**Jimma University**

**Jimma Institute of Technology**

**School of Graduate Studies**

**School of Civil and Environmental Engineering**

**Chair of Hydraulic Engineering**

# Assessment of Challenges for Design and Construction of Rural Water Supply Projects: A Case Study of East Belessa Woreda, Amhara Region, Ethiopia

**A Thesis Submitted To the School of Graduate Studies of Jimma University in Partial Fulfillment of the Requirement for the Degree of Master of Science in Hydraulic Engineering**

**By**

**Getachew Birara Binega**

**February, 2016**

**Jimma, Ethiopia**

**Jimma University**

**Jimma Institute of Technology**

**School of Graduate Studies**

**School of Civil and Environmental Engineering**

**Chair of Hydraulic Engineering**

# Assessment of Challenges for Design and Construction of Rural Water Supply Projects: A Case Study of East Belessa Woreda, Amhara Region, Ethiopia

**A Thesis Submitted To the School of Graduate Studies of Jimma University in Partial Fulfillment of the Requirement for the Degree of Master of Science in Hydraulic Engineering**

**By**

**Getachew Birara Binega**

**Advisor: Dr. Ing. - Esayas Alemayehu (PhD), Associate Professor**

**Co-Advisor: Mr. Mamuye Busier (M.Sc.)**

**February, 2016**

**Jimma, Ethiopia**

## DECLARATION

This thesis is my original work and has not been presented for a degree in any other university.

------------------------------------- --------------- -----------------

Candidate Signature Date

This thesis has been submitted for examination with my approval as a university supervisor.

--------------------------------------- --------------- ---------------

Advisor Signature Date

--------------------------------------- ------------------ --------------

Co-advisor Signature Date

## ABSTRACT

*Water is life and especially potable water is essential for life and health. So, access to drinking water, improves overall socio-economic and environmental existence. Numerous schemes have been planned and implemented, but only a portion of these schemes continue to provide water to the communities that they were intended to serve due to the problems caused by poor design and construction work. The aim of this study is to assess the challenges for design and construction of rural water supply projects. To this end, the study was undertaken in 30 existed and newly constructed water supply schemes among rural communities in East Belessa woreda. The study was conducted by applying both qualitative and quantitative method. The most common challenge investigated in the design of rural water supply projects were constructing of rural water supply points without checked the water yield of the schemes. Due to this only some of the schemes were flow throughout the year but most of the schemes flow intermittently. As a result at the end of the year especially from April to mid-June the available quantity of water become very low after fetching of almost 10-15 plastic pots (200-300 liters). So that the communities are searching another source by traveling long distance or fetching river water for drinking and cooking purposes. On the other hand 53% of the developed springs were decreased their flow rates during construction. This was due to blocking of the spring eye and improper collection of the eye during construction period. The other major cause for the reduction of flow rate was seeping of collected water through the cracks and the base (foundation) of the spring box due to construction of spring box structure on loss (unconsolidated) foundation, using of poor quality of construction materials and lack of regular follow up. In general, the findings on assessment of challenges for design and construction of rural water supply projects in the study area reflect a critical situation. Therefore, it is important to establish a design and construction standards (methods) depending on the reality of the Woreda.*



***Key words****: - Construction, Design, Flow rate, Hand dug wells, Springs, Water supply*

## ACKNOWLEDGMENT

For most the glory goes to the ALMIGHTY GOD for all his blessings; through him all things is possible. In him, I put my trust for protection and guidance.

I, wish to thank my main adviser Dr. Ing: - Esayas Alemayehu and co-advisor Mr. Mamuye Busier for initiating this study and giving me their time and advices throughout this thesis work.

My thanks extend to my sponsor the ministry of water, irrigation and electricity for giving me great chance and also to the Jimma University institute of technology for creating favorable condition to my study.

I am grateful to the staff member of East Belessa Water Resource Development Office for their cooperation by providing me with desired information and data. A lot of thanks go to the respondents of my questioners giving me valuable information at the site and kebele administrators during field visit of each site.

Last but not least I would like to thank to my families and my friends who have been always encouraging my academic understanding with prayer, moral inspiration and in several ways for the realization of the thesis work.

CONTENT

# LIST OF TABLES

## LIST OF FIGURES

## ACRONYMS

| | |
|---|---|
| ADB | African Development Bank |
| ADF | African Development Fund |
| BOQs | Bill of Quantities |
| DWAF | Department of Water Affairs and Forestry |
| HDWs | Hand Dug Wells |
| MoWR | Ministry of Water and Resource |
| NGOs | Non-Governmental Organizations |
| NORAD | Norwegian Agency for Development Corporation |
| ORDA | Organization for Rehabilitation and Development of Amhara |
| PSNP | Productive Safety net Program |
| RWS | Rural Water Supply |
| UAP | Universal Access Plan |
| UNICEF | United Nations Children's Fund |
| UNSW | University of New South Wales |
| USAID | United States Aid for International Development |
| WADO | Woreda Agricultural Development Office |
| WATSANCOs | Water and Sanitation committees |
| WHO | World Health Organization |
| WWRDO | Woreda Water Resource Development Office |

# 1.0 INTRODUCTION

## 1.1 Background

Water is one of the most abundant substances on earth without which life cannot exist. It covers more than 70 percent of the earth's surface and exists as vapor in the earth's atmosphere according to (World Bank, 2012). It is a useful natural resource for human and ecosystem needs, as well as economic development. Water is life and especially potable water is essential for life and health. So, access to drinking water, improves overall socio-economic and environmental existence (Gebrehiwot, 2006).

According to a report of USAID (2009) more than one billion people do not have access to safe drinking water and over 2.5 billion people have inadequate sanitation. Studies further revealed that one in six and two out of five people worldwide lack access to safe drinking water and sanitation facilities (Dawit, 2007). In Africa around 300 million people do not have access of safe drinking water and 313 million have no access to sanitation. Breakdown of water infrastructures may affect the coverage as well as the access of potable water supply. It is an alarming fact that, breakdown rates of water supply systems in sub-Saharan African countries exceed 50% (UNICEF, 2007). In global terms, it is estimated that, 30% to 60% of existing water supply systems are inoperative at any given time (Brikke and Bredero, 2003) and the globe is littered with failed water supply and sanitation projects (UNSW- water research center, 2010; Moe and Rheingans 2006). That means Africa has the lowest total water supply coverage of the other continents in the world (ADF, 2005).

Access to safe drinking water supplies and sanitation services in Ethiopia are among the lowest in sub-Sahara Africa. ADF 2005 report shows that about 33% of rural water supply projects in Ethiopia are non-functional due to lack of funds for operation and maintenance, inadequate community mobilization and commitment, less community participation in decision making as well as lack of spare parts.

Project effectiveness can be considered a proxy for project impact. Project effectiveness is a measure of the beneficial impact on communities, from the improvements in water service and other project outputs – improved quality, taps closer to homes, improved community organization, etc. (Carter et al. 1999). Project effectiveness is defined by Narayan (1995, p. 21), as a global measure of all project costs and benefits in the areas of construction, operation and maintenance, health and sanitation, education, institutional development, and income generation.

Sustained growth in human population and economic activity in the world has led to increasing demand for water. In developing countries national and regional governments, local and international NGOs and other concerned organizations invest large sums every year for the implementation of rural water supply projects (Gebrehiwot, 2006). Although numerous schemes have been planned and implemented, only a portion of these schemes continue to provide water to the communities that they were intended to serve. However, construction of water projects does not help if they fail after a short time. In order to make the investment in water supplies more effective, failure rates of these systems should be reduced (Habtamu, 2012). According to Gebrehiwot (2006), this can be accomplished by better integration of people who receive the water and water project suppliers in decisions concerning planning, construction and management of water supply systems.

Development of rural water supply schemes remains too costly for poor countries relative to their available resources (Lockwood, 2002; Biswas, 2005). The failure of many water sources developed through large scale projects or investments is the worst case scenario (Kleemeier, 2000). Kleemeier (2005) further indicated that as many as one out of four rural water facilities are broken down or poorly functioning in developing countries and the construction of new systems cannot even keep pace with the failure of the old ones in some countries.

The CSIR recommended that in planning for a water supply scheme in an area, the potential sources of water should first be assessed and consideration should be given to the quantity of water available to meet present and future needs in the area as well as the health quality of the water. For example, Pearson et al (2002) reported that based on a demand rate of 25 l/c/day, a spring flow of 0.1 l/s will provide peak hour demand for only two to three families while a flow of 1 l/s will provide a peak hour demand for about 20 to 50 families without the use of storage facilities. However, with the use of storage tanks enough water for up to 35 families and 350 families can be provides at each of the flows respectively.

The faulty in planning, at times lies with the implementing agency, often due to lack of awareness of unstained development projects and the need for improved planning and long term evaluation of projects (UNSW-water research center, 2010; Barnes, 2009). According to Barnes (2009) poor planning due to inappropriate planning tools and low capacity is in the center of the complex underlying issues in the rural water supply and sanitation service provision which in turn result in unsustain projects and then end up with perpetuated water and sanitation-related poverty.

For example, numerous water supply projects have been unstained because they were planned and implemented without taking into consideration the expressed needs or demands of the users (Breslin, 1999; Jones, 1999; Manikutty, 1998; White, 1997). However, project designs should reflect the demand of users for the service being provided, not only in terms of its management and financing throughout the project cycle (Deverill P. and Smout I., 2004).

In order for rural water supply to be sustainable, appropriate technology must be used. Where the technology deployed is remote from the user's capacity to maintain, operate or pay for it, prospects of sustainability of services are equally remote. Therefore, it is experience with a number of projects that can ultimately lead to a better choice of technology (Harnold et al.).

Great care should be taken in identifying sources of water supply from groundwater and surface water to make sure that the source has enough water to meet the needs of the people that it is going to serve. In a document titled guide lines for development and operation of community water supply schemes (DWAF, 1999) it has been stated that the common causes of scheme failures is the overestimation of the availability of water from water source.

Warner & Laugeri (1991) state that little attention was paid to whether the systems functioned as designed or whether people actually used them. Carter *et al.* (1999) indicate that few studies have actually quantified consumers' responses to 'improved' water supply technology with few projects measuring actual consumption and time spent on water carrying, pre- and post-construction.

HDWs and developed springs are the most common technology employed for rural water supply projects in the study site. Neto and Tropp (2000) state that without the mobilization and participation of people at all levels of society, including women, local communities and the poor, the goal of full coverage is unlikely to be attained. Successful development projects are those that are adapted to local practices and traditions, have community participation in the project planning, design, implementation, management, and operation, and have a community contribution so that there is a sense of community ownership of the water supply and sanitation facilities (World Bank OED 2002).

The quality of construction is crucial for sustainability (Sara and Katz, 1998). Therefore, the construction site should be selected where runoff cannot enter the spring; latrines have not been constructed upstream, and children and livestock are prevented from entering the site (Water Aid, 2011).Furthermore, the construction site should not experience saturation or subject to flooding and eroding processes (Water Aid, 2011).

### 1.2 Statement of the problem

Realizing the critical importance of supplying potable water, national and regional governments, local and international NGOs invest millions of capital every year in developing countries to tackle the problem through implementation of water supply projects (Prokopy, 2005). However, constructing water supply systems alone would not eliminate all problems, especially in rural areas. Functionality, utilization by intended beneficiaries, and resilience of water projects are important characteristics to be considered and integrated in order to achieve maximum benefits (Harvey and Reed, 2007).

A report from Water Partner International (2006) indicates the number of people who lack access to improved water supply could increase to 2.3 billion by 2025. Global Water Supply and Sanitation Assessment 2000 Report also indicates that the majority of the world's population without access to improved water supply or sanitation services live in Africa and Asia (WHO & UNICEF, 2000). A study by Hans Van Damme (2001) reported that, nearly 250 million water and sanitation related diseases are reported every year, with more than 3 million deaths annually. Each day this amounts to about 10,000 deaths. Moreover, diarrhea diseases affect children most severely, killing more than 2 million young children each year in the developing world. Many more are left underweight, stunted mentally and physically, and vulnerable to other deadly diseases.

Water supply and sanitation conditions in Ethiopia are not different from the general situation of developing countries as a whole. As of 2004, national water service coverage in Ethiopia was estimated at only 37% (24% rural coverage and 76% urban coverage) (ADF, 2005). The rural areas share was only 6,698,000 people. Thus, 87% of the rural population has no access to potable water in Ethiopia (WHO, 2000). Two reports, one by Water Supply Hygiene and Sanitation (WASH) (2005) and the other by Begashaw (2002), show the consequences of poor water supply coverage in the country is severe.

In developing countries like Ethiopia there are many abandoned schemes, installed by well-intentioned government authorities that were constructed without any consultation and participation of user communities. When these system broke down no one in the village repair them, since people felt no sense of ownership. User participation in design, implementation, and management of water and sanitation programs is seen by the World Bank as a way of increasing efficiency, equity, and cost recovery and of facilitating extension of service coverage to poor communities (Wright, 1997).

Proper design and construction of rural water supply schemes are currently not given due attention especially at the woreda levels; and therefore a limiting factor to the improvement of water supply. As Austin (1987) states that a poor choice of technology, inappropriate construction, and lack of spare parts and supplies for maintaining equipment have led to the deterioration of water facilities. According to Stephenson

(1987) the problems can be caused by poor design or the desire to save money, poor construction materials and construction work which were covered up, improper management or maintenance after installation, lack of training of the managers.

## 1.3 Objective

### 1.3.1 General objective

The general objective of this study is to assess challenges for the design and construction of rural water supply projects.

### 1.3.2 Specific objectives

- To investigate major challenges at the time of design stage of rural water supply projects.
- To identify the problems during the construction of rural water supply schemes in the study area.
- To assess the functionality and service level of the water supply schemes in the study site.

## 1.4 Research questions

1. What are the major challenges at the time of design stage of rural water supply projects?
2. What are the problems during the construction of rural water supply schemes in the study area?
3. How to assess the functionality and service level of the rural water supply schemes in the study site?

## 1.5 Significance of the study

The main purpose of this study is to look at what are the challenges in the design and construction of rural water supply projects and to assess the functionality and service level of the water supply systems in the rural areas of East Belessa Woreda of Amhara Region. Therefore the result of this study will serve as source of information and can also serve as an input for planning and designing for the same project.

### 1.6 Scope of the study.

Since the emphasis of this study is on assessment of challenges for design and construction of rural water supply projects certain limitations will be placed on the scope of the study. The study mainly concentrated on hand dug wells (HDWs) and spring developments those are mostly designed and constructed by woreda water resource development office (WWRDO). Others like shallow wells, deep wells, large gravity-fed spring developments and others are not within the scope of the study. The analysis in this study will use data from part of under construction and part of an existing rural water supply projects which can be considered to be representative of the whole projects as a case study.

### 1.7 Limitation of the study

Poor quality and coverage of secondary data in the zonal and woreda offices, secondary data are not well documented. Data on some issues are in the hands of individual experts. In some cases, even these experts were already transferred together with the data. Besides, most of the available data are estimated without field survey. Some of the sample schemes were very far from the capital city of the woreda and they were constructed far apart each other. However, due to limited time and resources it was necessary to reach the near water supply schemes without ignoring some of the remote sample schemes.

# 2.0 LITREATURE REVIEW

## 2.1 Introduction

Rural water supply (RWS) systems are commonly defined as those water supply systems that operate independently of other formal services (Schouten and Moriarty 2003, p. 10). These systems may be rural or otherwise independent of a municipal supply network or, simply, a RWS may be a water system established where the regional water management agency does not have authority or the ability to extend infrastructure (Deverill et al. 2004; Swartz and Ralo 2004).

RWS systems are also defined by a type of management and governance, which is often community based and derived from social rules and socially agreed upon modes of operation (Brooks 2002). RWS projects differ from municipal water development, large-scale irrigation works, or hydropower development in that a RWS project is focused primarily on the management of land and water resources for human consumption in rural areas, through the utilization of local institutions (Cairncross 1992; Narayan 1995; Paudel and Gopal 2004; Swartz and Ralo 2004). Moreover, a RWS improvement project is generally an action, by a community and any collaborators to materially improve the access individuals have to a clean and reliable water source (Lammerink 1998; MacDonald 2005, p. 32).

Pearson et al (2002) has reported that approximately 75 % of the fresh water on earth is fixed as ice, mainly in the polar ice caps. Out of the remaining 25%, 24% is ground water, and the remaining 1% is surface and atmospheric water. Thus, groundwater is the largest source of fresh water in storage on our planet, and these points to the vital importance of groundwater as a resource for fresh water supplies. However, its distribution in many parts of the world varies greatly with the distribution of suitable underground water-bearing rocks.

## 2.2 Sources of water supply

According to Turneaure and Russel (1974) water sources are divided into the following classes according to the general sources.

1. Surface water sources
   - Water from springs and seeps.
   - Ponds and lakes.
   - Streams and rivers.
   - Rain water harvesting from roofs.

2. Ground water sources
   - Water from shallow wells.
   - Water from deep and artesian wells.
   - Water from infiltration galleries.

### 2.3 Surface water sources

Water that does not infiltrate the ground is called surface water. Surface water appears as direct runoff over impermeable or saturated surfaces and then collecting in large reservoirs and streams or as water flowing from the ground to the surface openings (Water for the world, 2005)

#### 2.3.1 Springs and seeps

Rural communities often collect water from existing sources close to their homes. Many rural areas use a spring. A spring or seep is water that reaches the surface from some underground water system, appearing as small water holes or wet spots on hill sides or along river banks (Water for the world, 2005)

The intake structure is located at the source of the spring (called the eye, or the point with in the spring where the spring flow is concentrated and flows a stable channel), and collects the water for transfer to the collection tank (Water for the world, 2005).

According to Anderew Tayong the quantity of water a spring produces is known as yield. Yield is studied in terms of flow rate and consistency. Variation in the yield of a spring during the dry season and the rainy season is an important criterion to determine whether the spring is a suitable source. If the ratio between the highest yield in the rainy season and the yield in the dry season is below 20, then the spring has an acceptable consistency and can be regarded as a reliable source in both wet and dry seasons.

Christian and Kart (2001) states that springs intended to feed a water supply must be measured for at least a period of one year to estimate the minimum yield.

### 2.3.2 Development of springs into drinking water sources

Shaw (1999) states that the main objective of spring development and protection is to provide improved water quantity and quality for water supply. Spring development activities include the construction of an intake structures, collection tank, tap stand, and retaining wall and the provision of drainage, fencing and grassed surrounding.

Pearson et al (2002) recommended that a typical spring box should have a back wall built with an un-mortared open stone wall to facilitate inflow of the water and should lie between the water table and the impervious rock. The foundation box should be at least 50 cm into the impervious rock below the aquifer, and the top of the box should be higher than the position of high water table.

When springs are used for multiple purposes such as domestic use, livestock watering, irrigation and tanker supply, care should be taken to prevent contamination of water used for human consumption (Muthusi et.al. 2007). Relative to hand dug wells natural or developed springs is easily contaminated by different contaminant agents.

### 2.3.3 Types of springs

Pearson et al (2002) have divided springs into three categories namely:-

- Gravity springs
- Artesian springs
- Karst springs

**A. Gravity springs**:-Gravity springs occur where groundwater emerges at the surface because an impervious layer prevents it seeping downwards. This type usually occurs on sloping ground, although it can be found in areas that seem flat to the eye.

**B .Artesian** springs: - Artesian springs occur when water is trapped between impervious layers and is under pressure. The yield from artesian springs is uniform and the flow is very nearly constant in spite of seasonal variation in rainfall and evapotranspiration over the catchment.

**C. Karst springs**: - these occur where a surface stream disappears into a sinkhole and flows underground along channels, caves and other cavities produced by the chemical and mechanical actions of water on leachable or soluble rocks such as dolomite and limestone. The water finally emerges a spring at a lower altitude elsewhere. These types of springs also offer a good source of water supply.

### 2.4. Ground water sources

Ground water is particularly important source of fresh water supply and many communities can only be served from ground water resources. Harvey and Reid (2004) have attributed this to the fact that in most cases the respective population is low to justify the costs of construction, operation and maintenance of dams and treatment works, which are often required in surface water sources. It may also be that there are no suitable dam sites nearby. In such cases, the communities often have to rely on ground water.

#### 2.4.1 Locating potential groundwater sources

Ground water is stored underground in porous layers called aquifers. These aquifers are water saturated geologic zones which have connected pores or fractures that will yield water to springs and wells, and may be visualized as underground storages reservoirs (pearson etal,2002).

#### 2.4.2 Hand dug wells

Hand dug wells are water points that source water from shallow water tables and are excavated in unconsolidated and weathered rock formations such as clay, sands, gravels and mixed soils by the use of picks and shovels or hand hold excavation machinery like jack hammers. Soils can be excavated out with a bucket and rope. A properly constructed dug well penetrating a permeable aquifer can yield 2500 to 7500 $m^3$/day, although most dug wells yield less than 500 $m^3$/day (tood, 1980). Depths of hand dug wells range up to 20 m deep. Wells with depths of over 30 m are sometimes constructed to exploit a known aquifer (Watt and Wood, 1985).

The provision of wells as a method of rural water supply is considered carefully at the design stage to ensure a suitable water supply. Harvey and Read (2004) have recommended that the important factors to ensure should be:

- Correct design
- Correct construction
- Correct development/ completion.

The main objectives of a good well design should be to ensure the following for water supply boreholes (NORAD AND DWAF, 2003):

- The highest suitable water yield with proper protection from contamination
- Water that remains sediment free to protect pumps and to prevent the silting up of boreholes
- A borehole that has a long life
- Optimum operating costs in the short and long term

The materials considered in design include: well head, casing and screen, filter pack, annular seal and grout (USAACE, 1999). The well head should be built on an earthen mound 15 to 20 cm above the ground level so that water will drain away from the well. The casing consists of the solid casing and the perforated portion (NORAD and DWAF, 2003) and the screen is a perforated section of the casing to serve as the intake portion of the casing in a well. Gravel pack is necessary when pumping of water from a borehole may bring fine material such as sand out of the formation in to the borehole and therefore cause problems in the hydraulic performance of the borehole as well as abrasion in pumps. As stated by Todd (1980) wells should be grouted and sealed in the annular space surrounding the casing to prevent the entrance of water of unsatisfactory quality, to protect the casing from corrosion, and to stabilize caving rock formation.

The addition of a lining to the HDWs decreases the likelihood of a well collapsing and excessive loss from seepage. From the Technology Notes published by Water Aid (2011), four different linings have been suggested: pre-cast concrete caissons (cylinders), reinforced concrete, brick, and galvanized iron. When using caissons, the initial concrete cylinder is pressed into the excavation site and the soil extracted from within the cylinder, and as the depth of the well increases, concrete caissons are added as the depth increases (Water Aid, 2011).

## 2.5 Feasibility study of rural water supply projects

The project feasibility study phase involves the making of a project feasibility study that comprises an evaluation and analysis of the potential of a proposed project and is based on extensive investigation and research to support the process of decision-making.
Munns and Bjeirmi (1996) state that "the project definition and early decision making is critical to overall success and suggest that the broader decisions in selecting a suitable project in the first place are more likely to influence the overall success of the project." The project feasibility phase is the second phase in the lifecycle of a project but the first one is the conceptualization phase (Kerzner, 2006). According to Kerzner (2006) the conceptualization phase involves two critical factors: (1) Identify and define the problem, and (2) identify and define the potential solutions. Kerzner (2006) gives the following explanation of the feasibility study phase: "The feasibility study phase considers the technical aspects of the conceptual alternatives and provides a firmer basis on which to decide whether to undertake the project."

In other words, the feasibility study includes an analysis of the project´s viability and focuses on helping answer the essential question of "should we proceed with the proposed project idea?" The end result of a feasibility study is therefore the go/no-go decision. Kerzner (2006) gives a more detailed purpose of the feasibility phase:

- Plan the project development and implementation activities
- Estimate the probable elapsed time, staffing, and equipment requirements
- Identify the probable costs and consequences of investing in the new project

Feasibility studies are typically carried out before the project initiation in support of the proposed business case and provide an accurate assessment of the factors that might affect the project. A feasibility study enables a realistic evaluation of a project, incorporating both the positive and negative aspects of the opportunity (Gardiner, 2005).

## 2.6 Environmental aspects of rural water supply projects

Harvey and Reed (2003) take the environmental aspect into account in their definition: 'The water sources are not over-exploited but naturally replenished, facilities are maintained in a condition which ensures a reliable and adequate water supply, the benefits of the supply continue to be realized by all users over a prolonged period of time, and the service delivery process demonstrates a cost-effective use of resources that can be replicated' (Harvey and Reed, 2003, p.115). This definition takes the environmental aspect of the source into account, but it gives just a narrow vision on this aspect. Not only might the source be over-exploited; the environment might also be effected negatively by site-effects like wastewater or erosion.

## 2.7 Water consumption

Gleick (2006) stated that the international acceptable standards for water requirements for basic needs, commonly referred to as basic water requirement (BWR). BWR is defined as water requirement in terms of quantity and quality for the four basic needs of drinking water, human hygiene, sanitation service and modest household needs. This standard is defined by WHO guide line as 20 liters per capita per day (Admassu et. al, 2002). For example, according to Water Aid (2011), a flow of 0.1 liters per second (Lps) would result in a daily flow of about 3,000 liters which would supply a community of 150 people with their water requirements (20L per person per day). However, an addition of a spring collection box or tank would allow even lower flows (< 0.1lps) to be considered for water supply.

The human body's basic water requirement depends on climate, work load and environmental factors. If the work load is high and the season is dry the family use large amount of water per day, whereas the family size increases the amount of water consumed by one person per day decreases relative to the one that small number of family sizes. However, Gleick (2006) defined the minimum requirement for human body and found that it is between 3 and 10 liters per day. The amount of water needed for other purposes, including cooking or hygiene, is more variable and depends on cultural habits, socio economic factors and types of water supply in terms of quantity, quality and availability.

## 2.8 Selection of appropriate technology for rural water supply systems

It is assumed that whether a technology is appropriate depends on the quality of design and construction. The first sub-indicator is 'guidelines'. Guidelines can be an appropriate measure to ensure the technology is appropriate when they are meant to ensure the quality of the construction during design, construction and operation but are also allowing flexibility depending on local circumstances. This means that guidelines should not prevent from implementing the most appropriate technology. The second sub-indicator is the quality of design and construction. A bad design might already occur during construction, but also appear during operation. This will be judged as far as it is possible at the moment. Other elements of an appropriate technology are the attention for involvement of experts in design and construction and the role that maintenance aspects like costs, spare parts and intensity of maintenance have been played during the project.

The quality of construction is crucial for sustainability (Sara and Katz, 1998). Harvey and Reed (2003) stated that the choice of a technology is not the only factor determining sustainability, but that it can have a significant impact. The technology choice should not only be made based on the cheapest solution, but also on the availability of spare parts and the costs of operation and maintenance. If local solutions and/or local materials are available, they are preferable since it will eliminate the problems with spare.

### 2.9 Institutional support

Studies indicated that lack of backing of local community management body is an important reason for the failure of improved water supply schemes (European Commission, 1898, 42). According to Getachew (2002), lack of finance, skilled manpower, inadequate stakeholder participation, lack of coordination among stakeholders, lack of well institutionalized setup and appropriate regulatory framework, and poor infrastructure are considered to be the major causes for low coverage of rural water supply service in the country.

Inputs of experienced expertise of hydrology, geophysics, engineering, development planning and sociology are vital in the course of water resource potential assessment, well site selection, and depth to ground water and to choose the right hand pump option. If assessments such as, ground water resource and depth to ground water is not well identified, the result mostly would be dry wells and thereby unsustainable schemes (Sebsibe Alemneh, 2002:18).

## 2.10 Community education or Training

The project approach towards training is for both committee and household level indicated by the training done and by the effectiveness of the training. The effectiveness at household level will be indicated by attendance and awareness. At committee level it is determined by attendance and received topics. The effectiveness is not easy to indicate, but depending on the knowledge people show during interviews and the attendance lists it is possible to indicate whether it is good or bad.

Participation requires training on household and committee level. At committee level the training should provide the needed competences to keep the system operational. Brikké and Rojas (2001) mentioned that an assessment of the management capacity before a project starts is crucial. If capacity building activities appear to be too complex, it might prove necessary to choose for another technology. This also indicates the needed training to run the service efficiently. Training should provide committees with technical information about how to prevent major problems, to operate the water system and repair parts. Further the committee should receive the needed financial and managerial training, especially those skills related to budgets, organizing bills, collection, recording expenses and revenue, monitoring, and applying sanction (Brikké and Rojas, 2001). With regard to financial training of the committee Netshiswinzhe (2000) mentions a problem. Financial training of the water management committee has mainly focused on basic bookkeeping. The result is that committees don't have the capacity to do financial planning, for example, to recalculate tariffs and deal with non-payment. Training should broaden the local level of financial management capacities instead of focusing on the individual. At household level the main purpose of training is awareness to create user commitment. The first kind of awareness is on the linkage between hygiene and health. Ntengwe (2004) argues that this health and hygiene education should focus on single behaviors, which once they have changed have a positive impact on the community. The education should not be prefabricated, generalized messages, but depending on the situation inside a community. The second awareness is 'what it takes to produce water and have it delivered at the tap near or in households'. This contains the provision of information about cost of pumping, maintenance of lines, treatment, supply and their relation to the water tariff. Research proved that this kind of awareness has a positive effect on the willingness to pay, which will prevent financial problems during the operation and maintenance phase (Ntwengwe, 2004).

## 2.11 The concept of community participation in rural water supply projects

Community participation is one of the most important factors contributing to water supply service effectiveness (Narayan, 1994 cited in Haysom 2006). Without participation, it has been claimed that systems are unlikely to be sustainable even if spare parts and repair technicians are available (Arouna and Dabbert, 2008). The importance of community participation in rural water supply sustainability through prioritization and vocalization of community needs, selection of appropriate facilities, technology and location, financial contribution to capital costs, provision of labor for construction of systems and facilities, management of operation and maintenance, setting and collecting water tariffs, and physical maintenance and repair activities (Harvey and Reed, 2004).

White (1981) considers that the 'depth of participation' is the extent to which *all* members of the community are involved in *all* aspects of a project. To get a better idea from the extent of participation Arnstein introduced the ladder of participation in 1969, which describes the manner in which the community is involved in a project. This ladder shows that the highest form of participation is the one in which the community feels in control in all stages of the project. Netshiswinzhe (2000) argues that almost everybody agrees about the need for participatory development instead of a top-down approach, but still the reality remains that most development work is external driven or top-down. The kind of participation that works is the one in which 'all role-players actually believe that people, regardless of age, sex, educational background, socioeconomic status and history, can actually solve their own problems.' (Breslin and Netshiswinze, 1999 In: Netshiswinzhe, 2000) In summary implementing a project in a truly participatory way implies that the community members feel in control during all project phases and that the beneficiaries become owners, partners and managers.

Participation is about the extent to which *all* community members are in control during *all* phases of the project. This is in decision-making, execution, costs and benefits. The involvement of households during initiation will be indicated by the use of a demand-driven approach. The indicator participation will indicate other aspects of participation, like the empowerment through a community-based organization, the presence of participatory activities, gender-sensitivity, efficiency and transparency of the participation process. The attribution of scores towards all these sub-indicators will be done based on the degree to which the community is allowed and felt to be in control.

Musch (2001) describes three dimensions of participation in water projects: decision making; execution; costs and benefits. Full participation consists not only of a contribution in cash and kind, but also of participation in the decision-making and the benefits. To facilitate all these dimensions of participation there are a lot of participatory methods available. Another aspect of participation is the involvement of *all* community members. Gross et al (2001) concluded that the gender and poverty sensitivity pays off substantially in sustainability. It appears from research that the more men, women, rich and poor are in control in all phases of a project, the more satisfied they are and the better the service will be sustained. Sara and Katz (2003) argue that participation at household level is necessary, since community representatives the institution of a community-based organization to manage the project during and after implementation is also a form of participation. Sara and Katz (1998) prove that a designate community organization, which manage and oversee the system's operation, is a necessary component of success.' Netshiswinzhe (2000) argues that the more decentralized the system is operated, the better it is. She argues for the decentralization of maintenance and collection. Contribution of the community in cash and kind during all project phases is assumed as to enhance a sense of ownership. Sara and Katz (1998) however found out that it is often seen as a tax and that people don't see the link between their contribution and their choice for a water system. The reason for this is that there is no linkage between contribution and choices.

# 3.0 METHODOLOGY

## 3.1 Study area descriptions

East Belessa Woreda is located in North Gondar Administrative Zone of the Amhara National Regional State. It is boardered by Wogera and Janamora woredas in the North, Kemkem and Ebinat woreda in the south, Gonder zuria woreda in the west and Dahina and Ziquala woreda of Wagihimira in the east. Before 2000 Belessa area was categorized as one administrative woreda. However, after 2001 the woreda was subdivided into two administrative woredas, viz., Western and Eastern Belesa. Topographically, the woreda is characterized by flat/plain, mountainous and rugged features, which constitute 55%, 40%, and 5% respectively. According to the WADOs annual report, the total area of the woreda is estimated to be 318,259 hectares. The altitude of the Woreda extends from 1500 -2000 masl. It is bordered with Tekezie basin in the eastern part. Guhala for the east Belesa and Arbaya for the west Belesa are the capital of the Woredas.

The annual mean temperature for most parts of the woreda lies between 20-35 °C. The woreda receives an annual average of 600-900 mm rainfall. Most of this rain is received during mid-June to early September. The farming system of this woreda is characterized by a crop/livestock mixed farming. Small-scale agriculture is basically characterized by diverse socio-economic and biophysical settings. According to WADOs annual report, 45 percent of the flat/plain topography areas are dominated by black or "Walka" (Vertisol) soil type. Farmers classify this soil as the most fertile soil type. The red soil (Litosols), which is locally known as "Keyatie", covers 38.5 percent.

According to the woreda water office statics the woreda has a total of 423 water supply schemes. Out of these 328 are developed springs, 76 are HDWs, 9 shallow wells, 2 deep wells and 8 are rope pumps. The investment costs of the schemes constructed in the Woreda were covered mainly by the government and international donors. Most were financed by the government (82%) by support of ADB, PSNP (5%), ORDA (10%) and the remaining 3% are constructed by UNICEF.

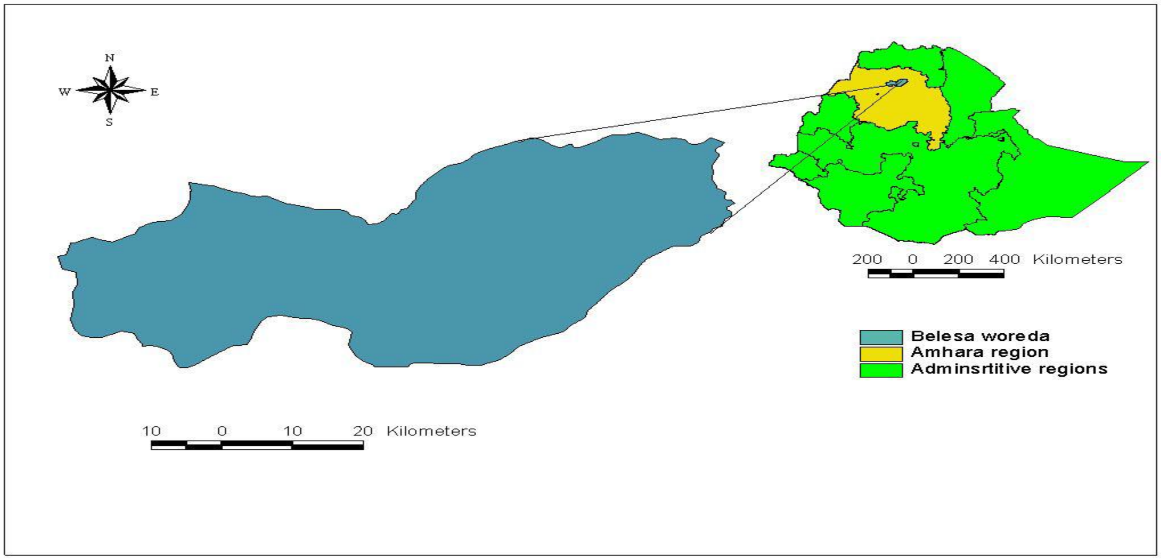



Figure 3.1 Map of Belessa woreda

### 3.2 Study design

The study has involved both qualitative and quantitative research methods to assess the challenges for design and construction of rural water supply projects. The study has emphasized on characteristics features of selected water supply schemes and appropriate investigative analysis of observed incidents. The villages and water points of the study area were selected in close consultation with woreda water experts. Out of the existing 423 water supply schemes in the east bellesa woreda, 70 water schemes were constructed during the last year. So that this research was conducted in the existing of 20 water points (8 HDWs and 12 developed springs) and 10 in the newly constructed water schemes (4 are HDWs and 6 are spring development).

### 3.3 Data collection methods

Before starting detailed data collection, some general information pertaining to the socio-economic and demographic characteristics, of the communities under study were gathered. This information has been used as a base for planning the field data collection instruments (questionnaires') were prepared and checked through consulting with experts and conducting initial interviews to obtain feedbacks for pre-testing. The feedbacks were analyzed and the necessary adjustment and corrections has been effected on the questioners, interviews and field observation. This improved data collection instruments were used to conduct the actual data collection.

Data were generated through a combination of primary and secondary sources. In this research primarily two types of data collection have been conducted.

**Primary data: -** the necessary data is collected through a prepared set of questionnaires for household survey, key informants interview (with woreda experts and artisans), personal observation or direct field observation.

**Secondary data collection: -** collecting all other data which could not be found through questionnaires, interviews and personal observation, such as old data and inventory data of the area. Similarly, official statistics and reports available in the project implementing agencies' offices were the major sources of secondary data in this study.

Structured questionnaires have been conducted with the households, artesian (local contractors), woreda water experts and in the study area. The questionnaires are used to assess the challenges of rural water supply projects during design and construction phase as well as to assess the functionality and service level of the schemes in the study area.

Direct field observations were conducted to know the real condition (physical) of the rural water supply schemes. This helped the researcher to identify the appropriateness of construction practice and design methodology, types of water supply schemes and the activities done by the communities, artisans and experts.

### 3.4 Sampling design

In Ethiopia, rural water supply projects are constructed by local and regional governmental officials, non-governmental organizations and other concerned organizations. In East Bellesa woreda the responsible organization for the construction of rural water projects are Organization for Rehabilitation and Development in Amhara (ORDA), UNICEF, woreda water resource development office (WWRDO) office, PSNP, zonal and Regional water resource development offices. The most commonly constructed systems are developed springs and HDWs.

A systematic sampling technique was employed as the major methods of sampling for the selection of sample schemes (water points) and kebeles. The selection of the schemes depends on the data from reconnaissance results. During the reconnaissance visit, the researcher discussed with the woreda water resource experts, technicians, water users and water committee and responsible body with reference to each scheme visited.

The sample size for each community was extracted from list of beneficiaries who can access the water supply points both within the range of 1.5 km radius and out of this radius based on the list of water supply schemes inventory of East Belessa woreda. So that 300 households were selected randomly from 30 water points. These 300 households were used as source of primary data for this study. About 89 % of the respondents (representing the household) were illiterate. On the other hand to establish a base line and acceptable scope (i.e. sampling frame) for the analysis and to ensure maximum comparability among sample communities, formal discussion (interview) with local contractors (artesian) were held to get another primary data source.

Sample size for respondents can be summarized by the following equation.

$$SS = \frac{Z^2 \times (p) \times (1-p)}{C^2} \quad \text{.......................................Equation (3.1)}$$

SS = Sample Size

Z= Z-value for 95 percent confidence level is 1.96.

P = Percentage of population picking a choice, expressed as decimal

C = Confidence interval, expressed as decimal (0.0499)

$$\text{New SS} = \frac{SS}{\left(1 + \frac{(SS - 1)}{}\right)} \quad \text{...........................Equation (3.2)}$$

Pop

Pop= population

$$SS = \frac{(1.96)^2 * 0.5 * (1-0.5)}{(0.0499)^2} = 385.70$$

$$\text{New SS} = \frac{SS}{1 + \frac{SS-1}{1350}} = 300$$

**3.5 Methods of analysis**

This is a process of data clearing; refining and transformation were used to analyze the collected data. On the other hand the data gathered have been analyzed in terms of the study objectives already designed and the existing situation of the water supply schemes. Depending on the nature of the survey different data analysis techniques were used among these descriptive statistics based on percentages were used to analyze findings. The percentage which were found from Microsoft excel entered to Microsoft word to convert in to different types of charts. Finally, data collected during water point mappings were analyzed using graphs and charts to present the information visually.

# 4.0 RESULTS AND DISCUSSION

## 4.1 Socio-economic characteristics of the respondents

The study was carried out in rural East Belessa woreda. Consequently, 95% of the respondents were farmers involved in crop cultivation (both irrigation and rain fed) and cattle production. Sixty percent and forty percent interviewees from the existing and newly constructed water supply schemes, respectively, were between 20-60 years old, the age group that make decisions about the water supply schemes. The average age was 35 years. Almost all respondents in both systems were married. Average only 10% were separated, widowed or not married. Most respondents were not educated because farmers need their children to help with farming, livestock grazing and household activities. Only a few (average 6%) that have support from educated relatives living in urban area were able to finish high school and join a university.

Agriculture is the basis of the economy of the woreda. The economic livelihood of most people in the area is centralized around rain-fed subsistence agriculture. Petty trading is another important economic activity in the district. Both sexes participate in all the two activities. Major crops produced in the locality are Maize, teff, and others.

Household size is another important factor that determines the amount of water a family requires. Families with more number of family members require more amount of water.
This in turn affects the total amount of water required at societal level. It is also said that family size affects household's participation in the development processes. A family with more members might participate more in laborious activities. The average household size of the respondents is 5. Minimum household size of respondents was two, with the maximum of 10.

Table 4. 1 Demographic characteristics of the respondents

| Characteristics | Category | No of respondents | | Percentage | |
|---|---|---|---|---|---|
| Age | | EWPs | NWPs | EWPs | NWPs |
| | Under19 | 2 | 3 | 0.67 | 1 |
| | 20-40 | 111 | 60 | 37 | 20 |
| | 41-60 | 63 | 51 | 21 | 17 |
| | Above 55 | 4 | 6 | 1.33 | 2 |
| | Total | 180 | 120 | 60 | 40 |
| Sex | Male | 41 | 50 | 13.67 | 16.67 |
| | Female | 103 | 106 | 34.33 | 35.33 |
| | Total | 144 | 156 | 48 | 52 |
| Marital status | Married | 150 | 120 | 50 | 40 |
| | Separated | 5 | 3 | 1.67 | 1 |
| | Unmarried | 7 | 9 | 2.33 | 3 |
| | Widowed | 2 | 4 | 0.67 | 1.33 |
| | Total | 164 | 136 | 54.67 | 45.33 |
| Size | 1-4 | 30 | 24 | 10 | 8 |
| | 5-8 | 98 | 93 | 32.67 | 31 |
| | 9 and above | 36 | 29 | 12 | 9.67 |
| | Total | | | | |
| Education | Not educated | 137 | 130 | 45.67 | 43.33 |
| | Grade 1 to Grade 12 | 15 | 18 | 5 | 6 |
| | Total | 152 | 148 | 50.67 | 49.33 |

## 4.2 Design of rural water supply projects

### 4.2.1 Community participation in the selection of new sites

The communities are the primary sources of implementation in identification process. The feasibility study of a rural water supply system aims to investigate the quality and quantity of water from the source. Local people are important sources of information and should be involved in decisions about the feasibility of developing any particular water supply system.

The following table shows that 36% of the respondents were not participated in the selection of suitable sites for non-functional schemes but 21% of the respondents were participated for the functional schemes. This means that community participation is lower in the non-functional schemes. However, the numbers of participants were lower in functional schemes. This means that the number of participants at the time of site selection were very low for functional schemes and those which were not participated are higher in numbers.

Table 4. 2 Respondents participation in the feasibility of projects

| Status of the schemes | % of respondents | |
|---|---|---|
| | participated | Not participated |
| Functional | 21 | 31 |
| Not functional | 12 | 36 |

The proposed rural water supply projects should be in line with the users need and fully accepted without any complain by the community. It is better to consider the time and distance of fetching water. On the other hand the location of the feasible project must be easily accessible by women, children and elders.

The only problem in the community was that they were not knowledge based in selection of feasible project because most of the rural communities are illiterate and lack of technical supports. Even though, they are not technical they are a good observer about the characteristics of the sources in their daily activities. So, they can observe the seasonal changes of their surroundings. Generally, community members are expected to be actively involved in the process of interventions through planning, implementation, and evaluation. Furthermore, they are expected to quire skills and knowledge that would later enable them to take over the project or program.

On the other hand 33% of the rural water supply schemes have been selected by community and others. As shown from the above graph out of 33% only 47% of water supplies points were selected by the community and out of these 72% were functional and only 28% were non-functional. The non-functionality was due to lack of technical supports such as large flow rate of springs located in hilly area and swampy area for HDWs. On the other hand out of 36% those were selected by both the community and staff members only 13% were not functional and 87% of the schemes were functional. This indicates that the non-functionality rate will became low if there was cooperation between experts and communities during selection of feasible sites. However, most of the experts were not volunteer to select sites with the help of the community rather they made independently.

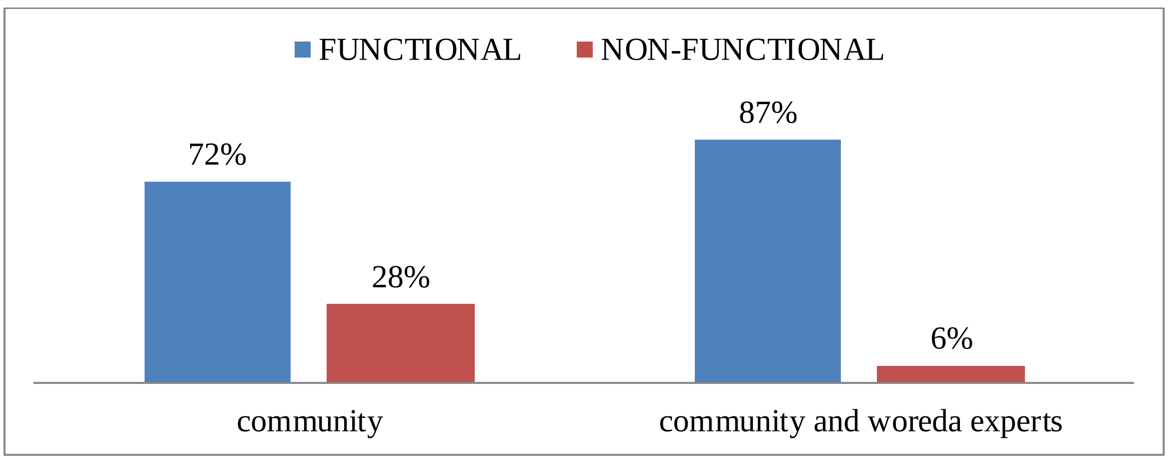



Figure 4. 1 Community participation in schemes functionality

The remaining were approved their feasibility by the NGO experts. Out of these 80% of the schemes were functional and the remaining 20% were served beyond their design period as a result of this it becomes non-functional. NGOs were better than WWRDO in the participation of community to identify the feasible project.

Therefore, a full exchange of information between the action agency and the community during all rural water supply project phases is very important for successful water system development and to feel the real ownership of the schemes. Generally, in the feasibility stage of rural water supply projects discussion with community members such as water beneficiaries and WATSANCos, was the most important issue to continue the whole project healthy and effective. This implies that community participation is the most critical issue in development and selection of feasible sites for rural water supply projects.

### 4.2.2 Organizational support during feasibility of rural water supply projects

According to the respondents 54% of the community said that they have not got any technical support and 19% of the community have got support at the feasibility stage of the project. Out of the total respondents 7% of the WATSANCos said that there was a support at the feasibility stage and only 10% of the WATSANCos said that there was no support during the feasibility stage. However 10% out of the total respondents said that they did not know about the support.

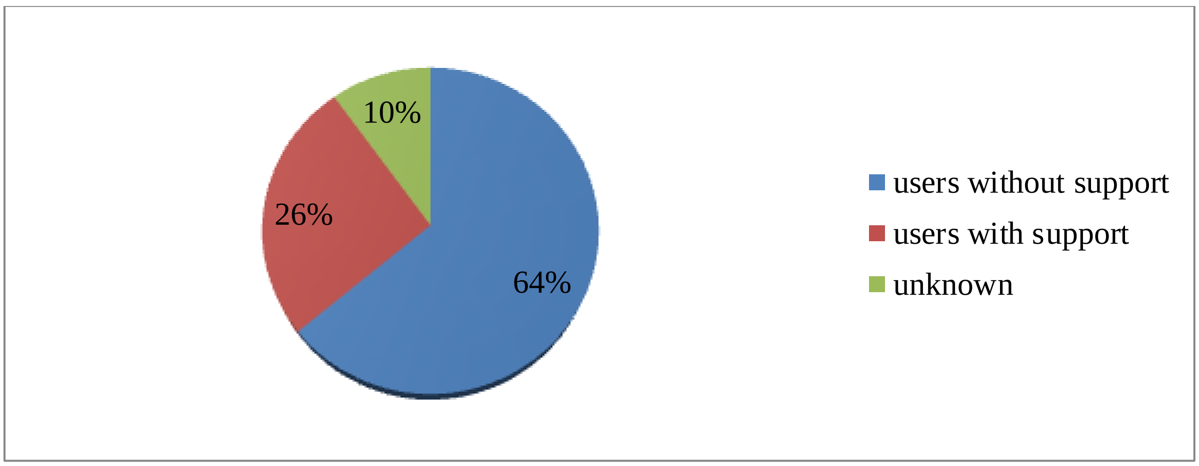



Figure 4. 2 Organizational supports in the feasibility of rural water supply projects

The rural communities and the WATSANCos by themselves select feasible schemes and report to the WWRDO for detail design and construction. However, due to the lack of support the respondents were select feasible project without any scientific baseline about the type of the water supply system. In those water supply schemes where there was support the performance of the schemes was good. However, in those schemes where there was no technical support the performance of the schemes was not good.

This indicates that organizational support whether it is from governmental or NGOs can play a great role in rural water supply projects at the initial stage (feasibility) of the project. However, the experts (water engineer, geologist and technicians) of the

WWRDO are small in number, especially water engineer and geologist, relative to the number of water supply systems existed in the woreda and area coverage.

Unfortunately there is no a geologist or hydro geologist to undertake the task of hydro geological nature of the water supply schemes. Due to (absence) small number of water experts the institutional support is very low. There is one water engineer and five technicians for the selection of feasible water project of the total water supply systems in the woreda without geologist support.

### 4.2.3 Woreda water experts in the identification of suitable sites for construction

Selecting the location of a new water point site within the community or homestead needs to take both technical and sociocultural aspects into consideration to ensure the long term sustainability of a resource. According to the WWRDO this woreda is divided into two climatic zones to give priority for the driest kebeles. Namely they are called woyna dega (wet kebeles) and kola (dry kebeles) by their water potential. Based on, the households that regularly collect drinking water from the water points travel distance not more than 1 km radius in the dega kebels. But in the kola kebeles the time to fetch water is very far from their residential area so that they used donkey to fetch water.

To summarize, around 67% of water supply scheme sites were selected by the WWRDO experts and out of these 68% are developed springs and the remaining 32% are HDWs. From survey result 57% and 44% of the developed springs and HDWs respectively were designed by woreda water experts on the poor sites. This indicates that more than 51% of the schemes were not designed on suitable sites. The following table shows the result by dividing in to four categories namely poor, medium, good and very good sites based on different criterions listed in the following flow chart (fig. 4.4).

Table 4. 3 Performance of site selection

| Types of water | Poor site | Medium site | Good site | Very good site |
|---|---|---|---|---|

| schemes | selection (%) | selection (%) | selection (%) | selection (%) |
|---|---|---|---|---|
| HDWs | 57 | 22 | 14 | 7 |
| Developed springs | 44 | 28 | 14 | 14 |

Based on the observation almost 92% of the developed springs was constructed on the hill side of the stream or river. This can cause the river runoff passed over the spring eye structure and infiltrates down to the spring water. Different dirty materials are settled over the spring eye. On the other hand the structures of spring eye box, out let pipe, wash out and over flow pipes become damaged.

In case of HDWs the poor site selection was that woreda experts have not considered the distance of the HDWs from the near river. For example, in Ayvashka kebele one HDW became non-functional in the rainy season due to deep percolation of surface runoff in to the HDWs.

According to the observation, there was one HDW in the Guhala kebele constructed downstream of the high school toilet at a short distance. The community used this water only for the purpose of washing their clothes and for drinking of their animals. Similarly, one best example for the poor site selection was a HDW constructed in similar kebele with in private house compound. In this private house there is mill and around the mill donkeys are excrete their waste and liquid waste from the house is damped around the HDW. As all known that the purpose of establishing water office in woreda level was to distribute or construct different water projects in the poor rural communities in equitable manner. But, in this site the community cannot accessed the water as they want because they fell this HDW was owned privately. The fee collected from this HDW is not fair (1 Eth. Birr) for 20 litters of plastic pot relative to others and the collected fee was not served to maintain this scheme inversely it used as private income.

Distance to supply area (the closer, the better)

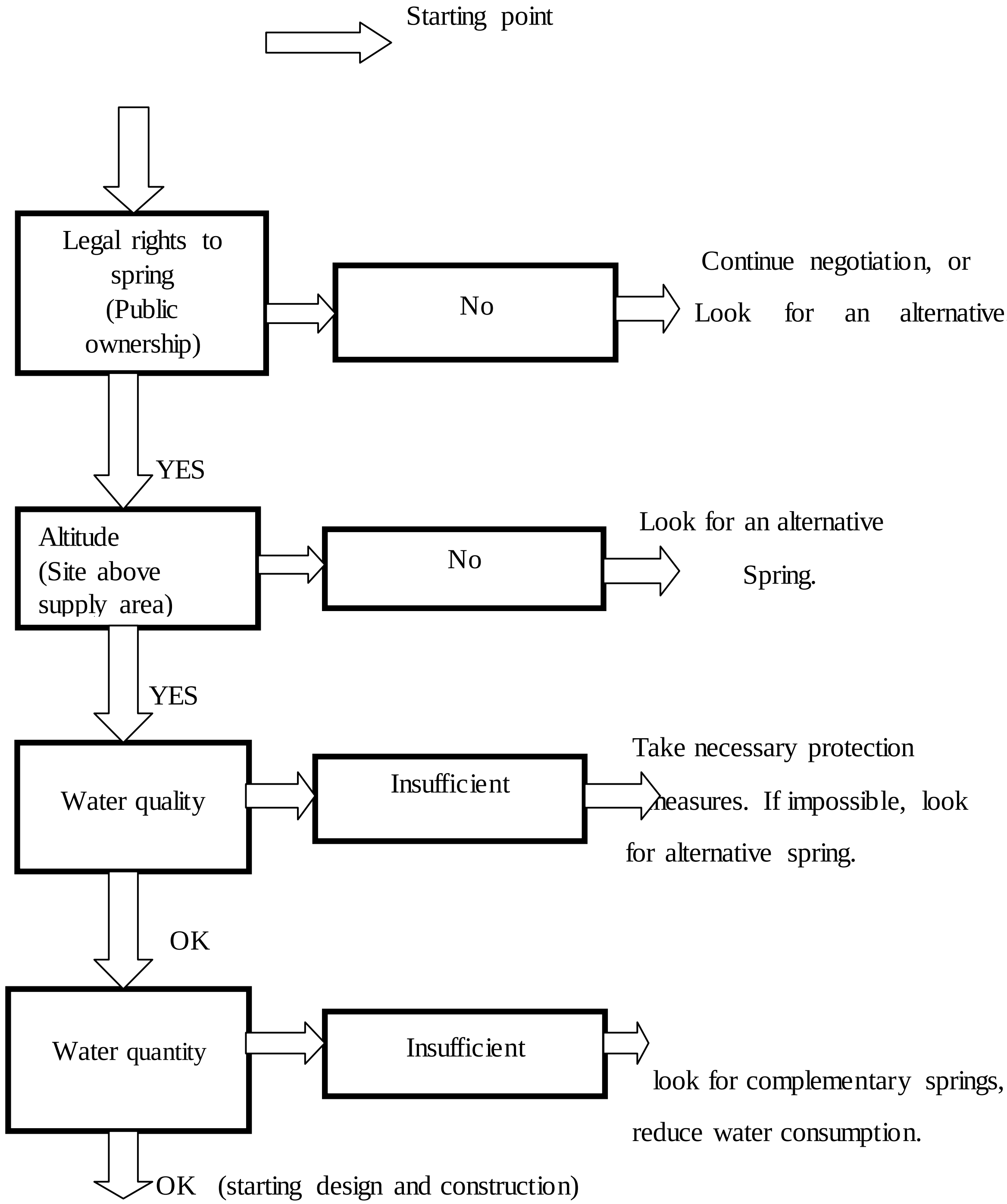



Figure 4.3 Sequences of selection process
(Source: Serious of manuals on drinking water supply, volume IV)

### 4.2.4 Selection of appropriate technology

Appropriate selection of technology is very important and it is the most technical part which was not gives attention by the experts. It also ensures the sustainability of the water points. Selection of technology should be considered the spare parts of Afredive pump and pipe fittings for HDWs and developed springs respectively. The most widely used technology for HDWs was Afredive pump and rope pump (recently used).

Selection of technology does not consider only the spare parts, but also consider the nature and types of the spring to construct the appropriate structures. According to different literatures, the structures for spring eye should be based on the nature of the spring flows whether it is artesian or gravity types. The main target or purpose of developing spring is collecting of the spring eye to flow concentrate towards the spring box. So that Knowing of this nature is important to collect the whole spring eyes.

Almost all (98%) developed springs were not considering the nature and type of spring box structure constructed during the design stage. From the response of the office members still they have not any idea about the flow characteristics of the spring. Due to the lack of awareness only one type of spring box structure was constructed in the study site. It is known as a spring box with a single permeable side for hill side collection.

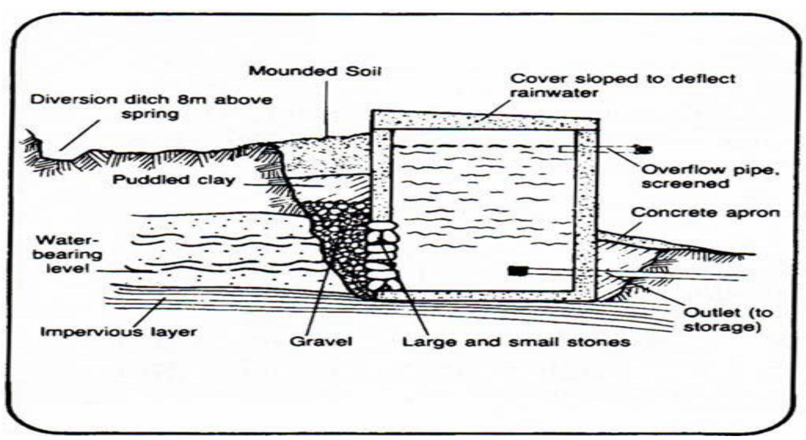



figure 4. 4 spring box with single side for hillside collection (Courtesy of USAID, 1982, available online at www.lifewater.org).

An example was the wrong choice of technology in Guhala kebele led to failure. The water supply system is an on-spot spring development having of large flow rate constructed without large reservoirs. Due to its great flow rate the water is flowing throughout the year without any purpose. The community used this water to wash their clothes and taking shower. As a result the liquid waste was then return back to the spring water through cracks.

Most of the woreda water experts have no awareness about what type of hand pump is fitted for any amount of discharge and similarly they did not make an estimate of pipe size (diameter) for each spring development. They used always 1.5 inch diameter size for any amount of discharge and afriedive hand pump for spring development and HDWs respectively. For example in Ayvashka kebele there was a developed spring having of a supply pipe (from spring box to reservoir) below the recommended diameter size. Due to The high discharge from the spring box the fittings and the pipe itself become out of function. Finally the community used this water system without supply pipe at the spring box site (like on-spot spring development).

### 4.2.5 Flow conditions of water supply schemes

To satisfy the water demand of the community it is mandatory to measure the flows of the spring and HDWs properly throughout the project life cycle during the driest season to know the reliable yield of water system. Mostly it is difficult to measure accurately the flow of each scheme. In the study area the well-known water projects are HDWs and developed springs. Selection of water points was made throughout the year due to this there are water points which was selected during the rainy season. This can cause shortage of water at the end of the year (starting from April up to mid of June). I have also observed that during my field visit some water experts were selected a water points for construction in the next period.

If the communities ask the water office to construct a developed spring around their area, there will be accepted and one water expert goes to the field to establish water committee. After forming water committees the next step is starting construction of the spring without ensuring whether the discharge is enough to satisfy the beneficiaries need or not. 22% of the developed springs were measured their flow rate by using a well-known volume of bucket without many trials. During measurement the area around the spring did not clean properly. Due to the difficulty of the topography some experts also took a false measurement. So that it is difficult to know the real flow rate of the spring.

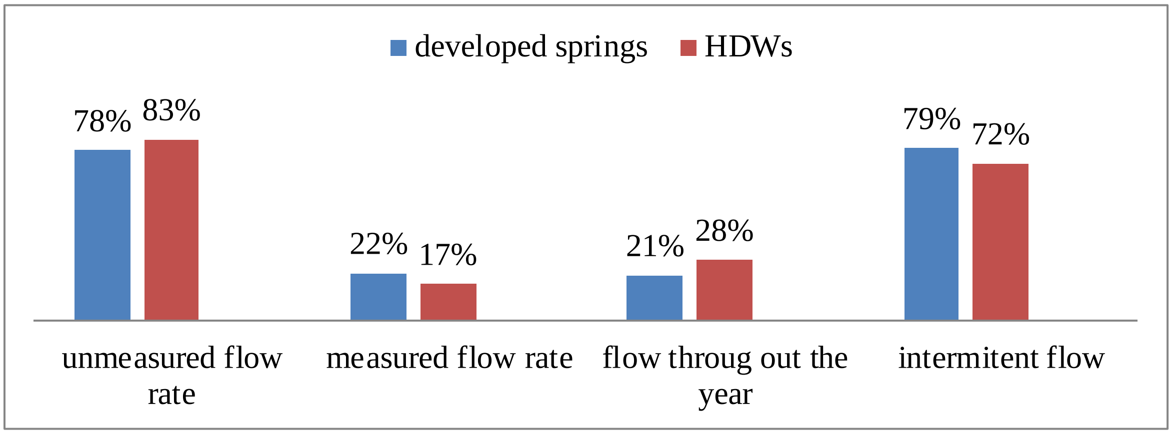



Figure 4. 5 Flow characteristics of the developed schemes

As shown from the above graph 78% of the total developed springs were not measured its flow rate during the design stage and the remaining 22% have been measured. Out of the unmeasured springs only 21% flows throughout the year and the remaining 79% flow intermittently. Similarly 83% of the HDWs have found unmeasured flow rates during the field visit. Due to this 28% of the HDWs flow throughout the year but the remaining did not flow regularly.

As a result at the end of the year (April-mid June) the available quantity of water become very low after fetching of almost 10-15 plastic pots (200-300 liters). So that the communities are searching another source by traveling long distance or fetching river water for drinking and cooking purposes. Fetching of water is mostly in the hand of women's and children's, so that when they travel long distance they have got different accidents and children's was absent from school.

In water points with shortage of water, majority of the beneficiaries suggested getting additional water point or at least increasing the depth of well and that could be the only way they believe to ease water scarcity problems. Non-sufficient depth drilling is what the beneficiaries believe to be the main reason for the lower discharge. The average depth of schemes is between 3-5m and still that's not enough to meet the water needs of the local users, but the reasons could be different, it could be the hydrological nature of the area and this needs some geological scientific research in order to clearly identify the source of the problem.

In the rainy seasons, the shortage of water almost or completely disappears as the ground water table increases and the users´ dependence on the water points decreases. According to beneficiaries, in the rainy seasons there are other alter- native Water sources like streams, rivers, water from their roofs or gutter and other surface waters. This eases the water shortage problem of the local community

### 4.2.6 Water demand of the beneficiaries

The water demand of the community in the research area can be depend on different factors like living standard, climate, hygiene and other factors. Because it is rural area the living standard and hygiene condition are not influencing much more their demand of water. According to the respondents the water they fetch was used for only drinking, cooking and washing of their kitchen materials. The community used river water for their animals and washing clothes.

The graph below shows the number of schemes with its yield and percentage of respondents with their daily consumption of water. Woreda experts did not make a water demand calculation for each water points. Instead they did the access and coverage of the whole water supply. Simply count how many households can be beneficial if this water supply schemes have been constructed by considering the average family size (5 family members in one household) for each water points.

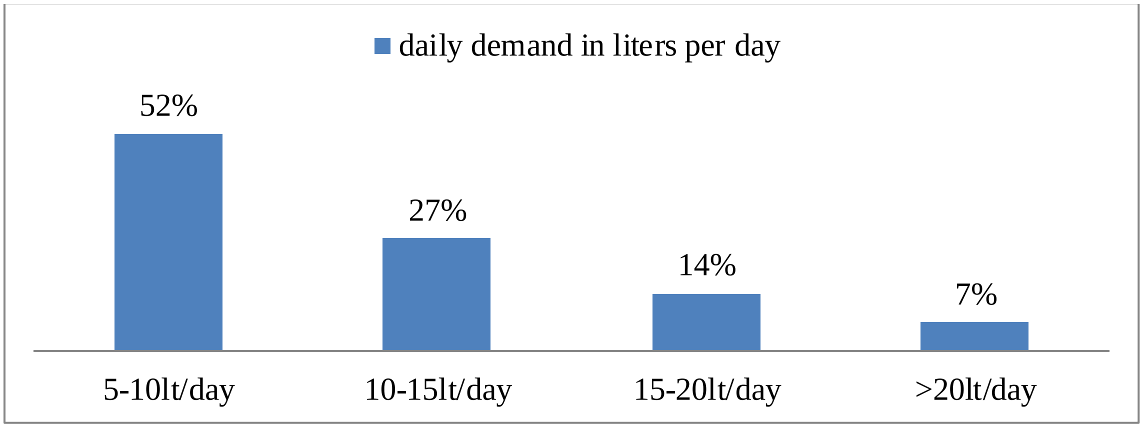



Figure 4. 6 Daily demand of the respondents

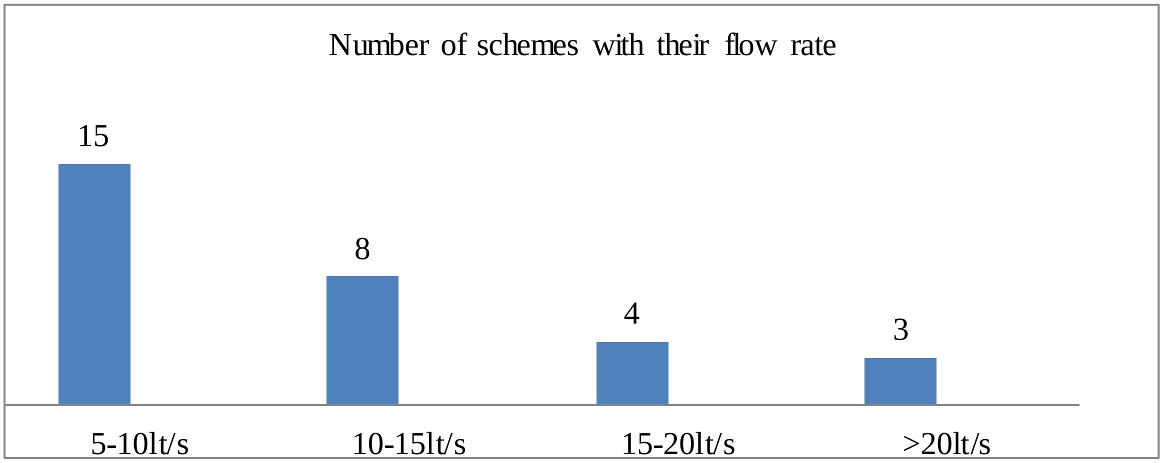



Figure 4. 7 Flow rates of the sample schemes

For example if a HDW is constructed in the study area, it will serve for 270 households and for a developed spring it is for 300 households. This means that the households can be below or above the mentioned number. Similarly the constructed water point cannot satisfy that amount of households.

According to the respondents (79%) in the area, they consumed below the standard of UAP target of 15lt/c/day per capita per day for service radius or distance of less than 1.5km and also below the standard of WHO 20liters per day for only their domestic purposes. The result of the second graph shows that, only 3 water points have a daily yield of 20 liter per second and the remaining's are below this. Different ideas were mentioned for their weak yield. The first and the most was the woreda experts did not make a demand and supply analysis for each supply schemes. They constructed the schemes without considering the present and future demand of the community. The second reason was when the schemes were constructed there is no follow up during the taping of the spring eye and excavation of the HDWs. There should be taped the whole eye of the spring and excavation of the HDWs with enough depth.

### 4.2.7 Environmental and social aspects of rural water supply projects.

Among other aspects which must be considered are impacts of the proposed system on the local environment. For example, the consumption of water may deny a supply to other human users, wild life or plant life. Similarly, the construction of a system might create problems with erosion in the area of the installation.

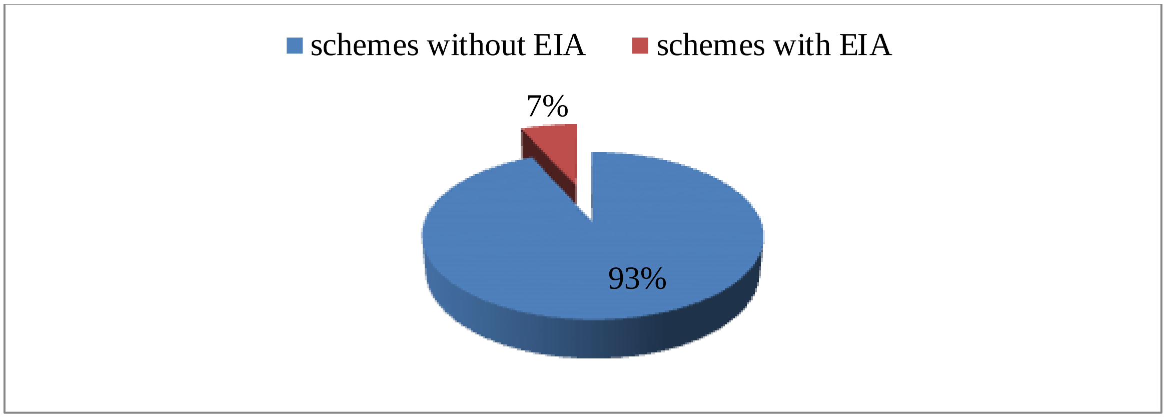



Figure 4. 8 EIA analysis of rural water supply projects

Almost 93% of the water supply points found in the research area was not made environmental impacts assessment due to that there was no expert or other experts have no awareness about this issue. However the remaining 7% of the constructed water schemes were made an EIA analysis related to such as, they tried to avoid eucalypts around the schemes and avoid construction near to toilet and highway. They may also consider the impact of land degradation during the excavation of the spring eye and HDWs. Those assessments were done by some NGOs, for example the above analysis was made by ORDA and UNICEF experts.

On the other hand (91%) of the schemes were not considered the water demand of the animals during the dry season. The WWRDO construct water supply schemes without cattle trough. 68% of the respondents were under this risk so that there was a conflict at the time of feasibility stage between the WWRDO and farmers.

For example, in every year at least 5 water point sites should be changed from one kebele to other kebele or with in its kebele. For example, in Dengora kebele one HDW site was changed due to lack of permission for construction from the owner of the land. This is due that the woreda water office did not make awareness before going to implementation for the society about the importance of the project.

### 4.2.8 Preparation of design documents for feasible rural water projects

For any type of rural water supply projects preparing of design documents and detail estimation of project cost for each water points should be on the hand of woreda water office. It can minimize the conflict between the artesian and the office at the time of the construction period and payment. From observation there was no water point having a detail design document except a similar rough estimation of labor cost for the purpose of bid document preparation. Because of this most of the water projects end later than the estimated period. There was no a guide how and in what way they construct the total project activity.

All local contractors perform the whole project without any design documents. This led to conflict between the contractor and the office and difficult to supervise the work activity. For example, fencing of water schemes was one of the activities that conflicts arise between the two parties. According to the local contractor it was the responsibility of the community but they have paid. According to the office members fencing of the scheme is one of the activities done by the contractor. So that at the time of payment always there was conflict.

## 4.3 Constructions of rural water supply schemes

### 4.3.1 Communities role in the construction of rural water supply projects

If the community involvement is high, it has an impact on the ownership feeling of beneficiaries. In the construction of water projects communities' contribution has different forms. The most common was in cash, labor, local materials and idea or food. In the most of functional water schemes 32% of the respondents was contribute in labor and 35% was local materials and 17% of respondents were contribute idea as a result those kinds of contribution leads the user's ownership. But in the case of non-functional schemes 81% of the respondents did not contribute to the project at the whole project life (from the pre-feasibility up to the end).

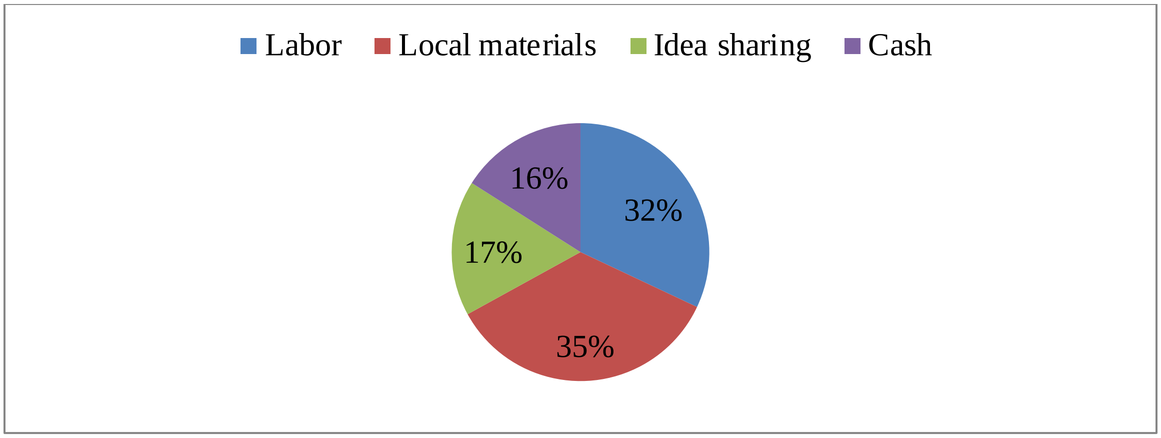



Figure 4. 9 Contribution of the community in the rural water project

It is known that around 85% of the population is living in the rural area and they lead their life in agriculture by hand to mouth life style. But In almost all water points the communities contributed money for operation and maintenance before the installation of the project and the contributed money was kept by the water committee treasurer together with WATSANCos accountant or a person selected by the community members. This kind of contribution (in cash) started from the pre-feasibility stage of the project up to the end of the construction period. Labor and local materials are the most predominant contributions of the communities in the study area.

### 4.3.2 Linkage between WWRDO and Water committee's

A water committee is an often voluntary body, selected by the community to represent it in discussions and decision making on all aspects of local water management. If a committee is going to function smoothly and meet the needs of the community, it should represent all segments of the community, better off and poor, male and female, groups living in different areas (Bolt and Fonseca, 2001). The users in twenty five schemes said that the water committees were elected through the active participation of the community. The water committees of these schemes affirmed that there was public participation during their elections. The users of five water schemes, however, said that the water committees were elected by the kebele Council and woreda water experts or technicians without the participation of the community. According to the woreda water experts, the election of the water committee might take place with community participation or the individuals might be selected by the kebele chairperson and the list sent to the office.

All the WATSANCos reported that the WWRDO does not carry out regular follow-up and support supervision unless asked by the committees. According to the WWRDO experts, every year there is a plan to follow up on and supervise schemes and the performance of the WATSANCos, but achievement of this is below 10% because of financial, logistical and human resource constraints. During the field investigation, it was observed that the WWRDO has no checklists for follow-up and supervision, and no field reports of the professionals were seen in the office. Generally, there are no signed agreements between the WWRDO and the WATSANCos.

Generally, in the Woreda, there are no clear rules and regulations addressing the accountability of the WATSANCos. No written rules and regulations are in place to facilitate decision making and regulate the user community and committee members. No WATSANCo has prepared a water constitution. According to WWRDO experts, lack of budget, human resources and logistics makes it impossible for the office to coordinate the committees and prepare such constitutions.

The WATSANCos played a great role in coordinating of the community to participate actively by registering who was present or absent. They communicate with the woreda water office experts or technicians about their daily activity. On the other hand they supervised the local contractors to finish the project with a good quality. The selection of the water committee was considering their educational back ground as well as their knowhow about their surroundings. They contribute more in idea sharing in addition to coordinating the community.

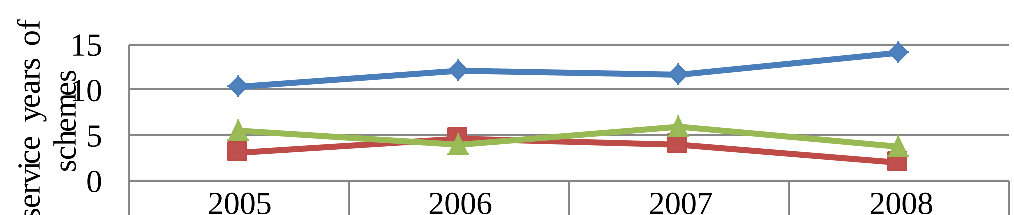
### 4.3.3 Artisans (local contractors) in the construction of rural water supply projects

In the study area there are artisans trained for the installation, construction and maintenance of schemes. They had been trained for two months in theory and practice until finally they were certified by construct one HDW and one spring. Mostly they perform masonry works, supervision of users digging wells, installing hand pumps and other technical labor. The artisans in the study area have more than 3 years' experience in the construction of rural water projects in their woreda and in the neighboring woredas. According to the artisan response almost all water projects were constructed without the details of technical parts in the form of design document. They constructed from experience. Because there is no clear distinction between the work of artisans and the community they complain when the payment cuts for the work that was not covered by the artisans

There is a good interaction between the community and artisans. 94% of the respondents said that there was a good interaction between the community and the local contractors throughout the project life cycle. They respect each other. The community was volunteer to contribute the necessary local materials and labors as well as food and shelter for artisans and daily laborers. The following graph illustrates the percentage of rural water projects those were constructed by artisans who trained by different organizations.

Almost 20% of developed springs and 10% HDWs, 26% of developed springs and 14% HDWs, 9% of developed springs and 6% HDWs were constructed by zone, woreda and ORDA trained artisans respectively.

As stated earlier 15% of water supply schemes were constructed by ORDA trained artisans. Out of this 90% of the water points served for at least more than five and ten years without any structural or spare parts maintenance relative to others. But in the case of woreda trained artisans the failures of structure exposed the water office for other extra expense to rehabilitate. The schemes were served not more than three years. The average service period for those schemes constructed by woreda and zone trained artisans were two and half years. The above result shows that technical support which was given can affect the schemes service period.




| | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|
| ORDA | 10.4 | 12 | 11.6 | 14 |
| WOREDA | 3 | 4.5 | 3.9 | 2 |
| OTHERS | 5.5 | 4 | 6 | 3.7 |

Figure 4. 10 Service year of scheme after construction by different institution

From the above chart, for example, a water supply schemes those are constructed by ORDA trained artisans were serving without major maintenance for at least 10 years averagely. Artisans who trained by ORDA staff members can manage the whole construction process by themselves except some technical works. But in the case of woreda trained artisans the schemes served at a maximum of four and a minimum of two years after construction. However, woreda trained artisans need a daily supervision because they were not attending successfully the training. This result indicates that the institution those are responsible to train local contractors influence the life of the schemes. Still some artisans did not know the procedures of the construction for those water supply systems. Now a day the woreda water office of the study area licensed more than 12 artisans every year starting from 2005 E.C with minimum requirement of $8^{th}$ grade completed. Even if they have good educational background but almost all are inexperienced in the construction of water projects.

### 4.3.4 Construction and capping of spring eye

The spring collection area is the heart of a water supply system that uses a spring source. Thus, care and experience is needed for proper spring construction. Construction starts with excavation from where the spring emerges to the surface. But in the most developed spring excavation of spring eye did not give attention by the artisans as well as by the experts. They simply excavated to make a large water pool but not to collect the whole eye of the spring. At the time of digging they only considered one direction of flow without searching another spring eye source on the other side. Sometimes they blocked the spring eye during excavation this was due to improper digging method. They started

Figure 4. 11 partially covered spring box during construction

Figure 4. 12 A spring box fully covered by reinforced cement concrete during construction

The reduction of flow rate during construction time was the most crucial problem of the study area. The most developed springs have a variable flow rate before and after the construction of the spring box. Almost 53% of the developed springs were decreased the flow rate during construction. This was due to blocking of the spring eye or improper collection of the eye during construction period.

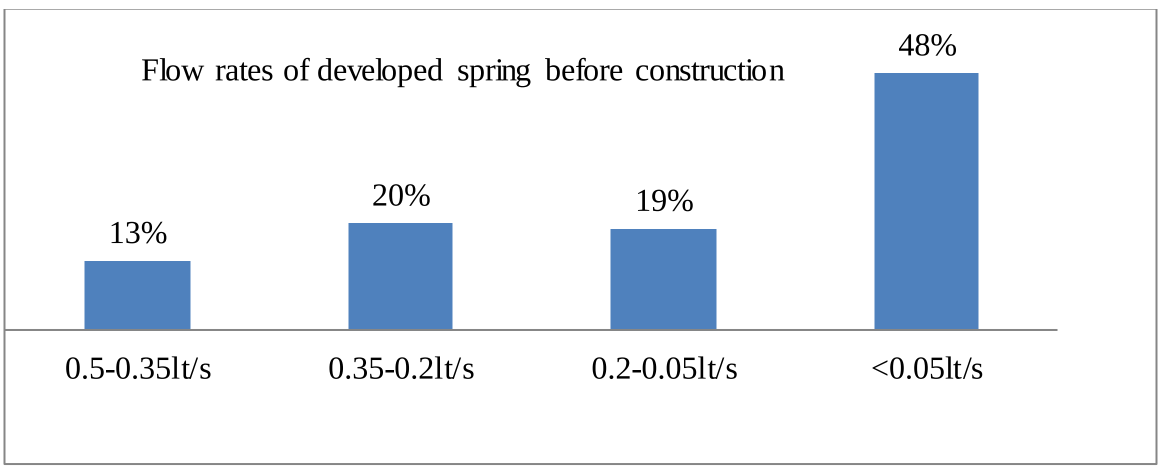



Figure 4. 13 Flow rates of developed springs before construction

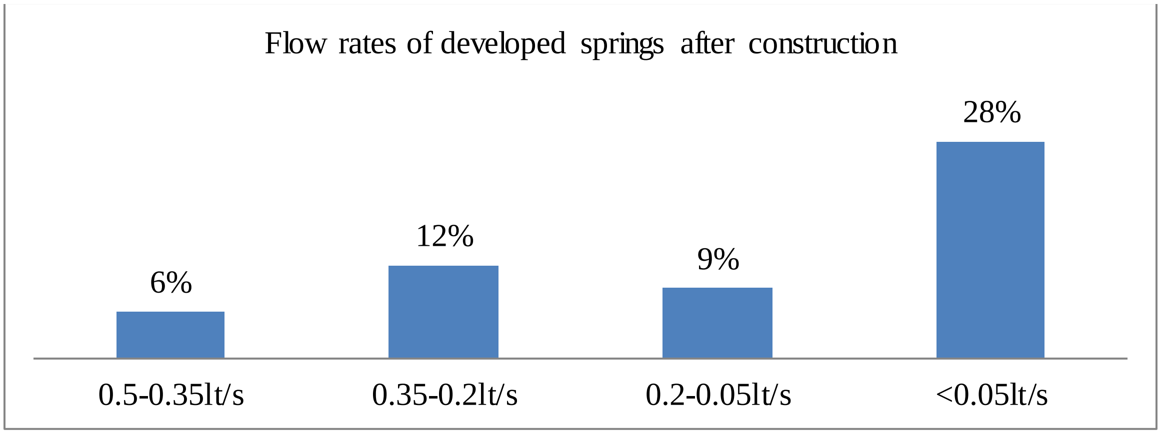



Figure 4. 14 Flow rates of developed springs after construction

The other major cause for the reduction of flow rate was seeping of collected water through the cracks and the base (foundation) of the spring box. This was due to construction of spring box structure on loss (unconsolidated) foundation. They did not excavate up to they found rock foundation to lay down the base of the spring box.From different literatures the arrangement of filter materials (stones and gravels) for developed springs are important to remove any dirt that may get caught by the water as it leaves the spring and moves through the filter and capture area. According to the artisans the only filter materials they used was a large stone around the spring eyes. They considered this as a hard core. They have not any awareness how to arrange the filter materials and which types of material can be used for this purpose.

In the study area most of the spring development is in the hilly area so that they need a runoff (flood) protection structures like, retaining walls and diversion ditches. But they were constructed without these structures. These structures were not familiar as the part of the project in that area. During the rainy season high amount of flood from mountainous area damaged the spring box as well as the reservoir and flood water entered to the spring water through cracks. Due to this at least 1,110,000 ETB invested every year to maintain these structures according to the woreda water office. The collected water in the spring box finally passed through supply pipe to enter the reservoir. These reservoirs were constructed without considering of the flow rate of the spring. According to the water office expert these reservoirs were constructed to store 3.6 cubic meter of water. But most (85%) of the reservoirs were collected 2.025 cubic meter of water per a day. This was happened due to less supervision of experts at the time of construction and does not have a well prepared design for each scheme.

### 4.3.5 Construction of hand dug wells (HDWs)

In most cases where hand dug wells are an option, excavation and construction relatively easy and does not require sophisticated equipment. Similarly the construction is cheap in comparison with other technologies such as the mechanical construction of boreholes because of community participation. The construction was done by locally available materials and equipment in addition to these no need of heavy machineries and skilled man power. The most common and familiar type of HDW is a 1.2m internal diameter and lined with pre-cast caisson rings. Before installing the caisson rings the excavated HDW has a 1.5m internal diameter to function freely the diggers.

Figure 4. 15 A hand dug well during construction

Figure 4. 16 A hand dug well after construction

The other water supply systems designed and constructed in the research area is a HDWs of having 1.2m internal diameter and a depth of not exceeding 10m. There are two types of measuring a HDW flow rate during excavation. The first is the excavated HDW is leaving for 12 hours to store water in the night time and after storing the water somebody can measure the depth by using meter in the morning, then calculating the well discharge (yield) by converting in to volume (in liter per second). The second method is during the excavation time the whole stored water is pumped out by diesel generator and then the well become empty. After empting the well leave to store water for some minutes by using stop watch up to the water reaches a measurable depth. Now measure the depth by a ruler or other known instrument and calculate the discharge in liter per second to know the yield of the well. The first method is applied in few HDWs.

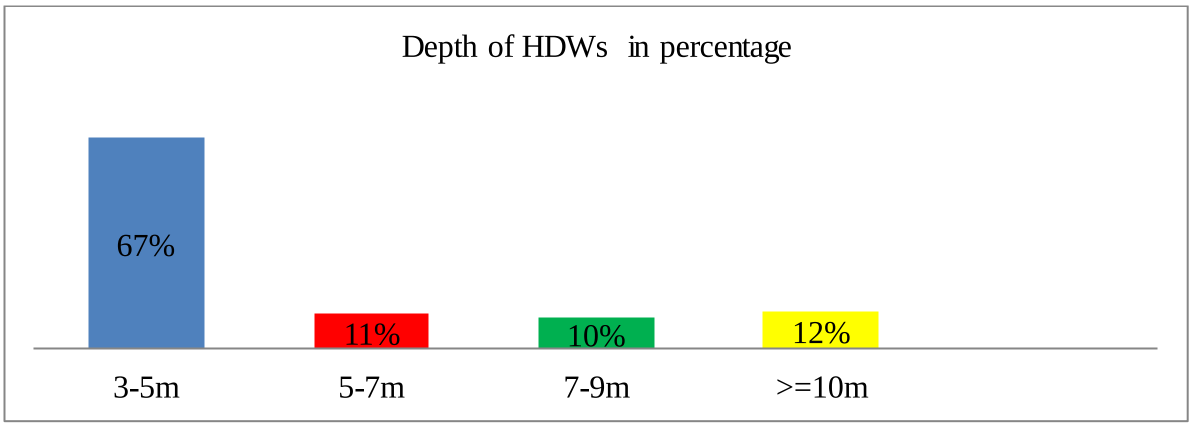



Figure 4. 17 Depth of a hand dug well during excavation

As shown from the above graph most of the constructed HDWs have a depth of 3-5 meters (67%). This depth was not satisfying the water demand of the community. Very few HDWs have a depth of more than 10 meters (13%). The water levels of most (53%) of the excavated HDWs were between 0.5-1m. This means the volume of water in the well was small or the yield was not enough to satisfy the water demand of the community. So that due to small yield more than 23% of users(only served by HDWs) search for other sources and travels far away from their residential areas. The users always complain the office to increase the well depth because they assumed that the water yield of the HDWs will be increased because of the yield is proportional to the depth.

At the time of caisson rings installation a 0.3 meter space left between the external wall of the rings and the internal wall of the excavated HDWs. This space was filled with gravel, sand and compacted clay or mass concrete to be used as a filter and for structural stability as well as to prevent the entrance of flood water. From artisans response they were not filled these materials because they were not awarded before constructed the schemes. Almost all (98%) of the constructed HDWs have not fill materials and due to this the surface runoff in the rainy season and the splashed water during fetching time entered to the well. So that the water quality decreased and the hand pump stopped its function due to heavy siltation, 35% of the HDWs were exposed to this flood water and much amount of money invested to clean (wash) the well and maintain the hand pump every year.

The super structure (head work) is part of the HDW which was constructed from cement masonry and reinforced cement concrete for the cover slab. This structure should be constructed in a great care to avoid the splashed water entrance back to the well water. This structure provided with a small drainage channel and a soak away pit to drain safely the splashed water on the cover slab. In the study site most of the HDWs have a drainage channel around the head work but not have a soak away pit. Due to this dirty water percolate to the well and it can cause health hazard.

#### 4.3.6 Technical supports given by woreda water experts for water committee

The major roles and responsibilities of the WWRDO, according to the WWRDO experts and office Head, include: construction of new schemes; maintenance and rehabilitation of existing water supply schemes; promotion of hygiene and sanitation; and follow-up on the quality of NGO waterworks construction. Despite the fact that the WWRDO has been given a number of responsibilities, performance regarding the annual and strategic plan is very poor. The WWRDO has no permanent head fully engaged in and performing the office's day-to-day activities. The office head is not a water expert by profession, although he has received a number of trainings related to water supply and sanitation and has rich experience in the sector.

Workloads and to the lack of commitment of some office experts, the office does not coordinate with other actors and sector offices to help the WATSANCos and everyone is busy with their daily work. Generally, the WWRDO does not provide the necessary support to the WATSANCos owing to a lack of the necessary human, finance and logistical resources in the office. Some NGOs has only very few human resources with the necessary qualifications and experience, who take care of all the organization's activities. Compared with other actors, the NGO has a good profile in terms of bringing different stakeholders together through a steering committee composed of the important actors in the sector. In the NGO, there is no detailed and centralized system to provide information on previous activities, which seriously affects the NGO's regular activities. This owes partly to the high turnover of individuals assigned to management positions.

In the WWRDO strategic and annual plan, there was no direct support for the WATSANCos expressed in terms of budget or human resources. According to the office experts, there was no direct support except help in the case of minor breakdowns or mismanagement. The WWRDO also has limited human and logistical resources to undertake its activities. The resource mapping showed that the number of positions in the office and the number of human resources present are not comparable With regard to structural linkages with the WATSANCos; the WWRDO experts had different perspectives. Some said that there is a legal structure between the office and WATSANCos and the office has been providing technical support to WATSANCos, with the WATSANCos responsible to the office. Other experts argued that there is no legal structure, and this is manifested by the absence of a reporting system to the office. The second group said that the WATSANCos are responsible to the kebele leaders. Despite the absence of a common understanding among the experts, WATSANCos have not been reporting financial or other activities to the office. The WATSANCos report to the office only when a scheme breakdown occurs. All the WATSANCos affirmed that they do not report their activities to the office except in the case of breakdowns. Generally, there are no signed agreements between the WWRDO and the WATSANCos, and the latter have no action plan.

### 4.5 Functionality and service level of water points

#### 4.5.1 Functionality of water points

Functionality refers to a condition whereby the system provides water to the users. Therefore, the scheme is said to be fully functional when the quantity and quality of the water point is sufficient that the people can fetch water from it. Though it is controversial, shortage of water or less discharge of the well can't fully satisfy the criteria of a functional and non-functional water scheme. According to rural water supply universal access plan fully lined hand dug well with raised platform fitted with hand pump designed to serve the community for minimum of 5 years and Capped springs designed to serve the community for at least a minimum of 10 years. About 13% of the schemes have served beyond their design period of more than 5 and 10 years, with the replacement of some important parts, such as pipe fittings and internal fittings for hand pumps. Four of these schemes have been serving the community for more than 10 years, with the maximum being 15 years. Out of all the non-functional schemes, about 90% were constructed in the two years; about 60% were constructed in the past three years. This indicates that most of the non-functional schemes have not even served their community for five years. When scheme breakdowns occur, the speed of maintenance is slow. Maintenance for minor breakdowns is performed within two weeks, whereas major breakdowns take a minimum of one month, with an average of three months. Despite encouraging efforts to increase the water supply coverage, a high rate of non-functionality of recently constructed schemes has been observed in the Woreda. Out a total of 30 water points, 34% are not providing a service to the community.

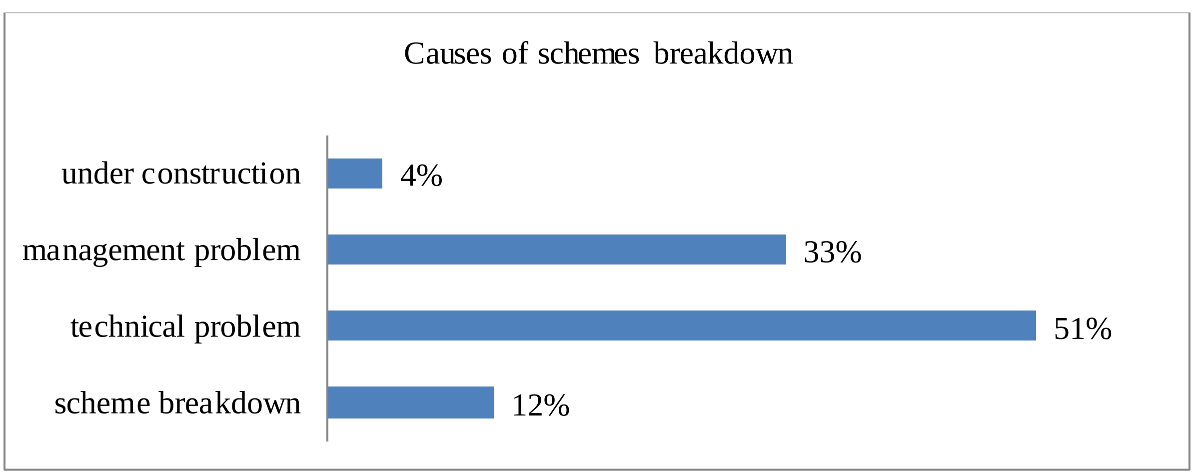


Figure 4. 18 The causes of schemes breakdown in percentage

As shown from the above figure the major reasons for the non-functionality of water points include: scheme breakdown (12%), technical problems (51%), management problems (33%) and 4% under construction.

### 4.5.2 Access to water supply points

In 94% of the water points, users reported that supply is predictable and is available both in the morning and in the afternoon (exact time not known). In the remaining 6%, supply is only available in the morning. The water points provide a service for one hour to three hours per day, with an average of two hours. In some of the schemes with more than one water point, the points are not placed within a reasonable distance to serve the majority of the community. During the survey, users said that the guard sometimes opens the water points when he/she see queuing around the water point. The time taken to fetch water from the main source ranges from 10 minutes to two hours (round trip), with an average of one hours and 15 minutes. These findings exceed WHO recommendations (WHO, 2006a), set at 30 minutes of walking time for a round trip, equivalent to a distance of about 1km. They also exceed the recommendations in the UAP, which plans to provide improved water to every rural dweller within a 1.5km radius by the year 2012 (MoWR, 2006).

Queuing time varies from season to season. During the dry season the queuing time ranges from 15 minutes to three and half hours, with an average of two hours. In the wet season, the queuing time ranges from 15 minutes to two hours, with an average of one hour and 45 minutes. Therefore, the average round-trip including waiting time is found to be four hours in the dry season and two hours in the wet season.

Generally, 61% of the respondents in the functional water supply points said that their present water supply schemes are far from their residential area, but 39% of the respondents said that their water points are near to their home.

### 4.5.3 Satisfaction on water supply service

In 96.9% of the water points, users consume the water from the main source for all domestic purposes without any complaints about quality. However, in the remaining

3.1% of the water points, users consume the water for all domestic purposes but have some complaints on quality (turbidity of the water from the source). The WWRDO has never carried out any water quality tests or regular monitoring of the source and the water points. 74% of the respondents in the study area fetch water once a day, but 21% fetch water twice a day and the remaining (3%) fetch three times a day. Due to this most of the respondents (67%) in the existing water supply points were dissatisfied with the provided service.

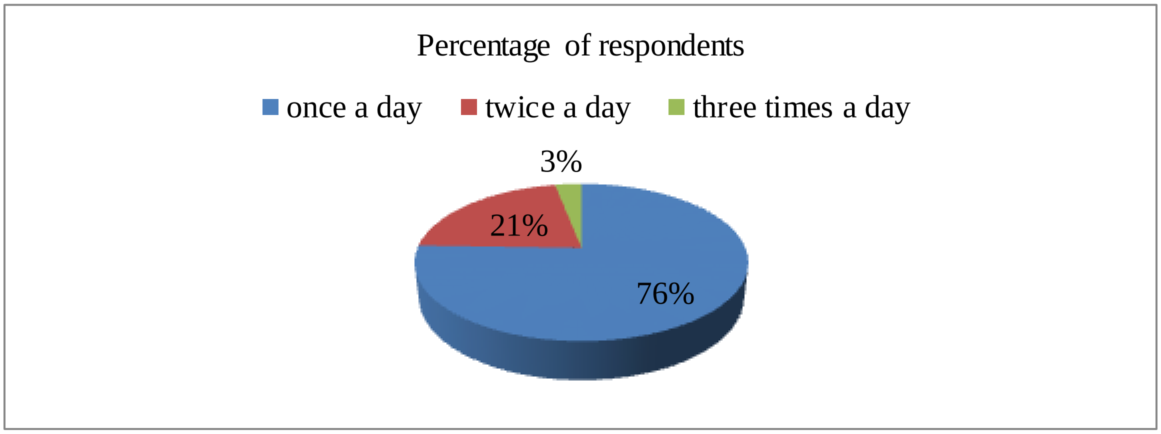



Figure 4. 19 Frequency of fetching water per a day

The average quantity of water used from protected sources per household per day was found to be 46L, indicating that on average 9L of water is used per person per day. This finding indicates that per capita consumption of water in rural parts of east belessa woreda is by 6L lower than the 15L standard set in the UAP (MoWR, 2006). The findings are also lower than those of Carter and Howsam (1999) and the WHO (2006a), which indicates that access to 20L of water per person per day is a minimum requirement in respecting the human right to water and minimum hygiene standards. During the wet season, the majority of the Woreda population, residing far from the improved sources, uses unprotected sources like ponds, rivers and unprotected springs for all domestic purposes, including drinking. In most of the schemes, watering cattle during the dry season also takes place at the water points.

# 5.0 CONCLUSIONS AND RECOMMENDATIONS

## 5.1 Conclusions

According to the analysis community participation starting from the design up to the end of the project as well as after construction was essential to feel the real ownership of the total project. However, in the study area the participation of community was very low (22%). Community participation in the functional water schemes were more than the non-functional water points. Selection of suitable site was the other challenge in the design of rural water supply projects in East Belessa woreda. In the woreda, most of the sites were selected by the woreda water experts and among these less than 24% were constructed in the suitable sites. Similarly choice of technology was additional challenge that was not given proper attention especially at woreda level. Those schemes designed by woreda water experts were not worried about the appropriate types of technology.

Another significant challenge was satisfying of the daily water demand of the users, from the analysis more than half (54%) of the community exposed for water scarcity in the dry season of the year. Only in the 19% out of the total water supply points were studied the daily demand of the beneficiaries before the construction of the schemes (at the design stage) by NGOs (ORDA). The woreda water office simply constructs schemes to increase the total water coverage of the woreda without considering the standard set by WHO and MoWR. As a result 73% of the users in the study area were consumed below the standard of WHO and MoWR. When there was shortage of water the community used unprotected river and pond water as an alternative source by traveling even out of their residential areas.

Poor quality of construction is the one which was identified as a problem in the analysis of the research work. Most (83%) of the developed springs had a variable flow rate. This was due to the poor quality of spring box construction during capping of the spring eye. Their flows were decreased by an estimated amount of 0.2-0.45lt/s. it is a great amount of reduction so that care should be given and a daily supervision during the excavation of the eye as well as technical support should be given for artisans. On the other hand deep excavation of the underground could yield reliable amount of water. However, the hand dug wells found in the research area had a depth of averagely 6 meters. The community served in the shallow hand dug wells always exposed for scarcity but not in the deep (15-20m) hand dug wells.

The water points provide a service for two hours per day on average. Water points often start providing a service when queues begin. The time spent to collect water is also high. The average round trip, including waiting, was found to be nine hours and five hours during the dry and wet seasons, respectively. The burden of searching for water is borne entirely by women and girls. During the wet season, those residing far from the improved sources use unprotected sources like ponds, rivers and unprotected springs for all domestic purposes, including for drinking.

### 5.2 Recommendations

The following recommendations have been drawn based on the facts found during survey result; in order to avoid challenges during the design and construction of rural water supply schemes as a result the service (design) period of the schemes will be increased. On the other hand the functionality rate of the schemes can be increased and the users will be satisfied on the service provided.

- Daily supervision when the spring eyes are cleared and capped to collect the whole eye of the spring.
- Check the reliability of the well water before installing of the caisson rings and establish design and construction standards depend on the reality of the woreda.
- Check the water yield of the schemes before and after the completion of schemes.
- Make the daily water demand of the beneficiaries before going to construction of the water.
- Participation of the community throughout project development phases to create a sense of ownership.
- Technical support for the woreda water experts, community, water committees and artisans regarding to the design and construction of rural water schemes.
- Regular follow-up and supervision during the design and implementation of newly constructed schemes to avoid leading to recurrent scheme failure.

## 6.0 REFERENCES

ADF (African Development Fund) (2005) Rural Water Supply and Sanitation

Admassu, Mengesha,Abera Kumie, Misganaw Fantahun (2002) Sustainability of Drinking Water Supply Projects in Rural of North Gondar, Ethiopia, *Ethiopian J.Health Dev*. 2003; (3):221-229.

Arouna, A and Dabbert, Stephan, 2008. Domestic Water Use by Rural Households without Access to Private Improved Water Sources: Determinants and Forecast in a Case Study for Benin, a paper presented on the Conference on International Research on Food Security, Natural Resource Management and Rural Development. University of

Hohenheim, Institute of Farm Management, Department of Production Theory and Resources Economics, Stuttgart, Germany. Assessment, Technical Report No-08, FAO-SWALIM, Nairobi, Kenya.

Austin, John D., and Jordan, James K. (1987). Operation and Maintenance of Water Systems in Developing Countries. *Journal of American Water Works Association,* vol. 79, no. 7, pp. 70-77.

Barnes, R.R. (2009). Planning for sustainable water and sanitation projects in rural developing communities. Ph.D. thesis, School of Civil and Environmental Engineering, University of New South Wales.

Begashaw (2002): Community Health, Water Supply and Sanitation: Proceedings of a MoWR/EARO/IWMI/ILRI International Workshop held at Addis AbabaEthiopia, Dec. 2-4, 2002

Biswas, A. (2005) an Assessment of Future Global Water Issues: *Water Resources Development*.

Breslin, N., 1999. Lessons from the Field: Rethinking Community Management for Sustainability. Paper presented at Conference on; Rural and Peri-urban Water Supply and Sanitation in South Africa - Appropriate Practice Conference 14-17 March 1999, East London. Available at: http://www.crosslink. net/~ehp/breslin.htm.

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

Brooks DB. (2002). Water: Local-Level Management. International Development Research Centre. Ottawa, Canada.

Cairncross S. (1992). Sanitation and Water Supply: Practical Lessons from the Decade Water and Sanitation Discussion Paper Series, DP No. 9.

Carter RC, Tyrrel SF, Howsam P. (1999). Impact and Sustainability of Community Water

CSIR, Building and Construction Technology (2000). Guidelines for Human Settlement Planning and Design (the redbook). Chapter 9. Revised 2003.

Dawit Kebede, 2007. *Water Supply and Access in Rural Africa*. "Churches for Water in Africa" May 21-25,2007. Botanical Beach Hotel Intebbe, Uganda. Available at: http://www.ian/

Gardiner, P. D. (2005). *Project management: A strategic planning approach*. Macmillan.

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

Getachew Abdi, 2002. Managing Sustainable Rural Water Supply in Ethiopia. Available at: http://www.ilri-org.

Gleick P. (2006) The World's Water 2006-2007. The Biennial Report on Freshwater Resources. Island Press, Washington, D.C.

Gross, B. Wij, C. Van and Mukhejee, N. (2001). Linking sustainability with demand, gender, and poverty: a case study in community managed water supply Projects in 15 Countries. Washington, DC USA, water and sanitation program and Delf, the Nethelands, IRC.

Hans Van Damme (2001): "Domestic Water Supply, Hygiene, and Sanitation," Focus 9 • Brief 3 of 14 • October 2001. International Food Policy Research Institute, 2033 K STREET, N.W., WASHINGTON, D.C. 20006-1002, U.S.A.

Harvey P.A. and Reed P.2004.Rural Water Supply in Africa: Building Blocks for Hand pump Sustainability, WEDC, Loughborough University, UK

Harvey, A. & Reed, A. (2007) Community-Managed Water Supplies in Africa: Sustainable or Dispensable? Community Development Journal 42: 365–378

Harvey, P. and Reed B. (2004). Rural Water Supply in Africa: Building Blocks for Hand pump Sustainability. WEDC, Loughborug University, UK.

Haysom, A, 2006. A Study of the Factors Affecting Sustainability of Rural Water Supplies in Tanzania, MSc water management, community water supply option.Cranfield University, Silsoe Institute of water and the environment.

Jennifer Sara and Travis Katz, *Making Rural Water Supply Sustainable*, Report on the Impact of Project Rules, UNDP-World Bank Water and Sanitation Program, 1998

Kerzner, H. (2006). *Project management: A systems approach to planning, scheduling and controlling* (9th ed). Wiley.

Kleemeier, E. (2000) the Impact of Participation on Sustainability: An Analysis of the Malawi Rural Piped Scheme Program: *World Development*.

Kleemeier, L,1995. From Supply Driven to Demand Driven Provision of Rural Drinking Water. A Tanzanian Case Study of the Arguments for Transition. CDR working Paper.

Lammerink M. (1998). Community Managed Rural Water Supply, *Community Development Journal,* 33(4): 342-352.

Lockwood, H. (2002) Institutional Support Mechanisms for Community managed Rural Water Supply & Sanitation Systems in Latin America: Environmental Health Project, U.S. Agency for International Development Washington, DC 20523. Loughborough, UK.

MacDonald A, Davies J, Calow R, Chilton J. (2005*). Developing Groundwater: A guide for RuSara*, J. & Katz, T. (1998) Making Rural Water Supply Sustainable: Reports on the Impact of Project Rules. Washington, DC: UNDP/World Bank Water and Sanitation Program. *ral Water Supply,* ITDG Publishing, Warwickshire, UK.

Manikutty S, 1998 Community Participation: Lessons from Experiences in Five Water and Sanitation Projects in India. ODI. Development Policy Review. Vol. 16 (1998), 373 404.

Moe, C. and Rheingans,R.D(2006). Global challenges in water, sanitation and health. Journal of water and Health.

Munns, A. K., & Bjeirmi, B. F. (1996). The role of project management in achieving project success. *International Journal of Project Management*. Vol. 14. No. 2, pp.81-87.

Narayan D. (1995). 'The Contribution of People's Participation: Evidence from 121 Rural Water Supply Projects', Environmentally Sustainable Development Occasional Paper Series No. 1 World Bank, Washington, D.C

Neto, F., & Tropp, H. (2000). Water Supply and Sanitation Services for All: Global Progress during the 1990s. Natural Resources Forum. 24(3), 225-235 No. 11, pp. 1801–1819

Norwegian Agency for Development Corporation (NORAD) and Department of Water Affairs and Forestry (DWAF). 2003. Standard Descriptors of Boreholes. Version 1.0.

Paudel GS, Gopal BT. (2004). Impact of social, institutional, and ecological factors on land management practices in mountain watersheds of Nepal. *Applied Geography* 24, 35 55. Projects in India: Evidence from Rural Water Supply, World Development 33,

Prokopy, S. (2005): The Relationship between Participation and Project Outcomes

Sara, Jennifer and Katz, Travis (1998) *Making Rural Water Supply Sustainable: report on the impact of project rules*. UNDP World Bank Water and Sanitation Program.

Sebsibe Alemneh (2002): Guidelines on sustainable Community management and financing of rural water Supply and sanitation. COWDO, Addis Ababa, 2002

Shaw R. 1999. Running Water International Technical Publication, London.

Stephenson, David (1998). *Water Supply Management*. Dordrecht, the Netherlands. Kluwar Academic Publishers.

Swartz CD, Ralo T. (2004). *Guidelines for Planning and Design of Small Water Treatment Plants for Rural Communities, with Specific Emphasis on Sustainability and Community Involvement and Participation.* Water Research Commission, WRC Report No: 1185/1/04. ISBN No: 1-77005-103-1.

Turneasure F.E. and Rusel H.L. 1947. Public Water Supplies, Fourth Edition, John Wiley and Sons, Inc. (pp. 32, 39)

UNSW-waterresearchcenter (2010). http://water.unsw.edu.au/site/waterunsw/community-outreach-projects/watsan/

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

Warner, D., & Laugeri, L. (1991). Health for All: The Legacy of the Water Decade. *Water International*. 16(3), 135-141.

WASH (2005): Financing water, sanitation and hygiene in Ethiopia: Making every drop count Water, Sanitation and Hygiene for all (WASH), Tear fund 2005 Water Partner International (2006): Water facts, http://www.water.org/crisis/waterfacts.htm

Water for the world, 2005. Methods of Developing Sources of Surface Water Technical note No RWS 1.M. Site Visited: May 20, 2014. Available www.lifewater.org

White, J, 1997. Evaluation Synthesis of Rural Water and Sanitation Projects. DFID Report EV 596. Loughborough University, UK.

WHO (2000): Global Water Supply and Sanitation Assessment 2000 Report World

WHO and UNICEF (2000). Global Water Supply and Sanitation Assessment 2000 Report. URL: http://www.unicef.org/wash/files/gafull.pdf

Wright A. (1997). Towards a Strategic Sanitation Approach: Improving the Sustainability of Urban Sanitation in Developing Countries, UNDP-World Bank.

# APPENDIX A

**Socio-economic and demographic characteristics of the respondents**

This questionnaire is part of a research work, which is being conducted to assess the challenges for the design and construction of rural water supply in East Belessa woreda. So that, you are kindly requested to fill the questionnaire as truly as you can and your answer will be taken in confident. Thank you!!

**General Information**

Project: ____________________________________________

Village: ____________________________________________

Questionnaire number: __________________________________

**Demographic and Socio-Economic Characteristics of the Respondents**

1.1. Respondents Demographic Characteristics

| Sex | Age | House hold size | Educational size |
|---|---|---|---|
| 1.Female | | | 1.illitrate |
| 2.male | | | 2.read and write |
| | | | 3.primary(1-8$^{th}$grade) |
| | | | 4.secondary(9-10$^{th}$grade) |
| | | | 5.above secondary |

1.2. What is your families' economic base?

A .farming    b. petty trade    c. others, (specify)

## APPENDIX B

### DESIGN OF RURAL WATER SUPPLY PROJECTS

**I. Community participations**

1. How many years have you lived in this area?
2. How many water points were there around your residential area before construction of this new water project?
3. Did you get any chance to participate in the identification of feasibility of these water supply systems? Yes or no
4. Did you have any contribution at the planning stage of this project? Yes or no.

5. What type of contribution did you have during the development of this project?

a. Planning. b. Identification of feasible projects. c. Implementation.

d. Labor e. local materials f. idea g. cash h. none

6. How many water points were selected by you in the project feasibility stage?
7. Did you get any support from the institution or woreda water resource development office?
8. What are the challenges did you face during the identification of feasible projects?
9. Do you think that your views and comments were respected and taken into account while the project was being developed? Yes or no.

**II. The roles of woreda water experts in the design of feasible rural water supply projects.**

1. How do you prepare water projects?
2. How did you know the yield of the well or the spring?
3. Have your organization followed demand driven approach?
4. Did your institution give chance to the community in the selection of appropriate technology?
5. Did the communities participate in choosing the suitable site for the construction of hand dug wells and spring developments?
6. How did you judge the knowledge of the communities in the selection of appropriate technology and suitable site for the water projects?

7. How much meter is this water project far from public institutions such as schools, health centers etc.?
8. By how much distance is this water point far from the river?
9. How did you measure the water yield of the spring and hand dug well?
10. In which season did you measure the yield?
11. In what ways did you measure the water yield of this scheme?
12. Did you make the water demand of the users before you construct this water point?
13. Why did you select this technology for this project?
14. How much liters of water does the community use per day?
15. Do you think that this water project is easily accessible by the users?
16. Does the community use this water project for other purpose (other than domestic purpose)?
17. How did you consider these needs during the designing phase?
18. Did your organization prepare design documents and BOQ for each water projects?
19. Did your institution give chance to the community in choosing feasible water points?
20. Did you get the necessary information from the community to decide whether the project is feasible or not.
21. In what ways did you approach to get this information?
22. What types of information did you get?
23. Did you think that this project was fully acceptable by the users?
24. How much money did you get per a water point?
25. What is the advantage to have this money?
26. How did you communicate with the community to contribute the O and M costs?
27. Did your organization make EIA for the whole water projects?

## APPENDIX C

**THE CONSTRUCTION OF RURAL WATER SUPPLY SCHEMES**.

**I .Points discussed with the communities or water committees.**

1. Do you have any contribution in the construction of this water projects? Yes or no.
2. If yes what type of contribution. a. Labor b. material c. food d. none.
3. Are you a member of water committee? Yes or no.
4. Who select you as a water committee?
5. When did you get the training? And by whom the training was given?
6. Did you get the training before the construction or at the time of construction?
7. How many days did it take to trainee?
8. Do you think that the training was important? Yes or no.
   If you say yes how you did implement during the construction of water points?
9. Did you follow the construction day to day? Yes or no.
   If not why?
10. How do you know the water yield for hand dug wells and springs?
11. Do you think that having large depth is enough to get the required amount of water? Yes or no.
12. What was your role to collect the spring eye and how did you know that the whole eye of the spring is collected or tapped?
13. Did you get any technical support during the construction in addition to the training that you have already achieved? Yes or no.

**II. Artisan's roles in the construction of rural water supply projects.**

14. When did you get your professional license?
15. For how many years did you participate in the construction of rural water supply projects?
16. For how many days (months) did you take the training? And by whom you get the training?
17. In what ways of tendering do you construct this project?
    a. Full type of tender (material and labor costs are by artesian).

b. Partial (only lobar cost is by artesian).

c. Negotiation between artesian and water office.

18. What are the advantages and disadvantages of these types?
19. How do you communicate with the communities to get the necessary materials (inputs)?
20. Did the communities contribute the necessary inputs in time? Yes or no

    If not what is the reason behind?
21. Did you get the full design document from the woreda water office? Yes or no

    If you say no how do you construct
22. Did you accomplish the water projects on time as much as possible?

## III. The roles of woreda water experts in the construction of rural water supply projects.

23. When did you start construction water points?
24. Why did you start in that time?
25. Is there any legal structure between your institution and communities during the construction period?
26. In what ways do you support communities and artisans to accomplish the project?
27. How did you manage the site preparation of a spring development to collect the whole eye of the spring?
28. Did you follow up while the spring eye is tapped (collected)?
29. Did you make contractor supervision during the installation of caisson rings for hand dug wells?
30. How did you prepare caisson rings for hand dug wells?
31. In what ways did you install the caisson rings?
32. Did you construct flood retaining wall or diversion ditches?
33. How many water points have this structure?
34. How did you arrange the filter materials for both spring development and hand dug wells?
35. What type of filter materials did you use for filtration purpose?
36. How many water supply schemes are protected by fence?

37. Which types of systems are more protected by fence?
38. Did you think that the whole scheme was finished on times? And why this is happened?
39. Is there any water point postponed for the next year? And how many are they?

## APPENDIX D

### FUNCTIONALITY AND SERVICE LEVEL OF WATER SUPPLY SCHEMES

**Points discussed with the water users on the functionality and service level of the schemes.**

40. What is your main source of water supply?
41. Is the water point functional?
42. For how low long has it been in operation?
43. For how long is the water point open every day?
44. How much is the volume of water a household is allowed to take? Do you have a restriction on water use?
45. What can you say about the quality and quantity of the water from this source?
46. Is the water sufficient for your daily activities?
47. What is the condition of water from the water points? (during dry season and wet season; presence of queuing up)
48. Where do you get water from when the scheme fails to work and there is a shortage of tap water? Does everyone have access to the water point?
49. . How far is the main source from your residence? (in time and distance)
50. How much time do you spend collecting water per day? (time spent at water point + time to travel – round-trip)
51. How many times do you fetch water per day?
52. What means of transportation do you use to transport the water?
53. Which members of the family are actively involved in fetching water?
54. How frequently you travel to fetch water per day? (dry and rainy season)