosphate	Mg/l	3.2	2.3	3.8	-	0.005
Potassium	Mg/l	1.2	1.5	2.4	-	10
Chlorine (free) (mg/l)	Mg/l	0.00	0.00	0.00	-	0.2-0.5MG/L
Chlorine (total) (mg/l)	Mg/l	0.00	0.00	0.00	-	0.2-1mg/L
Biological						
E.coli/TTC	CFU/100ml	0/100	0/100	14.27		

Appendix 9 Mean value of Physicochemical and Bacteriological analysis of sample points of source, storage and point of use from delewoyza kebele.

Parameters	unit	Spring			ES	WHO
		source	storage	Point of use		
Physical						
Temp.	(⁰ c)	25.3	25.1	26	-	12-30 ⁰ c
EC	(mv)	225	198	147	-	10-1000mv
PH	PH	8.1	7.8	8.0	-	6.5-8.5
Turbidity	(NTU)	1.01	0.88	2.63	-	<5NTU
Chemical						
TH (CaCO ₃)	Mg/l	189	147	160	-	300
Nitrate	Mg/l	0.1	0.4	0.5	-	50
Chloride	Mg/l	15	28	30	-	250

Fluoride	Mg/l	1.5	0.2	0.3	-	1.5
Iron	Mg/l	0.2	0.5	0.1	-	0.3
Magnesium	Mg/l	11	10	10	-	50
Phosphate	Mg/l	2.5	1.3	4.0	-	0.005
Potassium	Mg/l	5.5	2.6	3.5	-	10
Chlorine (free) (mg/l)	Mg/l	0.00	0.00	0.00	-	0.2-0.5MG/L
Chlorine (total) (mg/l)	Mg/l	0.00	0.00	0.00	-	0.2-1mg/L
TDS	Mg/l	116	42	119	-	10-1000 NTU
Biological						
E.coli/TTC	CFU/ 100ml	7	20	22	-	0/100

Appendix 10 Mean value of Physicochemical and Bacteriological analysis of sample points of source, storage and point of use from basso kebele.

Parameters	unit	Spring			ES	WHO
		source	storage	Point of use		
Physical						
Temp.	(⁰ c)	25.1	-	-	-	12-30 ⁰ c
EC	(mv)	214	-	-	-	10- 1000mv
PH	PH	8.3	-	-	-	6.5-8.5
Turbidity	(NTU)	0.00	-	-	-	<5NTU

Chemical						
TH (CaCO ₃)	Mg/l	205	-	-	-	300
Nitrate	Mg/l	1.0	-	-	-	50
Chloride	Mg/l	33	-	-	-	250
Fluoride	Mg/l	1.3	-	-	-	1.5
Iron	Mg/l	0.1	-	-	-	0.3
Magnesium	Mg/l	12	11	10	-	50
Phosphate	Mg/l	3.1	-	-	-	0.005
Potassium	Mg/l	4.5	-	-	-	10
Chlorine (free)(mg/l)	Mg/l	0.00	-	-	-	0.2- 0.5MG/L
Chlorine (total) (mg/l)	Mg/l	0.00	-	-	-	0.2-1mg/L
TDS	Mg/l	223	-	-	-	10-1000
Biological						
E.coli/TTC	CFU/100ml	0.00	-	-	-	0.00

Appendix 11 Mean value of Physicochemical and Bacteriological analysis of sample points of source, storage and point of use from fango kebele.

		Spring			ES	WHO
Parameters	unit	Spring source	storage	Point of use	-	
Physical						
Temp.	(⁰ c)	25.3	25.2	25.2	-	12-30 ⁰ c
EC	(mv)	220	210	202	-	10-1000mv
PH	PH	8.1	8.2	8.3	-	6.5-8.5
Turbidity	(NTU)	0.00	1.61	1.12	-	<5NTU
Chemical						
TH (CaCO3)	Mg/l	120	135	200	-	300
Nitrate	Mg/l	1.2	1.5	0.3	-	50
Chloride	Mg/l	39	23	14	-	250
Fluoride	Mg/l	0.4	0.1	1.1	-	1.5
Iron	Mg/l	0.8	0.2	0.4	-	0.3
Magnesium	Mg/l	10	13	11	-	50
Phosphate	Mg/l	2.8	3.6	1.4	-	0.005
potassium	Mg/l	6.3	4.4	2.5	-	10
Chlorine (free)(mg/l)	Mg/l	0.00	0.00	0.00	-	0.2-0.5MG/L
Chlorine (total) (mg/l)	Mg/l	0.00	0.00	0.00	-	0.2-1mg/L
TDS	Mg/l				-	10-1000
Biological						
E.coli/TTC CFU/100ml	CFU/100ml	2	4	5	0/100	0/100

Appendix 12 Mean value of Physicochemical and Bacteriological analysis of sample points of source, storage and point of use from kullo kebele.

Parameters	unit	Spring			ES	WHO
		Shallow well	storage	Point of use		
Physical						
Temp.	(⁰ c)	25.6	–	–	–	12-30 ⁰ c
EC	(mv)	218	–	–	–	10-1000mv
PH	PH	7.9	–	–	–	6.5-8.5
Turbidity	(NTU)	131	–	–	–	<5NTU
Chemical						
TH (CaCO3)	Mg/l	189	–	–	–	300
Nitrate	Mg/l	0.7	–	–	–	50
Chloride	Mg/l	31	–	–	–	250
Fluoride	Mg/l	0.6	–	–	–	1.5
Iron	Mg/l	0.6	–	–	–	0.3
Magnesium	Mg/l	13	–	–	–	50
Phosphate	Mg/l	1.9	–	–	–	0.005
potassium	Mg/l	3.1	–	–	–	10
Chlorine (free)(mg/l)	Mg/l	0.00	–	–	–	0.2-0.5MG/L
Chlorine (total) (mg/l)	Mg/l	0.00	–	–	–	0.2-1mg/L
TDS	Mg/l	256	–	–	–	10-1000
Biological						
E.coli/TTC CFU/100ml	CFU/100ml	12				0/100

Appendices 11. Different sources of water used by the communities in each kebeles

Sources of Water	Basso N=23	Kuto N=22	Kulo N=24	Fango N=20	Delewoyza N=21	Total 110
River	0%	0%	5.8%	18.5%	6.4%	6.14%

Protected spring	16.7%	100%	79.5%	0%	0%	39.24%
Unprotected spring	14%	17.5%	20%	0%	0%	10.3%
Public tap	0%	72.5%	27.5%	0%	100%	40%

Appendices 14. Projected Water Demand (m³/day) for the year 2015 -2035

Year	2015	2020	2025	2030	2035
Population number	154564	177450	203724	308275	535551
Average per-capita domestic water demand, L/c/d	20	25	25	25	25
Domestic water demand (m ³ /day)	3091280	4436250	5093100	7706875	13388775
Livestock population	92738	106470	122234	184965	321330
Average per livestock demand, L/c/d	3	3	3	3	3
Livestock water demand (m ³ /d)	278.2	319.4	366.71	554.9	963.91
Average day water demand (m ³ /d)	3091558.2	4436569.4	5093466.71	7707429.9	13389738.91
Losses in the system (% of average day demand)	10%	10%	10%	10%	10%
Losses in the system (m ³ /d)	309155.82	443656.94	509346.671	770742.99	1338973.891
Total Average Day Demand (m ³ /d)	3400714.02	4880226.34	5602813.381	8478172.89	14728712.8

Appendices 15. Respondent's satisfaction of water supply

Parameter		Frequency				
Are you satisfied with this amount water Available to your household daily for drinking, cooking and sanitation?		No			Percentage	
		No	76	69		
		Yes	15	28		
Does the source get dry during some periods in a year?		No	30	47.6		
		Yes	35	36		
Are you satisfied with quality of water you get from scheme?		No	44	45.9		
		Yes	61	57.6		
Does the source get dry during bega (Tir – Megabit)?	Delewoyza	Baso	Fango	Kuto	Kulo	
	Yes	34.6%	100%	100%	54.7%	0%
	No	65.4%	0%	0%	45.3%	100%

Appendices 16. Respondents satisfaction of water supply

Terms that carried a unique meaning for the purpose of this study are defined as follows
Drinking water, or potable water, is defined as having acceptable quality in terms of its physical, chemical, bacteriological and acceptability parameters so that it can be safely used for drinking and cooking (WHO, 2004a).

Coverage -proportion of people served with the adequate levels of water supply.

Sanitation: - WHO defines sanitation as group of methods to collect human excreta and urine as well as community waste waters in a hygienic way, where human and community health is not altered. It is managing human waste in a safe and healthy way.

Hygiene – things people do to stay clean and prevent the spread of germs. Hygiene includes washing hands and bathing, storing and preparing food, and keeping the home clean.

Sustainability: In context of drinking water supply schemes, sustainability refers to the ability to maintain efforts and derived benefits both at community and agency level even after the assistance (managerial, financial and technical) is withdrawn (WECD, 1999).

Operation: It deals with the actual running of a service (e.g. Provision of fuel, starting or handling of pumps, control of water collection points, general mechanical).

Maintenance: It deals with the activities that keep the system in proper working condition, including management, cost recovery, repairs and preventive maintenance.

Improved Water Supply: Provision of water in good quality or safe for health, good quantity or the required amount of water is available for use any time throughout the year; and collection of water need not take much of your time and effort.

Safe Water: the water protected from contamination.

Household: any unit of habitual residence where some consumption and/or production may be undertaken in common and where some members may recognize culturally defined relationships of kinship and/or affinity where the members are related in some way.

Protected spring: - a spring, which is properly covered by stone masonry and the distribution site is near the protection.

Unprotected spring: - a spring without any construction and flow on the open field.

Protected well: - a well with a constructed base and with a proper covered at the top

Unprotected well: - a well without construction and is open and easily polluted by waste.

Acceptable: - water source which is safe for human consumption.

Unacceptable: - water sources that are not safe for human consumption.

Part I. Questions answered by sample Households

Dear respondents, my name are Mekuria Mundare, and this questionnaire was created as a tool to do academic research for the completion of the Masters Science (MSc) program at the Hawassa University School of Bio system and Environmental Engineering Water Resource Engineering and Management program. The major goal of the study is to “assess the availability of water supply and sanitation coverage as well as the suitability of the water for drinking purposes in rural areas”. Your information will be crucial and it used for academic research. I'm hoping you can assist me out by responding to this query; none of your responses will be made public. Don't mention your name. All the details you provide to us will remain.

Thank you in advance for taking your time to answer our questions!!!!!!

1. Personal profile of the respondent

1.1 .Age_____

1.2. Marital status _____

1.3 .Sex_____

1.4 .House ownership _____

1.5 .Levels of education_____

1.6 .Occupational status_____

1.7 .Family size

1.8 .Monthly income _____

2. Water supply

2.1 What is the main source of drinking water for the people living in your home? {Check one}

A. Piped water to yard/plot. Rain water collection C. Public tap/standpipe

D. Borehole E. dug well F. River G. Spring H. other

2.2 How much water supply coverage in kucha woreda?

2.3 How much water do you bring home each day for domestic use? A. Number of container B.

Don't know

2.4 Has your village's water supply been interrupted?

A. Yes B. No

2.5 We do you know the container's volume in liters.

2.6. We do you know village's water supply coverage accessed?

3. Sanitation

3.1 Is there a bathroom in this home?

A. Yes B. No

3.2 Which type of restrooms do members of your homes typically use? A. Bucket B. Pit latrine
C. No facility,

3.3 Where does the flush go if you flush or pour flush? A. Piped sewer system B.
River/elsewhere C. Septic tank D. Unknown place 5. Pit latrine

3.4 Do other Households also use this facility? A. Yes B. No

3.5 If yes, how many people use it?

3.6 How to dispose the youngest child's feces? A. Child used toilet/latrine B. Thrown into
garbage C. Other, specify

3.7 What is the cause if there are no restrooms there? A. Lack of money B. Lack of permission
for construction C. Lack of space D. The house is rented E. Others, specify

4. Water quality

4.1 What do you think of the water source you are presently using? A. Very good B. Bad C.
Good D. Very bad E. Satisfactory F. Don't know

4.2 Do you take any steps to make your water safer to drink? A. Yes
B. No C. I don't know

4.3 What alterations do you often make to the water to make it safer to drink? A. Boil
B. Use a water filter C. Add Agar D. Filter it through a cloth E. Let it stand and settle .If you
use this alteration's? You should have say yes or no, if you say No, Why don't you use any
at-home treatments? A. Lack of money B. Lack of knowledge 3. Lack of treatment
mechanisms 4. Other, specify

4.4 Have issues with water and sanitation ever affected you and your family? A. Yes B No

4.5 If your answer Q4. 5 are yes, what is/are they?

4.6The water is always the same color, flavor, and odor? A. Yes B. No

4.7 If no, which one is mostly changed? A. Color B. Taste C. Odor

4.8 Is there present water losses in the water supply systems? A. Yes B. No
If yes, what is the causes:- -----

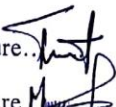
Part II Questions for Group Discussion


1. Do you believe that the community members are satisfied with the current conditions of the water supply and sanitation systems?
2. What steps does the neighborhood take to improve access to clean water for drinking and toilets?
3. What do you think about the link between infrastructure and economic growth?


Part III. Interview with woreda's water resource and mining office head


1. What are the basic problems in the community?
2. Is there sufficient water for all community members at any time?
3. Is the water quality sufficient for drinking?
4. What do you think are the main constraints to improving water supply and sanitation?
5. Have you recognized any problems caused by unsafe water consumption?
6. Do the government and NGOs attempt to promote public participation in water related development activities, and in what ways?
7. What are the major problems in relation to water supply and sanitation?
8. What are your suggestions for improving water and sanitation, and thereby improving food security, health and overall standard of living?

	Parameters	Reference Values
1	PH	6.5-8.5
2	Temperature	12-30 ⁰ c
3	Turbidity	<5NTU
4	Conductivity	10-1000mv
5	color	< 15TCU
6	Free Chlorine	0.2-0.5MG/L
7	Total Chlorine	0.2-1mg/L
8	TDS	10-1000 NTU
9	Fecal coliform	0.00
10	Total coliform	0.00

Name of analyzer: Temesgen Yigezu signature..  Date.. 9/09/2015

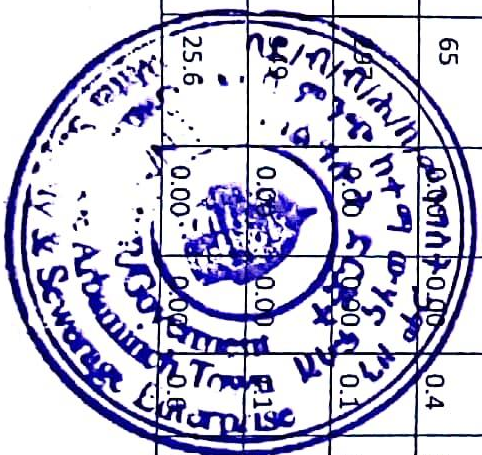
Name of analyzer: Mintesnot Tarku signature  Date.. 9/09/2015

Name of analyzer: Mekuria Mundare signature  Date.. 9/09/2015
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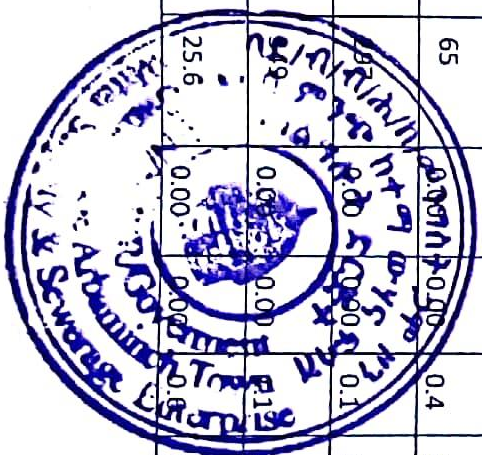
Approved Israel Assefa. Israel Assefa Melaku signature..  Date... 9/09/2015



S. No	Source of sample	time of sample arrival	Ph	Conductivity (mv)	Temperature (°c)	Turbidity (NTU)	TDS (ppm)	Cl (free) (mg/l)	Cl (total) (mg/l)	F (mg /l)	Fel (mg /l)	k /
1	Spring	4:50	8.4	213	25.2	0.00	149	0.00	0.00	1.2	0.1	1
2	Reservoir	5:25										
2	Reservoir	5:25	8.4	216	25.1	0.00	154	0.00	0.00	1.0	0.3	1
3	Source	5:50	8.5	223	25	0.00	154	0.00	0.00	0.5	0.4	2
4	Water point	8:00	8.0	147	26	2.63	119	0.00	0.00	0.3	0.1	3
4	Reservoir	8:20										
5	Reservoir	8:20	7.8	198	25.1	0.88	42	0.00	0.00	0.2	0.5	2
6	Spring	8:50	8.1	225	25.3	1.01	116	0.00	0.00	1.5	0.2	5
7	Spring	9:45	8.3	214	25.1	0.00	223	0.00	0.00	1.3	0.1	4
8	Spring	6:20	8.1	220	25.3	0.00	65	0.00	0.00	0.4	0.8	6
8	Reservoir	6:35	8.2	210	25.2	1.61						
9	Reservoir	6:35	8.2	210	25.2	1.61						
10	Shallowell	7:10	8.3	202	25.2	1.12						
10	Shallowell	7:10	8.3	202	25.2	1.12		0.00	0.00	0.1	0.2	4
11	Shallowell	8:30	7.9	218	25.6	131	25.6	0.00	0.00	0.6	0.6	3



S. No	Source of sample	time of sample arrival	Ph	Conductivity (mv)	Temperature (°c)	Turbidity (NTU)	TDS (ppm)	Cl (free) (mg/l)	Cl (total) (mg/l)	F (mg /l)	Fel (mg /l)	k /
1	Spring	4:50	8.4	213	25.2	0.00	149	0.00	0.00	1.2	0.1	1
2	Reservoir	5:25	8.4	216	25.1	0.00	154	0.00	0.00	1.0	0.3	1
3	Source	5:50	8.5	223	25	0.00	154	0.00	0.00	0.5	0.4	2
4	Water point	8:00	8.0	147	26	2.63	119	0.00	0.00	0.3	0.1	3
5	Reservoir	8:20	7.8	198	25.1	0.88	42	0.00	0.00	0.2	0.5	2
6	Spring	8:50	8.1	225	25.3	1.01	116	0.00	0.00	1.5	0.2	5
7	Spring	9:45	8.3	214	25.1	0.00	223	0.00	0.00	1.3	0.1	4
8	Spring	6:20	8.1	220	25.3	0.00	65	0.00	0.00	0.4	0.8	6
9	Reservoir	6:35	8.2	210	25.2	1.61				0.1	0.2	4
10	Shallowell	7:10	8.3	202	25.2	1.12		0.00	0.00	0.1	0.4	2
11	Shallowell	8:30	7.9	218	25.6	131	25.6	0.00	0.00	0.6	0.6	3





Stakeholders





Kulo shallowel