

**EVALUATION OF TECHNICAL
SUSTAINABILITY OF RURAL WATER SUPPLY
PROJECTS IN THE AMHARA REGIONAL STATE
CASE STUDY IN SOUTH WOLLO**



**THESIS SUBMITTED TO ADDIS ABABA UNIVERSITY
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Evaluation of technical sustainability of rural water supply schemes in the Amhara regional state case study in south Wollo.

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ABBREVIATIONS

CSA	Central Statistical Authority
MOWR	Ministry of Water Resources
MDGs	Millennium Development Goals
NGO	Nongovernmental organization
O&M	Operations and maintenance
RWSS	Rural water supply and sanitation
RWB	Regional Water Bureau
USAID	U.S. Agency for International Development
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
WHO	World Health Organization
WRC	Water Recourse commission
WSSP	Water Supply and Sanitation Programme

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ABSTRACT

The objective of this study is to evaluate the technical sustainability of rural water supply situation in South Wollo zone in the Amhara Regional State. The evaluation of water supply in selected rural areas is based on desk study of relevant literature and findings of the field assessment on the performance of the water supply systems

The study is carried out in two Woredas of south Wollo zone by visiting 29 water supply schemes. The three types of water supply technologies studied in the thesis are hand dug wells, spring development, and shallow borehole. Inadequate delivery of rural water supply system services, due to so many, difficulties are inhibiting the access of communities to basic Water Supply System infrastructure services. Existing facilities are often poorly constructed and insufficiently maintained, and do not adequately provide urgently needed basic services. The major problems, which are noticed in the sample water supply projects, are structural defects, quality, quantity, non reliability, inconvenience, too much user, lack of maintenance and repair, lack of trained person, attitudinal problem etc.

Among the numerous factors that contributed to the poor performance of the schemes, the two key reasons are technical and institutional problems. Poor facilities design, poor construction, and lack of provision for system management and operation and maintenance, Limited policy implementation, Lack of capacity to keep the system running after project completion, poor cooperation between the water agent and users, lack of involvement of the community in the planning and construction process have also compounded the problems

In the paper different kinds of water technologies suitable for small villages are discussed as options, by giving attention to VLOM Hand pumps and renewable energy IE solar and wind pumps.

The recommendations stress on the need for proper and routine O&M program, need of quality checking and control, importance of cooperation between different water supply implementing agencies, need for encouraging community involvement as the key to ensure project sustainability and reduction of costs, and on implementing systematic and decentralized management and monitoring system of water supply schemes at the village level.

1. INTRODUCTION

1.1 Back ground

Water evidently plays a very important role in the development of rural and urban areas. What ever the living standards may be, Supply of safe and adequate water supply dose not only reduce the numerous diseases caused and transmitted by polluted water but is very often the first step towards other development activities (MDGs).

Poor water supply continues to be a critical problem in rural areas of Ethiopia. Rural areas are usually small, dispersed, agricultural communities with population of 5,000 or fewer and with out the necessary economic, technical or institutional base to improve sustainable water supply (World Bank website).

A great deal of attention has recently been given to the question of sustaining rural services? (i.e. How to ensure, systems will continue to function and produce the intended benefits after project completion), and, how to improve services delivery. The discussion on sustainability of rural water supply project is very wide and the issue it encompasses will be multi dimensional. It deals with the technical, health, economical, Institutional, environmental, social and political issues (Jennifer and Travis, 2003).

In addition to constructing new water supply schemes, attention should be given to operation and maintenance of the existing schemes, in order to achieve the envisaged objectives. Substantial achievements will not be achieved unless the factors contributing to poor implementation of the old schemes are fully explored. Previous experiences should also be taken into account in the new schemes to avoid repetition of problems. In this context, great attention has to be paid to the fundamentals of sustainability, that is monitoring and evaluation (Issays, 1988).

Evaluation of impact is a longer-term activity. It is the process by which results of development projects are measured against their targets or objectives to see whether they have had the intended impacts or any undesired negative effects (Issays, 1988).

Amhara regional state is found in the highland of Ethiopia and it is one of the largest regions, in its area coverage and population size, in the country. The region has ten zones and 136 Woredas. About 90% of the population of Amhara regional state is estimated to be rural dwellers. According to the central statistical Authority (CSA), 2005 estimates

rural population of the region are 16, 925,000. The rural population access to safe water is very poor; it is around 23% (MoWR 2001).

In the region, there are 6231 functional, 1737 non-functional and the remaining 212 under construction water supply schemes in rural areas of the region. Functional schemes constitute 76.2% of the total water supply schemes available in rural areas of the region. Non-functional schemes are 21.2% of the total number of schemes. And the remaining is under construction. It can be seen that more than 21.2% of the total schemes are non-functional at any one time (Inventory of water supply schemes, 2003).

This is a serious issue to be taken into consideration for increasing the water supply coverage of the region. Increasing the rural water supply coverage is directly related to the functionality and non-functionality of the water supply schemes. Half of the Bore Holes and Hand dug wells are not functional in the region which implies that much work should be done to increase the capacities of each community on operation and maintenance (Inventory of water supply schemes, 2003).

Out of these zones, south Wollo is the one, which requires much emphasis due to highly vulnerability to drought. South Wollo zone has not yet enough public services such as health, education, water etc. Although many non-governmental organizations (NGOs) and donors got involved and did much works, the living standard of the people has not yet changed as expected. Recently, the Government, Donors and NGOs give much attention for the water sector as a precondition to achieve any development goals. Provision of clear drinking water is the first step towards other development, but priority should be given to assure the sustainability of the project (One of the millennium development goals). A fact clearly reflected is that, in South Wollo safe water supply system is poorly designed, inadequate in quantity, or poorly located, or both .The result being that people continue to use unsafe water and are exposed to a large variety of water borne diseases. Housewives and children spend most of their time daily in carrying a few litres of water from distant rivers and springs to their home.

The aim of this study is to assess the sustainability of the Rural Water Supply projects and to identify the cause and extent of failure of water supply schemes in terms of technical aspect (i.e. the physical system and their engineering aspects). This evaluation tells project planners and also other practitioners whether or not the approach for reliable and sustainable drinking water supply used in that particular case was successful and should be used else where or to look for remedial measures.

1.2 Area description

1.2.1. Demography, Geographical location and Climate

The population of South Wollo zone is about 2,429,344 of which 90% are rural dwellers, and is growing at an estimated annual growth rate of over 2.9% (CSA, 2003). The zone is characterized by unplanned expansion, with small and scattered settlements in different parts. This has burdened an already inadequate infrastructure and caused social and economical problems associated with insufficient water supply. Deficiencies in water supply services have resulted in social unrest. The administrative capital of south Wollo, Dessie is found about 400km North of Addis Ababa. South Wollo zone is at an elevation of 2150-2300 meters above mean sea level. According to the Ethiopian agro, climatic classification zone belongs to the Degas, Woinadega and Kola. The mean Annual rainfall is 1128mm with a variation of 20% of the mean. (See the geographical map of the study area Figure 1.1)

Kalu woreda is located in South Wollo Zone of the Amhara Regional state. The woreda capital is called Harbu and is located 45 km from Dessie. According to CSA data (Statistical Abstract, 2003), the woreda covers 38 Keble's including 35 rural and 3 urban. The data from the woreda indicates unprotected springs, rivers and ponds as the major sources of water for human and livestock consumption

Dessie Zuria woreda is located in South Wollo Zone of the Amhara Regional state. The woreda capital is called Titta and is located 12 km north of Dessie. The data from the woreda indicates unprotected springs, rivers, and ponds as the major sources of water for human and livestock consumption

1.2.2. Socio economic condition

Like any other rural woredas in the Amhara region, the study areas do not have the necessary economic, technical or institutional base. Farming is the backbone of the economy of the study woredas. It is estimated that 100% of the total income of the study area comes from agriculture. All the people derive their livelihood from this sector. The role of livestock in the study area is less important than that of crop farming. People in rural area get most of their cash income during the limited period of the year, which is at harvest time in the dry season.

1.3. Objectives of the study

General objective,

To assess and identify the problem of sustainability of rural water supply projects by focusing on technical aspects.

Specific objectives

- To give an overview of current data of rural water supply schemes.
- To evaluate the overall performance of the schemes.
- To identify the main problems related to sustainability issue.
- To propose a package for design criteria of trouble free operation and simple maintenance schemes.

1.4. Methodology and scope of the study

As it is not economically realistic to evaluate all existing schemes, it has been considered sufficient in a first step to evaluate selected rural water supply schemes. In order to conduct an evaluation that is as accurate and unbiased as possible, the study designs the systematic sampling method. This selection took place on two levels, woreda and scheme selection. The woreda selection was carried out based on climate, population size, accessibility of site, and data availability. The selected Woredas Kalu and Dessie zuria are the most densely populated from the other Woredas and have extreme climatic conditions that are Kola and Dega respectively. The selection of schemes was conducted on their accessibility of site and scheme types. The sample size 10% is chosen because of cost and time constraint. Twenty-nine different types of schemes were surveyed. The name and the location of the visited sites are presented in the digitized map of south Wollo zone in Appendix III.

As previously mentioned the technical sustainability evaluation was implemented across two Woredas of south Wollo zone namely, Kalu & Dessie zuria from June to July. The data were collected through interviews, questionnaires, discussion, and inspection. The questionnaire was designed to get much information on technical sustainability (the questioners are presented in Appendix I). All collected data with direct connection to technical aspect of sustainability of schemes are discussed below and presented in Appendix II.

The scope of rural water supply project sustainability evaluation is very wide. The issue it encompasses is many. It may look in to the technical, institutional, health, social and economical factors. In this study, only the technical factors will be discussed.

1.5. Challenge

- It was a big challenge to show the highlights of the study for the local officials. The fact that the study is an evaluation of achievement of schemes not an evaluation of them, made them open for the study.
- Frequently occurred that the communities of sample area were not willing to discuss with me because as they said, we have had lots of discussion with people from different organizations but no one changes the existing situation and tried to solve it.
- Evaluation task in rural area are often difficult. Here the big challenge is lack of data on design, construction, the magnitude, and the nature of drinking water source problems. Lack of information is possibly one of the main reasons why so far much of the schemes are unsustainable.
- Limitation of fund, lack of local transportation and inaccessibility of schemes are often serious problem confronted during the field visits.

Map of study area

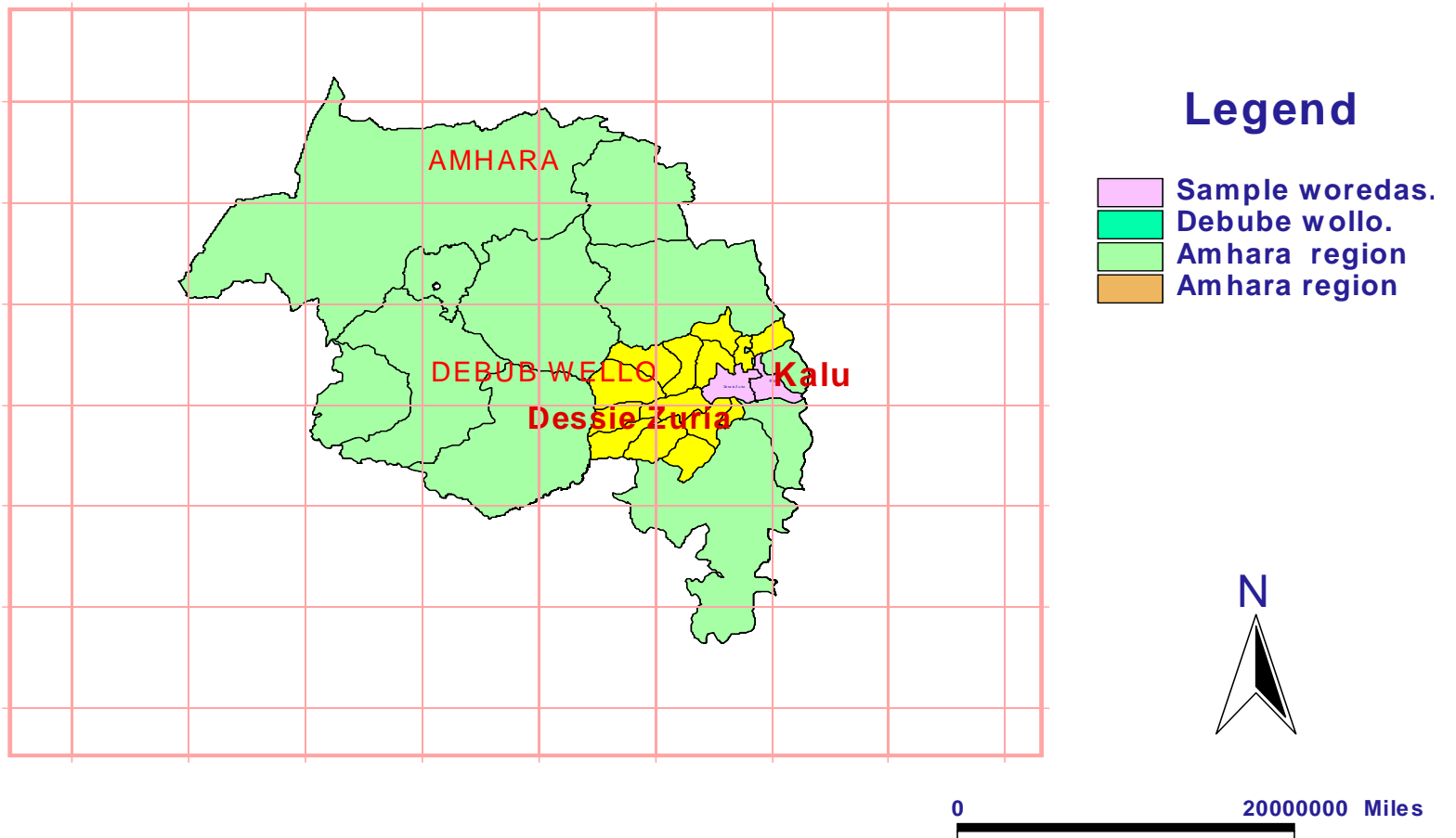


Figure 1.1: Map of the study area

2. OVERVIEW OF RURAL WATER SUPPLY SYSTEM

2.1 General

Rural water supply system (RWSS) provides potable water to rural communities for domestic uses (for example, drinking, cooking, bathing, and hygiene), and requires the supply of high-quality water on a continuous basis. In the rural area, families especially women spend a considerable amount of time trying to provide sufficient water for these uses. The potable water systems usually replace traditional sources of water, such as rivers, unprotected spring and open wells, which are often contaminated and distant from the household. Improved rural water solutions include a range of technologies from protected spring and wells equipped with manually operated hand pumps to more complex gravity-flow or pumped piped water systems connected to houses or public stand posts. The technical solution is location specific and will depend on a range of characteristics such as community demand, affordability, and willingness to pay, community size and household density, water resources and electricity availability, and topographical issues.

Various factors affect rural water supply systems. The first one is the technical factor. Technical factor of rural water supply systems include design and construction. To meet the objectives of the system, proper design and construction is required. For this, standard design and construction that can be slightly modified to meet local condition should be developed. It will help to ensure that the services to be provided are appropriate to the need and desire of the villagers. The second one is the management factor that includes operation, maintenance, cost recovery, community participation, and gender. These are the most important and vital parts to ensure sustainability of system. All these factors should be given much emphasis by water agency starting from the planning stage of project. Well-designed and constructed systems can not achieve the desired objectives, unless all the managerial factors are fulfilled. In this chapter, more important and common concerns are identified and briefly discussed.

2.2. Standard design parameter and specification of rural water supply schemes

2.2.1 SPRING

A spring is a place where groundwater naturally is released from the earth's surface. There are many different types of springs falling under two categories, according to the

condition under which water flows to them: gravity springs and artesian springs (Jo and Christine, 2002).

Gravity springs include depression springs, contact springs, and fracture or tubular springs. Depression springs occur when the land's surface dips below the level of the water table. Yield from depression springs is highly variable, depending on the level of the water table. In areas that experience a pronounced dry season, depression springs may not be a suitable source of drinking water if the water table drops below the level of the depression, causing the spring to become seasonally dry. Gravity contact springs occur when an impervious layer beneath the earth's surface restricts surface water infiltration. Water is channeled along the impervious layer until it eventually comes in contact with the earth's surface. This type of spring typically has a very high yield and makes a good source of drinking water. Fracture and tubular springs are formed when water is forced upwards through cracks and fissures in rocks. The discharge is often concentrated at one point, thereby facilitating the process of protecting the source (Jo and Christine, 2002).

Artesian springs occur when water under pressure is trapped between two impervious layers. Because the water in these springs is under pressure, flow is generally greater than that of gravity springs. Artesian fissure springs are similar to fracture and tubular springs, in that water reaches the surface through cracks and fissures in rocks. These springs make excellent community water sources because of their relatively high flow rates and single discharge points. Another type of artesian spring that can be developed as a high quality water source is the artesian flow spring. These occur when water confined between two impervious layers emerges at a lower elevation. Artesian flow springs often occur on hillsides, making protection an easy process (Jo and Christine, 2002).

2.2.1.1 Location of spring

It is easy for springs to become contaminated if they are located downstream from a source of contamination. For this reason, all sewage systems, livestock pastures, fuel tanks, and other sources of pollution must be located at least 30 m away from springs. However, depending on the soils, geology, and slope of the land, an even greater distance may be needed. Also avoid extremely wet areas when locating a new spring, because saturated soil can't filter out bacteria (Morgan, 1990).

It is also necessary to determine the reliability, quality, and the average/minimum flow of the spring. Ask the local residents of the history of the spring. Determine if the spring is seasonal or if it is constant year round (Will Hart, 2003).

2.2.1.2 Spring water quality

To the best ability, determine the quality of the spring water. If no equipment exists, try to observe physical characteristics such as smell and turbidity. If there is a strong odor, or the water is very turbid (has a lot of suspended sediment), it probably warrants additional treatment than the standard spring water, such as settling, filtering, and disinfecting. If there are no negative physical observations, make a judgment based on the survey of the area. One of the key sign of good springs is that the water maintains a constant temperature and the water should also be colorless (Jo and Christine, 2002).

2.2.1.3 Spring water quantity

The quantity of water a spring produces is known as its yield. Information about the yield is crucial in the decision making process for the tapping of a spring. A yield is expressed in terms of flow rate and consistency. Reasonably minimum flow of 0.11 liter/sec spring yield is acceptable as the WHO standard daily consumption of 15 lit/day /cap for 200 rural people.

The most important criterion to determine whether the spring is a suitable source is

$$\frac{\text{Spring yield in the rainy season}}{\text{Spring yield in the dry season}} = 3 \text{ to } 5 \text{ for a good Spring}$$

In general, if this ratio is below 20, the spring has an acceptable consistency and can be regarded as a reliable source in both wet and dry seasons. The springs intended to feed a water supply should be gauged before construction starts, for at least one year and if tested over a longer period. Perennial springs flow throughout the year, often with little or no decrease in yield. The yield of spring varies from very small amount of around 0.11 lit/sec up to very large flow of over 10 lit/sec (IRC, 1998).

2.2.1.4 Spring Water Protection

The main objective of spring development and protection is to provide improved water quantity and quality for human consumption. Before reaching the surface, spring water is generally considered high quality, depending on the composition of the surrounding soils and bedrock. However, groundwater can become contaminated as it

exits the ground's surface. Contamination sources include livestock, wildlife, crop fields, forestry activities, septic systems and fuel tanks located upslope from the spring outlet. Therefore, spring water sources need to be protected at the source or eye. Just as there are many types of springs, there are also many different kinds of protective structures, such as spring boxes, seepage spring development structures, and horizontal wells. However, spring boxes are typically cheaper, require the least skill, and can be made with locally available materials. In contrast to the generally held belief that discharges decline if the springs are touched, the development of natural springs often leads to improved yields (Will Hart, 2003).

2.2.1.5 Basic Design Features

Although there are many different designs for spring boxes, they all share common features. Primarily, a spring box is a watertight collection box constructed of concrete, clay, or brick with one permeable side. The idea behind the spring box is to isolate spring water from surface contaminants such as rainwater or surface runoff. All spring boxes should be designed with (Morgan, 1990).

- A heavy removable cover, in order to prevent contamination from rainwater while providing access for disinfection and maintenance.
- An overflow pipe that is screened for mosquito and small animal control. It is also important to provide some measure of erosion prevention at the overflow pipe.
- Approximately 8 meters upslope from the spring box, to provide a diversion ditch capable of diverting surface runoff away from the spring box, and
- An animal fence with a radius of at least 8 meters around the spring box. This protects the water source from livestock and wildlife contamination, as well as from soil compaction that could lead to reduced yields.

There are two basic spring box designs that could be modified to meet local conditions and requirements. The first is a spring box with a single permeable side for hillside collection, and the second design has a pervious bottom for collecting water flowing from a single opening on level ground (See Figures 2.1 and 2.2). The spring box with an open bottom is typically simpler and cheaper to construct because less digging and fewer materials are required.

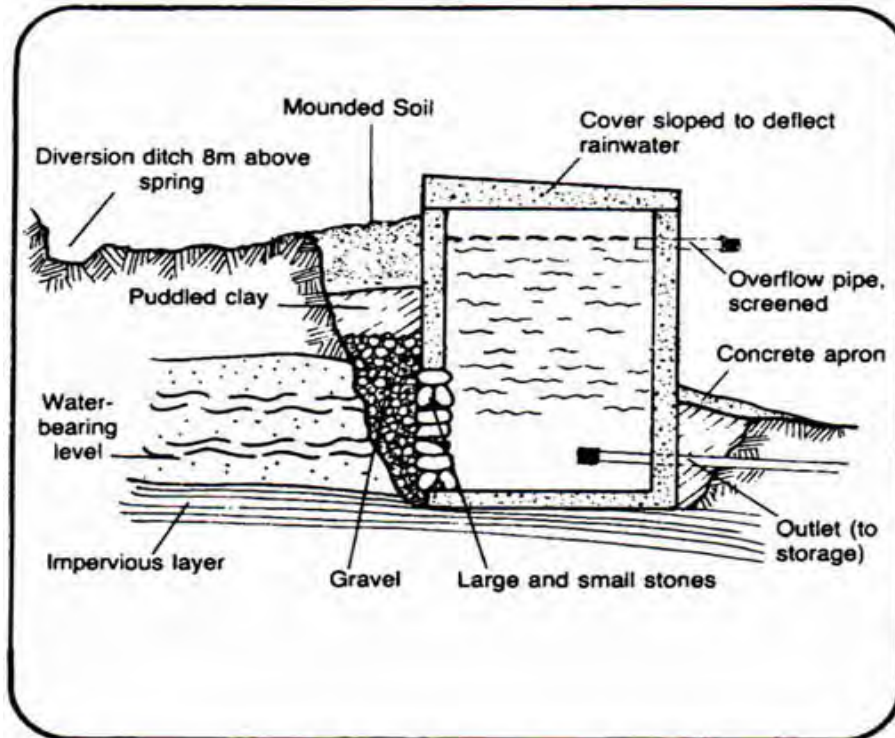


Figure 2.1: Spring box with single pervious side for hillside Collection
(Courtesy of US AID, 1982, available on line at WWW.lifewater.org)

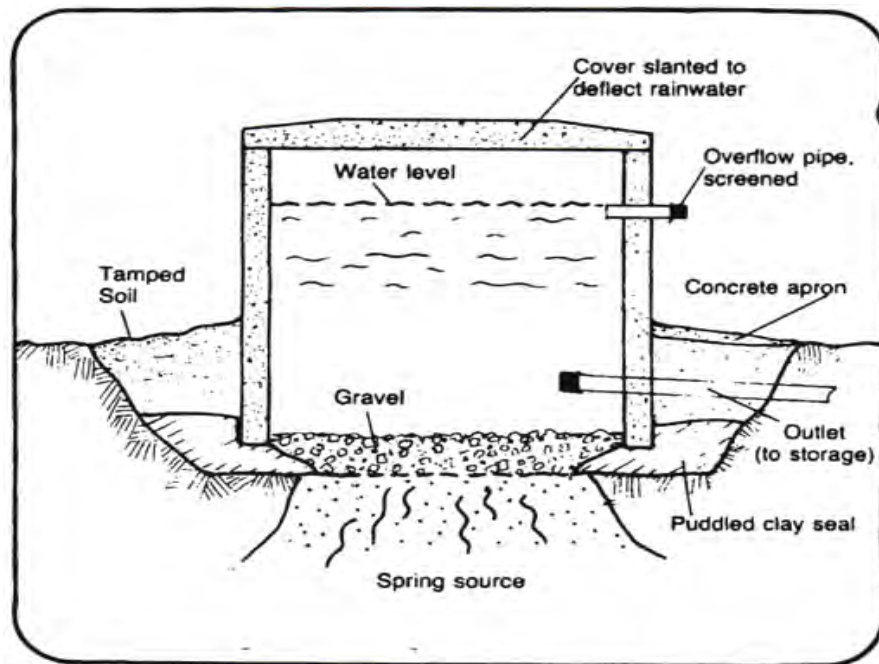


Figure 2.2: Spring box with permeable bottom for collecting spring water flowing from an opening on level ground (courtesy of US AID, 1982, available on line at WWW.lifewater.org).

If concrete is unavailable or if its use is prohibitive due to cost, the spring box could be constructed using locally available materials, such as brick. This alternative is especially useful when protecting a single-source spring on level ground. If location and transportation are not prohibitive, large prefabricated concrete tubes can be used much like brick and cement spring boxes (Will Hart, 2003).

2.2.1.6 Designing the Structure

Because each spring site is unique and every community has individual water supply needs, there is not a particular spring box design that will fit all circumstances. It is up to the project manager and the community to decide what will work best depending on local conditions. For instance, if the spring is located at a higher elevation than the distribution area and the distance is not too great, it may be preferable to design a spring box that is large enough to also act as a storage structure large enough to supply the entire community, thereby eliminating the need to construct additional water storage tanks. It is also possible to design a spring box with a built in sedimentation tank if the source has high sediment loads.

The design chosen for any particular project will depend on local conditions, spring yield, available materials and community knowledge and requirements. The goal of the design process is to generate a dimensional plan of the spring box. (Will Hart, 2003).

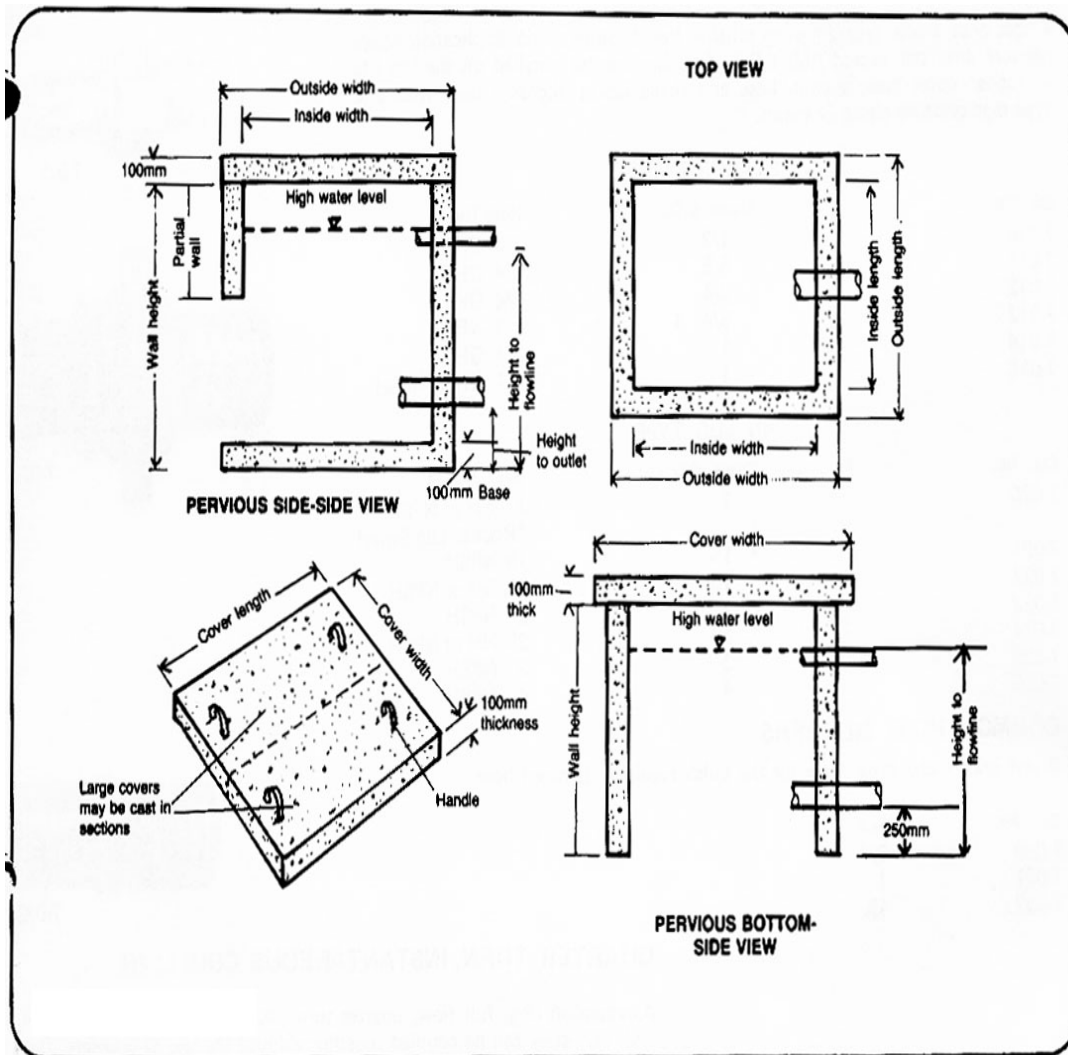


Figure 2.3: Dimensional plans of pervious side spring box and pervious bottom spring box (courtesy of US AID, 1982, available on line at WWW.lifewater.org).

2.2.1.7 Preparing the Site

The site should be fenced off to protect the site from animals, and a diversion ditch needs to be dug approximately eight meters upslope from the site to divert surface water runoff away from the spring. Next, dig out the spring until the flow is concentrated from a single source. If the spring is located in a hillside, it may be necessary to dig into the hillside far enough to locate the eye of the spring. Look to see if flow from major openings increases, or if flow from minor openings decrease or stop. These are signs that the flow is becoming concentrated from a single eye. Remember that the objective is to collect as much water as possible from the spring

and that it is generally easier to collect from a single opening than from many. If a single flow source cannot be located because of numerous, separated openings, it will probably be necessary to construct a seep collection system rather than a spring box. Depending on the terrain of the site, it may be necessary to dig a temporary diversion ditch to drain spring water from the excavation site (Will Hart, 2003).

Once a single eye is located, dig down until you reach an impervious soil layer. This will make a good, waterproof foundation for the spring box. Before installing the spring box, pile stones and gravel against the spring. This will provide some capacity for sedimentation and will prevent erosion from around the spring eye. This will also support the impervious section of the back wall of a pervious-side spring box (see Figure 2.1). If the spring is flowing from a single opening on level ground (pervious-bottom spring box), dig a basin around the spring eye until an impervious layer is reached. Line this basin with rocks and gravel, making sure to cover the spring eye so that water flows through the gravel before entering the spring box (see Figure 2.2) (Will Hart, 2003).

2.2.1.8 Constructing the Spring Box

Concrete construction requires that the concrete remain moist for at least seven days. Spring box construction should be done at the peak of the dry season, thereby ensuring that only the most reliable springs is protected. However, it is often necessary to excavate the spring before construction is made in order to determine the type of spring to be protected and the proper design to implement.

To minimize the possibility of contamination, it is important that the spring box be installed on a solid, impermeable base, and that a seal is created between the ground and the spring box so that outside water is unable to infiltrate the box. Place the box so that the permeable section of the spring box collects the flow of the spring. When installing a hillside collection box, make sure that gravel and stones are piled at the back of the box to provide support for the structure while allowing water to enter the box (see Figure 2.1). Next, create a seal with concrete or puddle clay, a mixture of clay and water, where the spring box comes into contact with the ground. This will ensure that water does not seep in under the box. For hillside spring boxes, backfill the area where the spring enters the box with gravel to the height where the permeable wall ends and the concrete wall begins. Place layers of puddle clay or concrete over the gravel backfill and sloping away from the spring box to divert surface water away from the water source (see Figure 2.1), and then backfill with firmly tamped soil. If puddle clay or concrete is unavailable, soil alone may be used, although it should be at

least 2 meters deep to prevent contaminated surface water from reaching the water source. For a level-ground spring box, puddle clay or cement should be placed around the spring box, sloping away from the water source to prevent infiltration (Will Hart, 2003).

Install the outflow, and overflow pipes. Seal around the pipes on both sides of the wall to prevent leaks, and secure screening over the pipe openings. Make sure the screen size is small enough to prevent mosquito infestation, yet strong enough to prevent small animals, and of a material durable enough to last a long time. Copper or plastic screening works best.

Before completely backfilling the spring box, disinfect the inside of the box and the cover with a chlorine solution and close the box. Remember that all backfill should slope away from the spring box to maximize runoff away from the box (Will Hart, 2003).

2.2.1.9. Maintenance

If properly installed, spring boxes require very little maintenance, however, it is recommended that the water quality be checked before being put into use, as well as on a yearly basis or as needed. It is also a good idea to check that the uphill diversion ditch is adequately diverting surface runoff away from the spring box and is not eroding. One maintenance item that is frequently overlooked is to ensure that the animal fence is in good repair. Although some grazing area may be lost, the loss in grazing area is preferable to a contaminated water source or compacted soil that could lead to decreased flow rates. For hillside collection boxes, it is important to check that the uphill wall is not eroding and is maintaining structural integrity. The cover should be checked frequently to ensure that it is in place and appears to be watertight. Make sure that water isn't seeping out from the sides or from underneath the spring box, and check that the screening is in place on the overflow pipe. Once a year, disinfect the system and remove sediment from the spring box. To do so, open the valve on the outlet pipe, allowing the spring box to drain. Remove any accumulated sediment from the box and wash the interior walls with a chlorine solution. The solution for washing the spring box should be mixed in a ratio of 10 L water with 0.2 L chlorine bleach (Will Hart, 2003).

2.2.2. Hand dug well

Digging a well by hand is the most widely used method of well construction in many rural areas of the world. Using simple construction techniques and suitable material, hand-dug wells can provide reliable amount of water (IRC, 1987).

A hand dug well can be divided into three parts: intake, shaft, and wellhead (See Figure 2.4.). The intake is the bottom section of the well that taps into the aquifer, supports the exposed section of the aquifer, and permits water to flow in while preventing solids from entering into the well. In stable geological formations (e.g. in sandstone or fissured rock), it is possible to eliminate this component, but in conditions where the aquifer is made of sand or gravel it is necessary for the functioning of the well (Watt and Wood 2001). The shaft is the middle section of the well. The lining of the shaft serves to retain the well walls in place, prevents inflow of potentially contaminated water near the surface, and provides a foundation for the wellhead. Even if a well is sunk into self-supporting rock, the top few meters should be lined and made watertight to avoid the risk of collapse at the top of the well. The intake is sometimes built telescoped and “floating” inside the shaft lining in order to prevent cracking or collapse of the shaft lining if the intake settles. The wellhead is the top section of the well, which seals the well and prevents foreign objects from entering the well (Watt and Wood 2001).

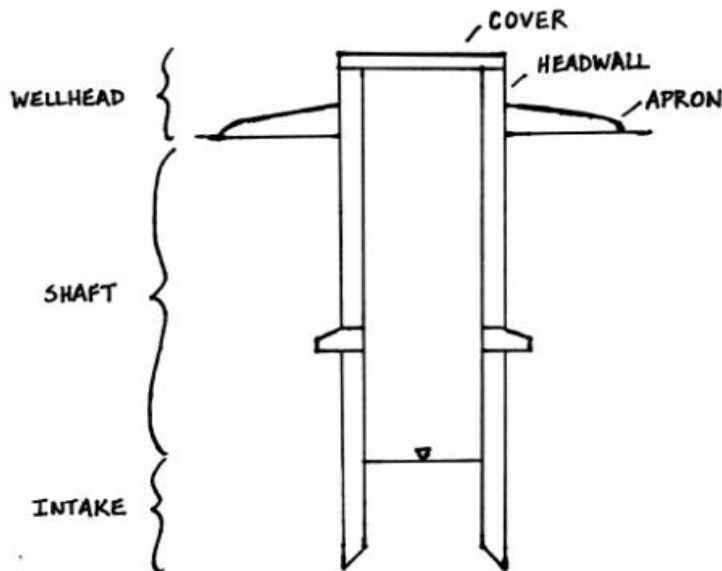


Figure 2.4: Diagram of Hand Dug Well (Watt and Wood, 2001).

2.2.2.1. Design of hand dug well

Proper design of hand-dug wells is important to assure a year round supply of water and efficient use. Designing involves determining the size, and the shape of the well; the method of lining and; the type of the intake; and the necessary personnel, material and equipment, and tools. There are several good methods of designing and constructing hand dug wells (Watt and Wood, 2001).

Size and shape

The size of the well refers to its depth and diameter. Although it is impossible to know the depth of the well before it is dug, an attempt should be made to estimate it. This will allow you to roughly calculate the quantities of materials needed for construction. Use information from the taste holes or existing wells in the area to estimate the depth of the water table (Watt & Wood, 2001).

Shape

Although wells can be dug in any shape, almost all wells are circular in shapes. The reason for this is that a round well produces the greatest amount of water for the least amount of work. In addition, a round lining is the strongest that can be built for the smallest quantity of material (Watt & Wood, 2001).

Diameter

For practical and economic reasons, well diameters are between 1.0m and 1.5m. The smaller diameter results in a savings in materials costs, and it requires less soil to be excavated the larger diameter means a higher materials cost but a more efficient work output, since two men rather than One can dig the shaft. A larger diameter provides a greater storage capacity and allows more water to enter the well. All these arguments favor 1.3 meters as the finished diameters (Watt & Wood, 2001).

Depth

The depths to which the well can be dug largely depend on the type of ground and the fluctuations of the ground water table. Important factor are the stability of the ground and the cost of digging. Dug well for communal use are frequently much deeper, 20-30m is usual and depths of 50m and more have been achieved (IRC, 1987).

Lining

With the exception of wells sunk in consolidated rock, a lining of permanent material is always necessary. This lining serves several purposes. It is protection during construction against caving and collapse, it retains the wall after completion, and it acts as a seal to prevent polluted surface water from entering to the well. There are many materials suitable for linings masonry, brickwork, and steel. All being in various

part of the world, according to circumstances; but for wide spread use there are great advantages in plain or in reinforced concrete. At least the upper 3m should be made waterproof by lining to prevent seepage from the surface layers, which most likely carry dangerous contaminant and the lining, should be built up 0.5 meters above ground level. A concrete apron should then be constructed on the ground surface extending about 2 meters all around the well. The space between the walls of the dug hole and the lining should be sealed with pebble clay or better with cement grout. The bottom of the well is stabilized with a layer of about 200mm of coarse gravel (Watt & Wood, 2001).

Although various materials have been used to line well shafts, concrete is the best and most common lining. It is strong, long lasting, and widely known. The lining is usually 75mm thick and the caisson rings are 125-150mm thick. The outside diameter of the rings is 50-100mm less than the inside diameter of the well to allow the rings to freely move downward.

The caisson rings are sunk into the aquifer as far as possible; that is, until the water becomes too deep to continue the excavation. Ground water may then enter the well either through the opening under the lowest caisson ring, or through the rings themselves. In the first case, the rings are made of standard concrete, which does not allow entry of water. In the second case, the rings are usually made of porous concrete, which allows water to pass through. Another way to allow water to enter through the caisson rings is to build the rings from standard concrete and perforate them with seepage holes. For all types of intakes, the bottom of the shaft should be covered with a porous base plug made from porous concrete or layers of sand and gravel. The plug prevents aquifer material from rising into the well. The type of caisson ring used depends on the nature of the aquifer. Normally, rings are made of porous concrete. However, if the aquifer is composed of fine sand, which would clog the pores or flow through the seepage holes, the rings should be made of standard concrete with out perforations (Watt & Wood, 2001).

2.2.2.2. Construction of hand dug well

Proper construction of hand dug well is important to ensure a year round supply of water and to protect the water from contamination. Construction involves assembling all necessary personnel, materials, and tool; preparing the site; excavating the well shaft; and lining the shaft.

Outlined below are the major steps involved in constructing a well. The appropriate community leaders, health committee, public works committee, and others who are interested should be involved in all the planning decisions (Watt & Wood, 2001).

- Dig and line the bottom section as far as possible into the aquifer. The method used to dig and line the bottom section will often be different from the digging and lining method used in the middle section. This may be necessary because you are not only concerned with digging, lining, and possible hole collapse (as in the middle section), but also with removing enough water from the well to permit work to continue.
- Install a simple sand and gravel filter or porous concrete plug across the bottom of hole.
- Extend the lining up 0.5 meters above ground to form the head wall.
- Build and install the well cover.
- Provide a manhole that can be tightly and securely locked to allow disinfections.
- Install the pump in the cover on the well.
- Disinfect the well.
- Build the apron (platform) around the head wall to channel the run-off to one particular place.
- Build a drainage pit or other device for removal of standing water.
- Build an animal trough. *
- Build a washbasin platform. *
- Hand dug well should be dug during the dry season. Ground water table fluctuate seasonally and may drop considerably at the end of long dry season. This is why it is preferable to sink a dug wells at the end of the dry season when the ground water table is low (Watt & Wood, 2001).

* These items are not always necessary but should be considered.

2.2.3. Borehole

Poorly designed and constructed well will quickly become expensive to maintain and eventually unstable, possibly even collapse. In order to design a bore hole a general understanding of water occurrence and movement through rocks (science of hydrogeology) is important. Also, the selection of the most appropriate equipment is an important process that should be care fully considered and continuously reviewed (IRC, 1987).

2.2.3.1. Borehole site

The choice of well site will affect the safety and performance of your borehole when one examines various sites for borehole he has to ensure that (IRC, 1998).

- The site is accessible
- The ground surrounding the borehole is sloped away from the well to prevent any surface run off from collecting or poundings
- The borehole is upslope and far from possible potential contamination sources.

2.2.3.2. Depth of borehole

The drilling depth has to be decided by the hydrologist on site. Too shallow a borehole may give an inadequate yield and it may have to seasonal fluctuations in water level. Too deep a borehole is expensive (i.e. cost is directly related to borehole depth) and will take longer time to drill. Therefore, a compromise needs to be found; drilling as deep as necessary is one of the important features of low cost borehole. In general, borehole can be shallow borehole drilled with machine drilling up to 60 m or deep well 200m or deeper depending on the method of drilling used (Jo and Christine, 2002).

2.2.3.3. Borehole diameter

The completion diameter of a borehole should be optimized taking in to account the anticipated yield, the obstruction requirement, the drilling methodology, and the type of pumping equipment to be used (Jo and Christine, 2002).

2.2.3.4. Casing

Well casing, also called riser pipe serve both as housing for the pumping equipment and as a vertical conduit for the water pumped from the aquifer. Although the well casing generally extends from the intake portion of the borehole up to the land surface, the lower portion of a borehole may be left uncased when the well is completed in competent bedrock (Jo and Christine, 2002).

Casing Installation (Michael & jay, 1973)

Casings may serve the following purposes:

- To protect the borehole wall from caving,
- To protect surface water from entering into the well and to seal out undesired groundwater,
- To protect the pump from damage.

The quality and standard of casing materials have to be assured or be accepted or should fulfill the standards set by internationally recognized institutions like API

(American Petroleum Institute), ASTM (American Society for Testing Materials) etc. For deeper wells, casings that have thick walls and wider threads are proposed.

There are different types of casings that are available in the market. Among the different type of casings mild steel, stain less steel and Poly Venile Chloride (PVC) casings are commonly used for water well drilling. Non-metallic materials should be used where corrosion or encrustation by irons bacteria is a problem.

Casing diameters (Filetcher, 1986)

When selecting the diameter of the casing the following points have to be taken into account:

- It should be able to accommodate the pump and the attached electric cables,
- The diameter has to be large enough to entertain the up-hole velocity of the water, which should be 1.5 meter per second or less. If the up-hole velocity is greater, excessive head loss will occur.

2.2.3.5. Screen Designs

A single factor with great influence on efficient performance of a well is the design and construction of the well screen. A properly designed screen combines a high percentage of open area for relatively unobstructed flow in to the well with sufficient screen strength to resist the force to which the screen may be subjected both during and after installation in the well (Filetcher, 1986).Screens provide the same service as casing in supporting the formation. Besides, they act as a filtering media in preventing sediment from entering into the well.

Types of screen

There are different types of screens. Continues slots, v-shaped slots and continues wire slot types etc. are the common ones. Continuous slots are widely used for urban water supplies and the like but their cost is too expensive to be used for rural water supply. V-shaped slots that are narrowest at the outer face have the capacity to reduce clogging (Filetcher, 1986).

Length of the Screen

The length of a screen in a given well determined by the aquifer thickness and the nature of stratification, its position and the available draw down during pumping. Since there is difference in the hydraulic conductivity and porosity of aquifers, it is advisable to distinguish these zones properly and to set the screen at the highly

permeable and porous zone of the subsurface formation. This can be achieved by closely examining the driller log, formation sampling, and logging and by performing borehole geophysics. Generally, 80-90 percent of the thickness of the aquifer should be screened (Fletcher, 1986).

Diameter of screen

The diameter of screen is determined according to the required percentage open area. There have to be enough screen openings that allow the water to flow into the well smoothly. In order to reduce turbulence flow that result in excessive draw down and incrustation, the screen diameter should be sufficient enough that adequate open area is available. Thus, the entrance velocity (which is the ratio of expected yield and the total open area) of the water should not be greater than 0.03 m/sec. The reason for this limitation of the entrance velocity is to minimize friction losses and to avoid the formation (creation) of corrosion and incrustation (Fletcher, 1986).

Percentage of open area

The percentage open area of a screen is designed in a manner that it allows minimizing well loss as much as possible. It is a common practice to design an open area between 15 to 20%. However, it is possible to increase the open area by taking into account the diameter of the screen, its quality and the intended purpose of the well (Filetcher, 1986).

The required size of screen openings will depend on the grain size distribution of the aquifer, the degree of well development and on the presence of the filter pack. Limited open area hinders well development and then facilitates higher draw down and finally may result in higher pumping costs.

2. 2.3.6 Gravel Pack

It is applied to maintain good quality of groundwater by replacing some of the formations immediately around the screen with a clean rounded and more permeable specially graded material. Moreover, to support the borehole wall it is a custom to put selected gravel between the annular space of the borehole wall and the screen. However, it may not be necessary to apply artificial gravel packing in every well.

Typical geological formations that favor artificial gravel packing are formations that contain unconsolidated finer materials, semi consolidated and friable formations, and loosely cemented and extensively laminated formations. Thus, the nature of the

subsurface formation and the design of the screen are the governing factors during applying gravel packing.

If gravel packing decided to be applied, the design of the well diameter has to be prepared in a manner it can accommodate the thickness of the gravel that is mostly 15 to 25cm. The gravel is usually packed about three meters above the top part of the screen. The annular space above the gravel pack is mostly filled with sand, cement and selected back fill.

The selection of the grading of gravel pack material is usually based on the layer of finest material in an aquifer. The gravel pack material should be :

- Its 70 percent size is 4 to 6 times the 70 percent size of the material in the finest layer of the aquifer, and
- Its uniformity coefficient is less than 2.5 and the smaller the better (Gibson & Stinger, 1969).

2.2.3.7. Well Development

The purpose of well development is to remove the mud cake and then to obtain smooth groundwater flow from the formation into the well. Another objective of well development is to change the physical characteristic of the aquifer by removing the drilling mud and thereby enable the groundwater to flow as freely as possible into the well (Filetcher, 1986).

2.2.3.8. Pumping Test

Conducting pumping test is performed after the drilling and related works are completed. However, the main purpose of pumping test operation is to have the following information:

- To determine the performance and efficiency of the well,
- To determine the hydraulic parameters of the aquifer, And then to understand more about:
 - The performance and efficiency of the well and the aquifer,
 - The sustainable abstraction rate, and
 - Water quality condition.(Fletcher, 1986).

2.2.3.9. Grouting / Sanitary Seal

In order to protect the surface pollution, grouting the annular space between the borehole wall and the top part of the casing that is located above the screen is a common practice. For grouting, the main components are cement and water. The ratio between these two components usually is 5 to 6 gallon of water to a 94-lb sack of Portland cement (Filetcher, 1986).

2.2.3.10. Well Head Construction

The wellhead has to be designed in a manner that it can be used as part of the pump house in most cases. During wellhead construction, the casing has to protrude above the ground surface say 30 to 80 cm depending on the local hydro geological condition in order to avoid surface water from entering into the aquifer.

Direct contact between the outer part of the casing and the concrete should be avoided. Leaving space between them is required in order to avoid the damage of casing by the concrete due to thermal expansion (Gibson & Stinger, 1969).

2.2.3.11. Sealing the Well Head

In order to protect external materials from falling into the well the top of the well has to be secured either by welding or by using nut and bolt until the permanent pump installed (Gibson & Stinger, 1969).

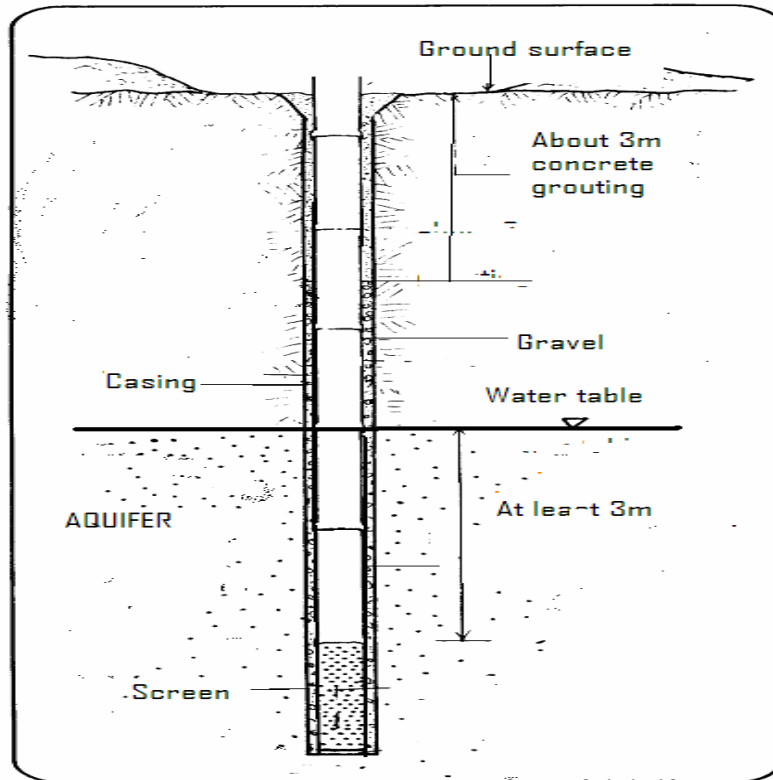


Figure 2.5 Typical Bore hole diagram (Water aid paper)

2.2.4. Water lifting / lifting device

In rural areas, some village may be situated in the ways that enable them to obtain their water supplies entirely by gravity. This is a big advantage and should always be considered first when investigations for water supply start. It can be said that it is always safer to construct a water supply, which works by gravity if this is possible, than which requires pumping. The gravity system needs less maintenance and keeps the running cost low. The running cost and maintenance for pumps can be considerably high for community, which is financially weak. Nevertheless, in certain cases it is inevitable to install pumps to obtain the necessary water.

2.2.4.1 Types of pump

A wide rang of pump type is available on the market. Prevailing local conditions and management capacities determine the type that is most suitable and sustainable. Pumps commonly used in domestic water systems can be classified as centrifugal, positive displacement (piston) and impulse (ram) the type of pump chosen depends on the

volume of water required, pumping head, and type of power available. Pumps can be divided in to two categories based on their power sources (Getenet, 2001).

Category 1

Pumps, which can be powered by animal, human, wind or water, these pumps usually, produced low volume of water at or near the source. They include bucket, positive displacement, and impulse pumps.

Category 2

Pumps, which are usually, powered by electric motor or external compunction motor. These pumps include single stage suction, jet, submersible and line shaft turbines. They produces medium to high quantity of water compared to category 1 pumps. The positive displacement pump mentioned in category 1 could be power driven to produce high quantity of water.

The simplest pumps of all are those operated by human power. In this category come a range of hand pumps and foot pumps. They are capable of lifting relatively small amount of water. Using human power for pumping water has important benefits for small community in developing countries (Getenet, 2001):

- The power requirements can be met with in the users group.
- The capital cost is generally low
- The discharge capacity of one or more manual-pumping device is usually adequate to meet the domestic water requirements of small community.

2.2.4.2 Hand pump

Hand operated pump can be used in wells of any depth. Most hand pumps installation Practical limit of depth ranging up to 45meteres.While very few of them can be used up to 100 meters and also hand pumps can be installed in large diameter hand dug well or tube well. Volume of water that can be pumped from a well varies depending on the pump model, depth of pump setting and strength of users (Getenet, 2001).

Hand pumps generally categorized as suction pump and deep well lift pump. In both types the piston valve are connected to the handle with pump rod.

1. Suction pump

Suction pump is a water pump whose cylinder assembly is installed on the concrete slab cover of the well. This pump should always be primed by filling the pump cylinder with water. Priming help to wet the piston (plunger) and the valve until water comes through column pipe. This pump is very cheap and normally suitable for shallow well of up to 7 m in depth only.

2. Deep well lift pump.

Deep well lift pump's cylinder assembly is installed at the bottom of well, submerged in water. The piston is connected to ground surface by steel or wooden rods. Since the cylinder assembly is deepened in the water it does not need priming during operation.

Table 2.1. Information on types of pump (water Aid)

No	Description	Pump type	Pump setting depth	Suitability for various diameter well
1	Indian mark II	VLOM type reciprocating design	With minor modification, up to 90 meters.	Suitable but with modification in large diameters
2	Indian mark III	VLOM type reciprocating design	Up to 45 meters	Suitable but with modification in large diameters
3	Afradev	VLOM type reciprocating design	Up to 45 meters	Suitable but with modification in large diameters
4	Aquadev	VLOM type reciprocating design	Up to 45 meters	Suitable but with modification in large diameters

2.2.4.3. Hand pump selection

Water pumps are designed and provided by many manufacturers using different specifications for different purposes. To select suitable type of hand pump specific water sources dug well or deep well data should be known. This specific data of the well obtained after completion of well construction. The well specific data mainly consists of well diameter, type of casing installed, well depth, static water level, operational water level, maximum water yielding capacity, position of well screen, quality of water etc...

In all cases, Afridev hand pumps are recommended for the following depth:

- Less than 15 m: Afridev Kabul
- 15 - 45 m: Afridev Indus
- 45 m - 60 m: Afridev Pamir

2.2.4.4. Operating and maintaining pump

Proper operation and maintenance of pumping equipment is an essential part of managing a water system failure to provide timely maintenance, including making minor repairs before they become major, which is a primary cause of system failure. Operation and maintenance normally includes the following activities for all types of pumping systems (World Bank, 1990):

- Keep equipment and pump house clean and painted to prevent rust or weathering.
- Keep equipment lubricated.
- Tightening nuts and bolt.
- Recognize potential mechanical problems and make adjustments before failure occurs.
- Replace failing or filed parts of equipment.
- Keep buildings, including doors and windows in good operating condition.

2.2.5. Public stand post

The layout of the scheme and the sitting of the stand posts is one of the most important aspects in the design of a public stand post water supply system. In general, stand post should be located as near to as many houses as possible, easily accessible to all users, but protected from contamination sources. The walking distance to the farthest dwelling should preferably not exceed 200m.

A stand post consists of platform with a drainage facility a supporting structure for the pipe and taps, a stand for buckets, the services pipes with valves and meter (optional). The platform should be extended for at least 1.0m around the tap(s) and be constructed of hard and impermeable materials, preferably concrete or masonry. It should be raised at least 0.1m above the ground to ensure good drainage and slope away from the taps to wards a drainage channel. Alternatively, the platform may slope in wards; the wastewater is then collected in a gutter underneath the taps and is discharged in to the drain. If possible, the wastewater should be put to some use, for instance; irrigation and cattle watering. It may also be led through an open channel to a watercourse (WHO, 1979).

The slope of both platform and drainage channels should be in range of 1:50(2%) to 1:20 (5%). the minimum dimension of the gutter is 0.2m wide and 0.05m deep at the beginning of the drain.

The supporting structure and the attachment of the taps should be solidly constructed .The best way to protect the pipe is encase it a brick or concrete column of at least 0.3m square. To protect the taps, the supporting structure should extend 0.1m above them. Underneath the taps a raised stand can be constructed to support buckets and containers whilst being filled. The height of the stand, and of the taps themselves, is determined by the size of the container used, the manner carrying them, and the question of whether children as well as adults will fetch water, the distance between the tap and the top of the container should be less than 0.5m in order to reduce spillage of water.

The stand post should be surrounded by a wall or fence with a locking gate for protection during unsupervised houses.

The maximum walking distance

In general, it is advisable to limit the walking distance to 200m and in densely populated areas. It is often possible to limit the distance to 100m.in very sparsely populated areas a walking distance of up to 500m may some times acceptable .in densely populated areas, however, the application of this criterion may result into many users per stand post and per tap. Therefore, a second criterion that relates to the population density in t a particular area is required (WHO, 1979).

The maximum number of users per stand post

It is advisable to limit the number of users per stand post to 100-250. In no cases should this number exceed 500. The number of users per taps should preferably be in the range of 25-125. This criterion is directly related to the maximum discharge capacity of the taps and to the water collection patter during peak hour (WHO, 1979).

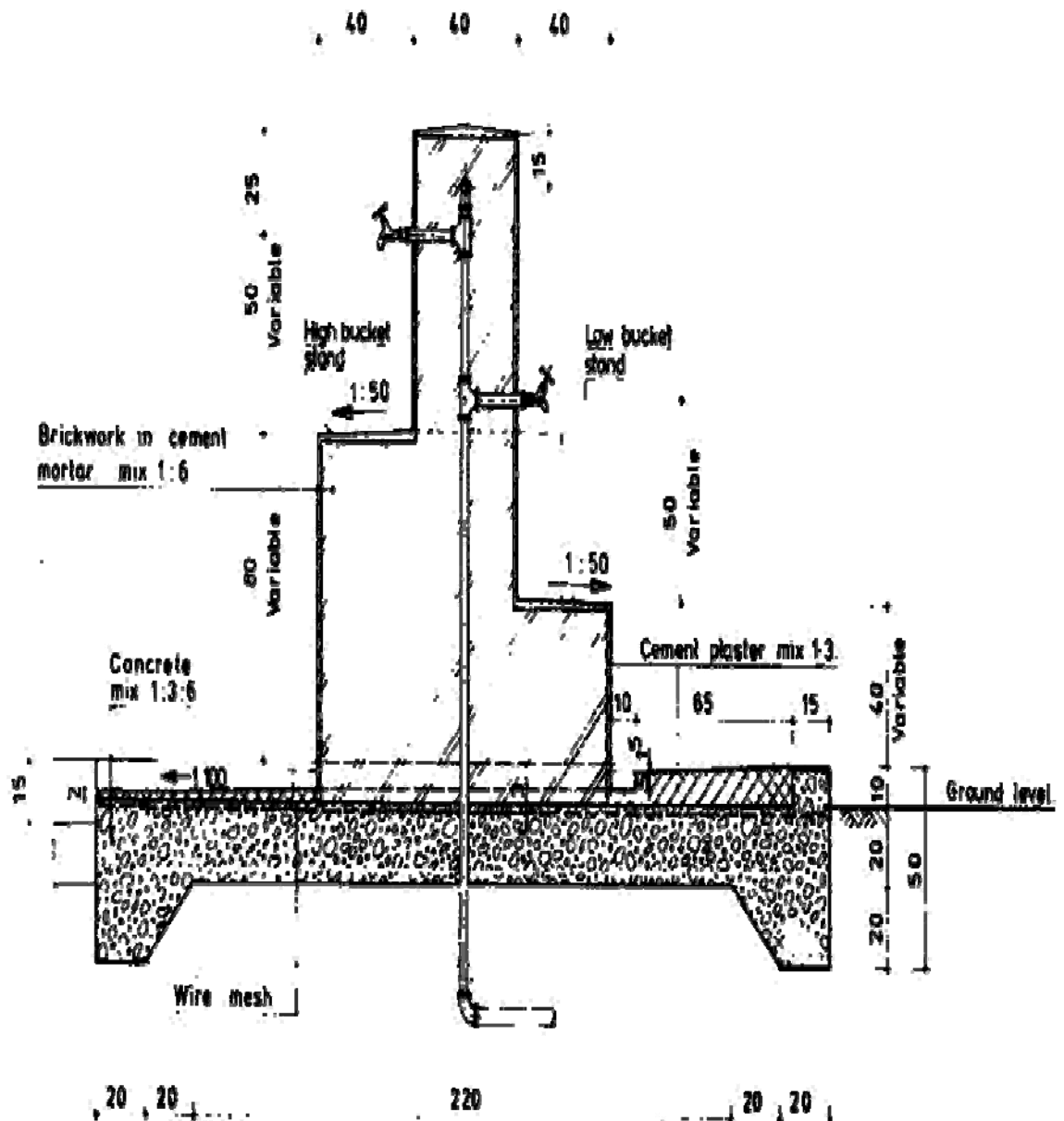


Figure 2.7: example of brickwork stand post. Modification can be made according to local requirement. (IRC, 1991)

2.2.6. Washing slab and cattle trough

Many descriptions made of washing slabs show complex raised plat forms with sinks and ridged surfaces designed so that they can be used standing up. These are being used closer to the site of well, spring in the communal land. However, much simpler

techniques can be used with success. A simple, suitably-shaped concrete surface provided near a tap or water point and served with a water run-off channel and water seepage area is all that in the first instant (Morgan, 1990).

Rectangular washing slab

This shape is more popular because it offers more room on the periphery of the slab. The concrete is laid on the ground and cast with reinforcing wires running through it. Washing slabs do wear away with use and the concrete mixture should be strong enough to last several years. The slab should be constructed around the water delivery point, such as the tap. Approximately one meter of slab per peripheral length should be measured for each potential user. A slab for 12 people will therefore be approximately 6 meters long and 2 meters wide. This will accommodate six persons on each side. The whole slab should be sloped so that wastewater runs off away from the tap and into the water channel (Morgan, 1990).

Cattle trough

Many rural water supply systems installed in areas where cattle watering may be essential, and very often some distance from where people live. A fence can also be constructed around it. The cattle trough is connected by pipe to the water source so that some water is delivered to the trough during routine use of the source. When the source is used directly to fill the trough, the end of the water outlet pipe can be closed off with a hand or with a plug made of wood or some other local material. The dimension of the cattle trough should be set 200cm length by 80cm width by 25 cm height. Top of the trough must be located down hill from the outlet of water source and about 20 meters away (Morgan, 1990).

2.3 Operation, maintenance and Rehabilitation of rural water supply system

The Difference between maintenance and rehabilitation of project is defined as follows: Maintenance is a minor activity carried out by a technician with skilled labor and caretaker services provided by the village. Rehabilitation on the other hand means major overhaul and reconstruction, often costing as much as a new project. Further distinction is made between maintenance and repair. Maintenance is carried out by the villager maintenance worker and concerns on preventive care to ensure that the system continue to function. Where as repair is required, when the system has actually broken down and need outside assistance in terms of material and expertise. The main

objective of rehabilitation of rural water supply projects, are to improve the water quality and to raise water production to demand level (IRC, 1990).

In many places once the construction phase has been completed the project is really only just beginning. This is the stage when many projects failed because they are considered being finished. A well-organized maintenance structures is required for smooth operation.

One of the most important steps in establishing sustainable community water supply system is arranging for efficient operation and maintenance of the facilities. With out proper care, a water facility will deteriorate and fail to provide the services for which it was designed and built. A malfunctioning system will almost certainly be improperly used and eventually abandoned by the community. It is crucial that the community understand that with out proper operation and maintenance by trained system operators, no water supply facilities will continue to function properly and safely. Such proper functioning is essential for sustainability of water supply system. Operations and maintenance plans should not only list maintenance tasks, but also provide a detailed task schedule focused on preventative maintenance and specifying responsibilities (IRC, 1990).

For a water supply system to run sustainably needs well-trained people to operate it. There fore Capacity building and training at local level are also highly linked to the projects success. Experience tells that for operation and maintenance to be long lasting, communities need to be trained before, during, and after facility construction, make choices based on all available options, and be given the opportunity to develop their capacity (IRC, 1990).

Involvement of user volunteers will increase the feeling of community owner ship and responsibility for the schemes. The prime aim is to create a system that will keep all the schemes functional by ensuring that repair is carried out as soon as possible. The involvement of the community in preventive maintenance and repairs will relieve a considerable burden from the government. Involvement of user ensures regular servicing to increase schemes life and repair is likely to be carried out more quickly. It is hoped to involve women in the care taking as much as possible as they are who collect the water and who suffer if the pump is not functioning properly (IRC, 1990).

Rehabilitation of defective schemes can provide an economic alternative to invest in new projects, but that decision should not be automatic. Just as with a new scheme, the

rehabilitation option has to be evaluated by balancing community needs, preference, and capacity to sustain with the support potential of the water agency. In assessing the scope for rehabilitation, the community and the agency together need to review what went wrong last time and ensuring that lesson are incorporated in any remedial measure. Above all, rehabilitation should not simply be a matter of replacing broken equipment or infrastructure .The most common cause of failure is organizational: either the agency or the community has been unable to provide the resource needed to keep the system in operation. Replacement of failed parts will not eliminate that causes, unless it is combined by appropriate organizational changes and acceptance by both the agency the community (IRC, 1990).

2.4. Community participation

Rural Water supply project activities are not likely to achieve their objectives with out the active and continuous participation of the users, during pre-planning, planning implementation, and operation and maintenance. Concept of community participations means, that the community plays an active role in its own affairs by sharing and exercising decision- making and implementation (IRC, 1987).

A fundamental element of sustainability of water supply scheme is the participation of the community and its support for continued upkeep of the systems. The water agencies have to initiate proactive measures like awareness building, community mobilization, constitution of community-based institutions like water user association and water committee, strengthening democratic process in them and broad basing involvement of community by transferring responsibility and authority to them in all aspects of implementation and O&M of schemes.

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

The advantages, which are foreseen as arising from community participation:

- With participation, service can be provided more cheaply;
- Participation is a catalyst for other development;
- Participation encourages a sense of responsibility;
- Participation ensures things are done the right way;
- Participation uses valuable indigenous knowledge;

- Participation frees people from dependence on other's skills;
- Participation increases project efficiency; and
- Participation increases project effectiveness.

2.5. Gender

Gender plays a key role in the collection and use of water for basic needs and productive activities. Women are involved in fetching water in most of the time. The occasional involvement of men in fetching water is restricted at the time when whose wives were not available at the time, and they did not have children who could assist in the absence of the wife (UN, 2005).

Water collection in rural areas is traditionally women's work, even if children, especially girls, assist them to a great extent. In spite of this, women have been consistently excluded from all dialogues about the priority of improved supply, the possible improvement, implementation and arrangement for operation and maintenance. Consequently, they have not always been reached with the necessary promotion or instructions on the proper use of the improved supply, or with adequate water related health education (IRC, 1987).

Total exclusion of women from the whole process of improved water supplies may be the most significant factor for disastrous failure rate for water supply system. If women are not included in the planning and implementation of the improved water sources, as they have been in the past for traditional water source, their motivation to use and maintain the new source will be small (World Bank, 1976).

2.6. Cost

Water has an economic value in all its competing uses, and should be recognized as an economic good. With in this principle, it is vital to recognize first the basic right of all human beings to have access to clean water at an affordable price. The failure or malfunction of Rural Water Supply systems has direct welfare consequences on the beneficiaries. They no longer have water for essential daily life. Thus, the social cost of poor operations and maintenance is high (IRC, 1989).

All improvement in water supply system calls for money and other resource, not only for initial investment but perhaps more importantly, for operation, maintenance, and repair. If water supplies are to be sustainable, there is clearly a need for a continuing as well as an initial financing source and commitment. However, apart from the initial investments, an ongoing commitment sustained by cost recovery is also necessary to

ensure that improved water supplies continue to function, ideally for 365 days of the year. If funds are not available to meet the cost of operating, maintaining, repairing, and upgrading the water supply, the system will deteriorate. This deterioration both increases the cost of getting the system in to its shape again, and decreases the preparedness of the users to pay for the service. Good financing and financial management are thus important (though not the only) conditions to create and maintain well functioning improved water supply in all community (IRC, 1989).

Villagers should be required to pay as much as they can towards the costs of constructing and operating their system. Nevertheless, in most cases, government fund will be necessary to cover a large part of the initial construction cost.

Commitment is necessary to embark on village water program. As the financial sustainability of services depends on the revenue collection, introduction of a system is required to fairly measure consumption and cost allocation. Fixing and revising the tariffs to meet the total O&M cost for the development of efficient revenue collection system and staff training and high-level political support for tariff collection will play major role to overcome the cost recovery problems and financial sustainability of rural water supply system (World Bank, 1976).

3. SUSTAINABILITY AND TECHNICAL ASPECTS OF RURAL WATER SUPPLY PROJECTS

3.1. General

The traditional way of implementing rural water supply projects have not yet brought change as expected in the rural areas. There are difficulties in obtaining safe water, causing many disadvantages such as the spread of waterborne diseases, or having to walk long distances to reach the places with water. Donors, NGOs and government give much attention on new projects whereas the exciting schemes are mishandled and abounded before their design life. The donor/NGOs community developed much of the new rural water systems (a particular example being a number of hand pumps). However, often the establishment of spare parts distribution networks and repair services needed to maintain the equipment has not accompanied the introduction of new technology. When the equipment fails, it is not repaired, and users return to their original contaminated source of water. The sustainable supply of services for rural water supply (RWS) continues to be a challenge in rural areas.

Detailed study of sustainability is essential for any water supply project to avoid system breakdown and premature abandonment. The major constraints that cause failure of water supply systems are technical problems, financial, attitudinal, institutional, and legal framework problems, and lack of community participation, O&M problems, and political interference. Poor performance is often caused by poor planning, construction, and by inadequate operation and maintenance. It is clear that attention needs to be given to these aspects in order to make efficient use of available sources.

3.2 Sustainability

“Sustainability is the most desirable, yet elusive characteristic of water supply projects’ Adapted from WHO, 1994

Failure of all type of water projects can be frequently be associated with either poor implementation or the community or the water agencies have been unable to meet the commitments necessary to keep the installed facility functioning. Because so many water systems have fallen in to disrepair, the key concept for water projects today is to

ensure sustainability. That is, to design build and managed improved water services in such a way that they continue to function reliably and well, and the fund for keeping them functioning to be available.

The concept of sustainability was first employed in relation to natural resources and how they should be used at present with out affecting the future. Recently, sustainability becomes the issue of different sector. Different sectors have different sustainability concerns (Boserup, 1965).

In water sector, a sustainable system is one, which is based on affordable, appropriate technology, and continues to deliver a high level of water related benefits after completion of the project (Jennifer and Travis, 2003).

The water supply continues to be available for the period for which it was designed in the same quantity and at the same quality as it was designed, the scheme is said to be sustainable and all of the many elements that are required for sustainability must have been in place (IRC, 1991).

A number of studies have identified various determinants of water system sustainability, including technical, institutional, economical, environmental, and social aspects.

3.3 Technical aspects of rural water supply

The technical aspects are those related to the planning, design, construction, operation, and maintenance of rural water supply system. This is the most determinant of water supply sustainability.

Technical sustainability Aspects

Technical issues relating to the design and construction of rural water system are the most obvious determinants of water system sustainability. Poor construction quality or use of low-grade materials may lead to the failure of the water system before the end of the design life. Similarly, design mistake of schemes, and overestimates of the water sources may cause a system to fail from the outset.

Technical sustainability evaluation

In general, the technical issues relating to the design, construction, operation, and maintenance of rural water supply system are the most determinant of water supply sustainability. Because water system sustainability depends on a number of factors,

which vary between community and type of scheme, therefore, measuring sustainability is a difficult task. This study bases its analysis on indicators that measures the technical aspect. The main aim of technical evaluation is to investigate the extent and cause of break down of the village water supply and to look for remedial measures. The cause might be due to poor design, construction, operation and maintenance or all of them. Sustainability is the capacity of project to continue to deliver its intended benefits over the design period (Issays, 1988).

3.4. Indicators of technical sustainability Aspects for Water Supply Schemes

The function of a water supply system is to provide water from a source, treat the water to make it suitable for its intended use, and deliver the water to the user at the time and in the quantity desired. Since such factors as the yield and quality of raw water sources; topography, geology, and population density of service areas; and intended uses of water may vary, it is obvious that not all water systems will be alike. Nevertheless, there are certain general considerations that designers of virtually all water systems must take into account. With the above understanding, the overall technical sustainability of the Project can be qualitatively measured by functioning, utilization and over all performance of systems. Functioning and utilization of schemes are most critical in assessing the scheme conditions (Issays, 1988).

3.4.1. Functioning

Functioning implies the system supply enough water to meet at least the basic needs of all households in the defined project areas, and that this water is consistently acceptable .It also means that the system are expanded in time to cope with population growth. In addition, increased water use, and that enough fund continue to be available to maintain the agreed standard of operation. There are four indicators of the functioning of the water supply facilities (Essays, 1988).

- Water Quality
- Water Quantity
- Reliability of water supply
- Convenience

Water Quality

Water quality requirements are directly related to intended use. The highest intended use considered in this case is human consumption. Thus, it is assumed that all the water supplied must meet or exceed appropriate local, state, and Federal drinking

water standards. These standards include microbiological, chemical, physical, and aesthetic requirements that are applicable to water sources as well as finished water. However, different classifications of water systems are subject to varying levels of regulation. The quality of available water sources is often a very important factor in water system planning and design.

Water generally, is said to be clean only if the following factors are fulfilled.

- If it is free of bacteria, germ and other worms
- If it is free of toxic chemicals
- If it is clear, odorless, colorless and have its natural taste

Potable water means water free from impurities in amounts sufficient to cause disease or harmful physiological effects, with the physical, chemical, biological, or radiological quality conforming to applicable maximum permissible contaminant levels.

Water Quantity

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

Reliability of water supply

Reliable system is the one, which function throughout the year with continues operating time and only with infrequent breakdowns, which are quickly repaired (IRC, 1991). In community water supplies one of the most important influences on system reliability is the length of time for which schemes stay ideal when it is broken down. In considering the service level to be provided by a particular technology, reliability is important parameters (*World bank, 1990*).

It is also considered not to be acceptable if the breakdowns cause interruptions longer than a week. Further, it is not acceptable if water is not available at the source for longer period.

Convenience

It is difficult to judge the attitude of people towards this situation as it has become a regular part of their life. However, it is obvious that a reduction of time spent on water collection would yield spare time that could be used for other activity. It is considered unacceptable if the walking distance to water supply is more than 2 km. This is corresponding to a minimum of 3 to 4 hours daily spent on water collection for a normal family. It is also considered a disadvantage if people regularly have to queue more than 1 hour at the water supply (*World bank, 1990*).

3.4.2. Utilization

When it is assured that the scheme is functioning properly, the next fundamental step will be assuring whether users use it or not. Even a technically perfect scheme is not considered successful if it is not utilized. Four indicators of utilization of rural water supply facilities are:

- House hold using water
- Volume of water used
- Price acceptability/Affordability
- Participation
-

Household using water

It is important to know who uses the facilities, how much number of people uses it, and why the non-user prefers other sources. It helps whether the water point serving as designed or not. Table 3.1 presents rough estimation of different water supply technologies and the allowable number of users.

Table 3.1 water supply technologies versus the allowable number of users (WHO, 1994)

No	Scheme type	People served per unit	Remark
1	Hand dug well with hand pump	500	With good aquifer and if animals watering included the number of people should reduced
2	Spring development with point source	200	With washing slab and cattle watering
3	Spring development with public fountain	500	For one tap user ranges 25 - 125
4	Small piped supply	3500	Usually an electrically pumped borehole and spring using storage tanks

Volume of water used

Water supply facilities are normally designed to provide for domestic needs such as drinking, cooking, washing clothes and launder; also water for domestic animals is allowed. The main objective of the rural water supply is provision of adequate water for the selected users, to improve living and health conditions of selected rural communities. For improved health and living condition, one person should get 15-20 liter per day.

Price acceptability/Affordability

Beneficiary contributions, whether in cash or in-kind, are important determinant of financial sustainability. People should be capable and willing to pay for services that provide immediate and easily observable benefits. The fixing of the charges for water consumptions is to some extent, a political decision. However, it can of course also be an economic decision based on knowledge of varying ability and willingness to pay for the consumptions in different areas. An affordability analysis of water rates in relation to household income was conducted to ensure that the proposed water charges did not go beyond the prescribed limit of 5% of monthly household income (WHO, 1994).

Participation

It is believed advantageous, from the utilization point of view, that the people feel that they are sharing the water supply. This is also strengthened if they have actually participated in the implementation with labor or cash or ideas but also a good organization of operation and maintenance with local responsibilities are deemed good.

The subjective criteria are that a scheme is judged non-successful if non-participation of the users, in a broad sense, is causing non-utilization, acceptable or successful if participation exists to a certain degree.

3.4.3. Performance Indicators

Performance indicators can be defined as variables whose purpose is to measure the change in a process or function. Indicators may be quantitative or qualitative in nature. For example, the operating pressure in a pipeline and the informal water costs are both quantitative indicators. In contrast, a community member's perception of his/her satisfaction with the existing water supply is qualitative. Some of the important performance indicators that can be applied to water supply systems are water coverage, water production, water consumption, frequency of break down, unit operation cost, and continuity of service.

4. DISCUSSIONS AND EVALUATION OF RESULT

4.1 General

The objective of this study was to assess the water supply situation in South Wollo zone, in order to identify technical sustainability rural water supply problems in the zone. This chapter presents the results of the water supply study that was conducted in south Wollo zone. First, it describes the overview of the sample schemes present situation in detail, providing background information on the schemes location, population served, and level of services. Based on findings of the survey, remedial measures to improve the water supply are proposed from the referenced literature presented in chapter two. Finally, there is a brief discussion on qualitative data analysis, and suggestions for future work are presented.

4.2 Overview of schemes in the study Woredas

During the last, three or four decades considerable effort have been devoted to improve the water supply conditions of south Wollo zone which is the most drought stricken area of the region. The schemes constructed by different Non governmental organization (NGO'S) and donor's have been handed over to the zone water bureau, there by the woreda water desk of direct responsibility for operation and maintenance.

The organization of the zone rural water supply is a section of the zonal agricultural and development bureau. Rural water supply is often seen as one of the most important sector of development program (one of the millennium development Goal (MDGs)). Many of the national regional and zonal water bureaus have set ambitious goals of supplying water and arranging proper sanitation to their people during this international water supply and sanitation decades. In the context of the present institutional set up, the water sector can not achieved the desirable goal of development activity. Supplying clear water for people should not be the responsibility of one single section.

The traditional approach of rural water supply has frequently resulted in services that have not been sustained in the zone. Projects are highly supply driven. Government, donor, and NGOs tend to pay more attention to build new facilities than to ensuring the use of existing ones. Roles for project planning, implementation, cost recovery, operation, and maintenance are poorly defined. Projects do not properly establish.

The rural drinking water supply schemes are implemented by governmental, (NGOs) and donor's agencies. However, NGOs are the dominant implementing agency in the selected woreda. The implementing agencies have not constituted the woreda Coordination Committees to work together.

Inadequate delivery of rural water supply services, due to aging infrastructure, institutional constraints, and fiscal difficulties is inhibiting the access of communities to basic water supply infrastructure services. Existing facilities are often poorly designed and insufficiently maintained, and do not adequately provide urgently needed basic services. The capacity of concerned bodies must be developed to enable them to implement sub sectors and to undertake operation and maintenance (O&M) of the constructed systems. In line with the Government's policy to use a decentralized community management approach, the Project will enhance the coverage of basic water supply facilities; contribute to improving living and health conditions and improve the institutional, organizational, and managerial capabilities of the sector agencies.

In south Wollo zone, the level of services ranges from a hand dug well with hand pump and simple protected spring to a spring development and shallow well with little elaborate distribution system. The schemes with distribution system serve few consumers through private house connections.

4.2.1 Hand dug well

Estimated 45 communal use hand-dug wells exist in the study Woredas. Out of 45 hand-dug wells, nine were visited in the field inventory of the existing wells and their general conditions. All hand-dug wells are fitted with Afridev hand pump and lined with concrete ring. The depth and the diameter of each specific well are not known. The depth of hand dug well in south Wollo zone, in general, ranges from 5m to 20m. The diameter of wells also ranges from 90 cm to 120cm, which is the minimum diameter for two people work together. In the zone, the numbers of unused and non-operative hand dug wells are huge. In the nine sample schemes, questionnaires were discussed with community from the result of the finding the existing situation, major problem encountered and the remedial measure that has to be taken to improve the service for each of the nine schemes are discussed below.

4.2.1.1. Ali dally I

Existing situation

Hand dug well in Ali dally I is found in Kalu Woreda, Located about 1525m elevation. It was serving 100-house hold. Nowadays, since 1992 E.C it is not utilized for any purposes due to high turbidity, silt intrusion, and bad smell

Major problems

- I. In the area, there is problem of landslide .The platform of the hand pump is distorted and buried in the soil. The manhole of the well is not properly sealed, cracked and its outcrop level is exactly equal to the surrounding ground level. It is located on the downstream of farmland; there are no any drainage facilities to divert surface runoff away from the well. In addition, there is no apron protect erosion of the headwall and no drain to keep spillage water away from the shaft. The scheme is not fenced, which is susceptible for pollutions, damage, and unauthorized entry.
- II. The pump handle has unusual voice and vibration.
- III. The finding from the survey indicate that the community were not well organized to operate and maintenance their water system. No clear responsibility was set for operation and maintenance, manpower development, trainings and for distributing and purchase of spare parts. It is found that, water committee was created and had not yet received any training from any organization to manage and control the system; even they do not know where to get help for major repair. They have no access to tools, and spare parts.
- IV. Due to all these problems people use alternative unprotected source with its potential health hazard. People especially children are regularly cited to diarrheas,

Remedial measures

- I. The initial task has to be to clear all rubbish and silt from the bottom of the well and to plug it with concrete or gravel.
- II. Because the area is prone to land slide the stability of the shaft may not be achieved unless and other wise a special treatment is done. Therefore it is desirable to reinstall lining. The lining being built up on a concert-cutting ring (i.e. concrete ring with reinforcement). The old excavation may have certainly irregular shape. There is likely a considerable gap between the caisson and parts of the shaft wall. This space has to be filled with gravel, except for the top 3 meters that should be plugged with puddle clay before the wellhead is constructed.

- III. Erosion at the top of the well can occur due to either the lack of a wellhead or the lack of a watertight seal at the top of the well and apron. Therefore as described earlier, improved wells have to be provided with a wellhead structure consisting of a headwall built up with rocks and compacted clay that is plastered with mortar.
- IV. The simplest, but most important, single improvement to an existing well is the construction of a wellhead consisting of headwall and drainage apron. This single measure can eradicate cause of water born diseases and considerably reduce other health risks. Concrete apron should be constructed on the ground surface all around the well. The Concrete apron also seals any fissures between the well lining and the wall of the excavated hole and prevents polluted surface water from seeping in to the well.
- V. Regular tightening of the bolt and nut, greasing of pump joint is required.
- VI. Identifying sources of contamination, regular water quality checking, and application of disinfections is required. This should be repeated at regular intervals. Rainwater and spillage has to be drain away from the shaft. After which head wall and drainage apron are constructed in permanent material.
- VII. Another method of improving an existing dangerous or unsanitary well like Ali Daly I is to convert it in to what is known as a 'sealed' well. One in which the only accesses to the intake is through a small diameter pipe leading to the surface. The narrow pipe rising to the surface can be made of any material. It must be strong enough to stand up to the soil pressure, be durable, and large enough to take the rising main pipe for the hand pump and must be sealed to prevent polluted surface water from soaking in. The joint between the pipes are usually mortared solid clay. This even have a disadvantage of once sealed it is not possible to deepen the well, or to extract any sand that may have entered with the water. In some ways, this is cheaper than rehabilitating the well in the conventional manner like expensive lining of shaft.
- VIII. The ground around the well top has to be graded to ensure that rainwater and spillage drains away from the shaft .The scheme should be fenced to protect unauthorized entry of children and animals. Scheme attendant and water committee should be select from the community and should receive relevant trainings. User community especial women should involve in management and control of scheme. There is a need to explore ways to involve them more effectively in protecting or improving their drinking water.
- IX. Villagers should raise sufficient funds for operation and minor repair. The water bureau should arrange regular visitors for the scheme operation and maintenance

until villagers attain capability to run the schemes. Supplies of tools, spare parts will have to be organized, as well as bureau assistance for the more major repairs.

4.2.1.2. Ali dally II

Existing situation

Hand dug well in Ali Daly II is found in Kalu woreda 034 Keble, located about 1515m elevations. The yield of the well on average is estimated 0.111 liter per second with seasonal variation. The number of users is not exactly known but it is expected more than 200 households.

Major problems

- I. Insufficient quantity of water, users of Ali dally I are sharing the scheme i.e. too many users, limited working hour of the operator and the well does not deliver enough water quickly.
- II. Women and children spend much time each day on fetching water because of long walking distance and long queuing. Also at months April, May and June the community face severe water shortage. Because of this, the water from the hand dug well is only used for cooking and drinking. For personal hygiene, laundry and cattle they use the nearest river. Use of this safe water for drinking and cooking reduce water borne diseases. However, there may be insufficient supply for proper personal hygiene, so that "water wash diseases," (like, Trachoma and skin diseases) cannot effectively controlled.
- III. Quality of water is not satisfactory, children are consistently cited for diarrhoeas, and the taste of the water is salty.
- IV. Insufficient physical protections of well like provision of proper drainage facilities to divert surface runoff and to keep spillage water away from the well shaft. The spillage water from the pump stands around the scheme and the vicinity of the pump become muddy that result diseases spread by insects, which either breed in water or bite near water. Like Malaria. Even the inspection manhole of the hand dug well is not properly sealed.
- v. The installed pump was not maintained and repaired. It has unusual noise and vibration. Failure to collect adequate charges from the users, the monthly revenue is one birr per family per month, which is not enough to meet operating expenses and the cost of minor repair. Poor maintenance routines and frequent system failure make users unwilling to pay for the service they received.

- VI. Collaboration difficulties between community and water bureau, lack of responsibility on the part of the users, non-participation of the users and shortage of trained personnel are the major problem.

Remedial measures

- I. The problem of inadequate yield is either unsuitability of site or decreased in power of the pumping units or due to long age services and poor operation and maintenance of system. Cleaning and providing storage at the bottom could improve this. Also by changing old pump unites. Arranging proper operation and maintenance are essential for efficient use of existing water supply.
- II. A regular checking of the water quality is essential in order to ensure safety of the water and regular well cleaning and application of disinfections requires. Preventive maintenance program should be arranged in order to improve functioning of the pump. If simple breakdowns are report early, by monitoring team and subsequent repair done disastrous, failure will not be occur.
- III. The well should be completely sealed with a watertight slab on which a pump is mounted to draw water. A manhole should be tightly and securely locked to allow disinfections. The ground around the well top is graded to ensure safe removal of rainwater and spillage water away from the shaft, after which a head wall and drainage apron are constructed in permanent material. The scheme should be fenced to protect unauthorized entry of children and animals. Scheme attendant and water committee should be select from the community and should receive relevant training. User community especial women should involve in management and control of scheme. There is a need to explore ways to involve them more effectively in protecting or improving their drinking water.
- IV. Villagers should raise sufficient funds at least enough to cover operation and minor maintenance costs. This practice has been found to create the sense of owner ship and responsibility with in the villages for proper operation and maintenance. As finance is one of the big problems then the community should be convinced to pay for the services they get to increase the level of services.

4.2.1.3. Derek Woyira and Endode Bere

Hand dug well in Derek Woyira and Endode Bere are found in Dessie zuriaya woreda 012 and 014 located about 2273m and 2259m elevation respectively. The two schemes are non-functional. It had installed hand pump outside the village, which were not working very well. The seals had broken on the hand pump and it was very inefficient, needing a lot of hard work to pump the water, no spare parts had been left. In the

instance users had not been motivated to repair the pump, there was a fault in the design of the whole. Users due to insufficiency of the water source damage the wells. The installed hand pumps are broken and displaced from their position by users. To get direct access of water close to the source with a rope and bucket .Now a day users restored to unsafe traditional point with its obvious health hazard.

Vandalism affects sources indirectly through the malfunctioning of the systems. Also directly, as it concerns the source and the catchments area, this exposes the ground water to possible contaminations. Poor planning, construction and inadequate operation and maintenance often cause poor functioning. It is clear that attention needs to be given to these aspects in order to make efficient use of available sources. Proper source and sit selection contribute to the reliability of the water supply system. Locating area with high yielding site and low risk of contamination by seepage from the surface will result sustainable supply.

Hand dug well supply System must be designed for simple, trouble free operation equipment must be able to with stand hard usage, and replacement part must be available. In addition, capable of being operated and maintained by local technician's

4.2.1.4. Gerado High school

Hand dug well in Gerado High school is found in Dessie Zuriya woreda, located about 1525m elevations. It is owned by the school and serves for the school community. Like any other wells in the woreda, it has so many structural defects and failure of the pump to function. Structural defect on the wellhead noticed are distortion and cracks, there is no apron and drainage to lead away surface runoff and split water. In addition, its location is not safe against pollution source there is a toilette and farmland at a distance less than 10m. Failure of the pump to function like needing much effort to get water, abnormal noise, and vibration, lack of capacity to maintenance and repair. This entire problem is mainly caused by poor construction, operation, and maintenance. Therefore consideration should be made to improve the construction of well and the capacities for maintaining pump and facilitate the provision of spare parts to keep the schemes running. Provision of apron and platform is required .It also requires to raise the headwall 300mm above the surrounding ground surface so that runoff and spilt water are diverted from the opening of the well. This helps to prevent runoff and spilt water from entering and contaminating the well and eroding the top of the well.

4.2.1.5 Kelem Myda

Existing situation

Hand dug well in Kelem Myda is found in Dessei Zuriya woreda 02 Keble, Located about 2376m elevations. The well depth is around 12m. The well becomes non-reliable due to its very low yield. Its yield per day is 150 liter approximately. The number of users is not exactly known but it is expected around 150 house hold.

Major problems

- I. Water shortage occurs through out the year. The yield of the well becomes very small. One family allowed carrying only 20-25 liter per week. They use the water only for drinking. The scheme is fallen in to disrepair for more than two year. Women and children travel more than 5-8 km to get safe water and spend a lot of time each day queuing for water. The long walking distance and the time wasted on queuing all contribute to make the community use unprotected source like, river, pond, and unprotected spring.
- II. Other problem encountered are lack of responsibility on the part of the users and the water bureau, institutional weakness of the water bureau, insufficient revenue, lack of tools, spare parts, material locally and lack of trained manpower.
- III. It represents a waste of money and effort and has a strong discouraging effect on the community.

Remedial measures

- I. Yield of perfectly functioning well may become insufficient because of the reduction in capacity of the pump due to excessive worn parts. On the other hand, the excessive wearing of pump may due to pumping of sand entering the well. Most commonly, a decrease in the capacity of a well result from the clogging of the well intake by deposits. This incrusting deposit soil material such as silt and clay. The initial task has to be clear all rubbish and loss silt from the bottom and change the worn part of the pump.
- II. To improve the yield of the well, there are two principal in which the mount of water entering a well may be increased by deepening it, thus producing a great difference of water level between the inside and out side of the in take and by increasing the area of intake in contact with the aquifer.
- III. The scheme should be fenced to protect unauthorized entry of children and animals. Scheme attendant and water committee should be select from the community and

should receive relevant trainings. User community especial women should be involved in management and control of scheme. There is a need to explore ways to involve them more effectively in protecting or improving their drinking water.

- IV. Concrete apron should be constructed on ground surface all around the well with 2 meters width. The Concrete apron also seals any fissures between the well lining and the wall of the excavated hole and so prevents polluted surface water from seeping in to the well.



Figure 4.1 Hand dug well in Kelem Myda

4.2.1.6 Miawa

Existing situation

Hand dug well in Miawa is found in Kalu woreda 033 Keble, Located about 1485m elevations. The yield of the well on average is estimated 0.15 liter per second with seasonal variation. The number of users is not exactly known but it is expected around 150 households. The water from the pump used only for drinking and cooking.

Major problems

- I. Water shortage occurs all most through out the year, especially in months April, May and June the community face severe shortage. One family allowed to carry only 20-25 liters per day. They use the water only for drinking. For cooking, laundry, personal hygiene, and cattle's they use the nearest river and unprotected spring with its health hazards. People especially children are cited regularly to diarrhea.
- II. Long queue is the biggest problem of the system. Women and children spend a lot of time each day queuing for water because of limiting working hour of the operator and the well dose not deliver enough water quickly. The quality of the water is not good. It has turbidity and salty taste.
- III. The scheme in Miawa is located in the center of farmland owned by investor. The use of fertilizer and pesticide might cause contamination of ground water.
- IV. There are no drainage facilities to divert properly runoff from the surrounding farmland and water spilt from the pump. Apron distortions and cracking due to landslide was noticed.
- V. It has installed a hand pump outside the village, which is not working very well, and people are still using the traditional water points. The seal of the headwall is broken on the hand pump and it was very inefficient, needing a lot of hard work to pump the water, no spare parts have been left. There is no apron provided.
- VI. The community hired system operator. He is simply appointed by the community with out considering his ability to operate the system and perform minor repairs and maintenances. He has not yet received any training from any organization, even he do not know where to get help for major repair. He has no access to tools, spare parts, and manual.
- VII. There was a water committee created at the time of project implementation. But the member of the committee have not yet received any training on operation, maintenance, and other topics to manage the system therefore they are not capable to perform their intended work.
- VIII. There is no system to carry out preventive maintenance and regular application of disinfections. Maintenance and repairs are carried out only when the scheme breaks down. Whenever breakdown occurs there is no an immediate measure taken. It takes in average 10-15 days.
- IX. There is a revenue collection system (i.e. 0.60 birr per family per month) mainly for the salary of operator and purchase of material for minor repairs Because of frequent scheme failure and poverty most of the villagers are unwilling to pay more.

Remedial measures

- I. Protection of ground water source deserves urgent attention. Digging well near area with potential source of contamination like Meawa in the center of farmland should be avoided. A location safe distance away from a pollution sources required. In case of lack of alternative site, the situation could be improved by Provision of watertight lining and backfill, at least on the upper few meters to prevent surface water from seep into the well. Physical protection of well by providing apron and drainage facilities to lead away surface runoff and split water is required. Manhole of the well should be inspected and cleaned regularly and any algae growth or pollutants materials should be completely removed
- II. In addition provision of drainage apron to divert water away from the wellhead area, prevent water from pooling at the surface near the well opening, and provides a structurally sound and more hygienic surface for well users to walk on and rest their water collection vessels. User should be instructed to not stand on the headwall and manhole while drawing water in order to reduce the chance of contaminated spilt water from entering the well
- III. Yield of perfectly functioning well may become insufficient because of reduction in capacity of the pump due to excessive worn parts. On the other hand, the excessive wearing of pump parts may due to the pumping of sand entering the well or due to long age services and poor operation and maintenance of system.
- IV. Most commonly, a decrease in the capacity of a well result from either unsuitability of site or clogging of the well intake by incursion deposit. These incrusting deposits soil material such as silt and clay. The initial task has to be clear all rubbish and loss silt firm from the bottom. This could be improved by cleaning and providing storage at the bottom and by changing old pump unites. Arranging proper operation and maintenance are essential for efficient use of existing water supply.
- v. The space between the walls of the dug well and the lining should be sealed with puddle clay, or better with cement grout. The upper parts of the lining should be water tight preferably to a depth several meters below the lowest draw down level. An apron should be constructed around the raised top of the lining and the ground around the well top is graded to ensure safe removal of spillage water away from the shaft.
- VI. A regular checking of the water quality is essential in order to ensure safety of the water and regular well cleaning and application of disinfections requires.
- VII. Scheme attendant and water committee should be select from community and should receive relevant training. Regular monitoring and preventive maintenance program should be arranged in order to improve functioning of the pumps. If simple

breakdowns are report early, by monitoring team and subsequent repair done disastrous, failure will not be occur.

4.2.1.7. Tulu Abba Jibbo

Existing situation

Hand dug well in Tulu Abba Jibbo is found in Kalu woreda 034 Keble, Located about 1460m elevations. The yield of the well is estimated 0.101 liter per second with seasonal variation. The numbers of users are estimated around 90-house hold.

Major problems

- I. Quantity of water is not sufficient for all domestic purposes. Water from the scheme is only for drinking and cooking. For, personal hygiene, launder and cattle they use from nearest river .In particular on months April, May and June one family allowed to carry 20-25 litter per day. Quality of water is not satisfactory, children are consistently cited for diarrhea and the taste of water is salty. There is no any system arranged for regular application of disinfection and cleaning of well and it's surrounding.
- II. Manhole of the dug well is not completely sealed and there is no any drainage facilities provided to divert properly surface runoff and split water .Its location also not safe that is center of farm land. The seal broken on the hand pump and the pump is inefficient, needing lots of hard work to pump the water. No spare parts left. In this instance, the villages are not motivated to repair the pump.
- III. The average walking distance women and children travel to fetch water is around 4km and regularly they have to queue more than 2 hour at the scheme.
- IV. There is a revenue collection system mainly for salary of operator and purchase of material for minor repairs i.e.0.50 Birr per family per month.
- V. There is no system to carry preventive maintenance. Maintenance and repairs are carried out only when the scheme breaks down. Whenever breakdown occurs there is no an immediate measures taken. It takes in average 15 days.

Remedial measures

- I. It is essential that well should be located and constructed in such a way that it protects the ground water source from contamination. In addition, it must be operated and maintained in hygienic manner. Provision sealed manhole, drainage facilities and headwall is required to develop the scheme in its design performance.
- II. The problem of inadequate yield is either unsuitability of site or decreased in capacity of pumping unit or due to long age service and poor operation and maintenance. Cleaning and providing storage at the bottom could improve this. Also

by changing old pump unites. Arranging proper operation and maintenance are essential for efficient use of existing water supply.

- III. The ground around the well top has to be graded to ensure that runoff and spillage drains away from the shaft, after which a head wall and drainage apron are constructed in permanent material.
- IV. Provision of drainage apron keep waste water away from the wellhead area, prevent pooling of water on the surrounding, and provide a structurally sound and more hygienic surface for well users to walk on and rest their water collection vessel.
- V. Wells, which run dry or do not give enough water, can be rehabilitated by sinking a tube well in to the bottom of the well and then back filling the original well with puddle clay. By this method, it is possible to reach much further down in to the water bearing layers and thus improved the well yield.
- VI. Scheme attendant should be selected and trained properly. The project should supply basic materials, tools and spare parts for the scheme attendant.
- VII. Users should raise sufficient funds at least enough to cover local operation and maintenance cost. This practice has been found to create the sense of ownership and responsibility among users.

4.2.1.8. Wuha anbo

Existing situation

Hand dug well in Wuha Anbo is found in Dessei Zuriya woreda, located about 2215m elevations. The yield of the well on average is estimated 0.278 liter per second. The numbers of users are not exactly known but it is expected 200-house hold. The number of users increased because of users of kelem myda hand dug well and spring are sharing the scheme.

There is some indication at least in this scheme that villagers do care for their pump. It was noticed that they use guard, lock the pump and fence for certain period of the day. This positive trained of users trying to care for their scheme could be turned in to full-scale village level maintenance with proper training, organization and back up service in spare parts, tools, and occasional major repairs.

This scheme is implemented by Kale Hiwot church. It is noticed that the church, crew always, visit the scheme with in 6-8 month interval and do preventive maintenance of the supper structure of scheme like greasing, tightening of bolts, regular clearing of well surrounding and repair of fence to keep out unauthorized entry from the immediate surrounding of the well; also disinfection is applied regularly.

Major problems

- I. There is no drainage facility provided to divert properly surface runoff and spillage water from the pump.
- II. Fluctuation of yield with seasons, at dry season the yield of the well decrease which causes unnecessary queuing problem and other inconvenient to the consumer.
- III. Children and women spend 3-4 hour each day queuing (i.e. too many users) for water after traveling long walking distance around 3km and also due to limiting working hours of the operator.
- IV. There was a water committee created at the time of project implementation. Nevertheless, they have not yet received any training on operation, maintenance, and other topics to manage the system. Their duty is only informing the implementing agency whenever breakdown occurs and collecting revenue for guard salary.
- V. The implementing agency take all responsibly of the scheme such as preventive maintenance. There is no any effort made to participate users on any stage of the scheme.

Remedial measures

- I. The scheme should be operated for sufficient time during the day so that there will be little queuing and the maximum of convenience for water users.
- II. The addition of drainage prevent water from pooling at the surface near the well opening, and provides a structurally sound and more hygienic surface for well users to walk on and rest their water collection vessels.
- III. Water committee and guard of the scheme should get relevant training to operate and repair their water system. Tools, spare parts must be readily available so that simple breakdown can be repaired in due time before minor damage growth in to major break down.
- IV. After completion scheme should be over handed to the respective villages to be operated and maintained. The main aim is to establish sense of responsibility with in the villages for proper operation and maintenance of their water system.

4.2.1.9 Discussion

Pumps discussed above actually deliver water to ground level, and with out any surrounding but a pump plinth (as is the case inmost of the well) the vicinity soon become muddy, unhealthy and unpleasant place. Standing water around pumps will result mosquito breeding, attract flies and animals be a potential health hazard, to some extent negating many of the benefits that improved water supply could provide. Furthermore, the risk of standing water getting back in to the well and wet area reduce

infiltration capacity of soil therefore avoidance of wet area is required. Particularly if the pump plinth is cracked, pollution of the water source is greatly enhanced. Therefore, it is important to minimize standing water to eliminate the health hazard. Drainage has to be provided to keep water away from the pump pedestal, to avoid erosion and hence entry of polluted water in to the well. These drains are covenanted to be included in the design. Simple brick-lined drains 10 meters long should be constructed at each well to lead any spilled water away from the immediate site of the well. If it is needed to keep water away from the pump plinth use 3 m extension pipe to take water from the pump out let to a completely separate apron.

In most of the Visited schemes, pumps are not operating due to minor technical problems that occurred after a few years of use. In some cases, minor repairs, including fixing loosen bolt, greasing the pump, could not be done because the water committee lacked one or more of the following: tools, skills, or funds. Several facilities are abandoned due to unanticipated failure that required major repairs and rehabilitation. On average, the existing pumps mostly Afraidive hand pump require repair once in every 6-12 months. Attention is required to the plunger, foot valve, bushes or adapter unions. On project, assistance together with one or two labors from the village can attend to repairs with out the use of the heavy vehicles.

A well fitted with a pump is generally capable of providing as much water as people can pump. It is therefore beneficial that as many water using activities as possible are encouraged close to the water point, particularly those that are associated with personal hygiene and general cleanliness. An important example is the washing of clothes. An activity that is traditionally carried out by a river, using flat stones for pounding provision for washing cloths at the water point will gather, and will probably result in more regular washing with all the associated health benefits of improved personal cleanliness.

One further potential hazard may render the water in the well unpleasant or impossible to drink. A concentration of salt dissolved within the aquifer or it might be washed from the surrounding farmland (pesticide and fertilizers). Both are difficult and expensive to remove. Salt concentrations in the ground usually occur over a wide area, and evidence of their presence in near by wells should always lead to suspicion that any new well may produce water that is not safely potable. The most prominent water quality problem with hand dug well supply in Kalu woredas is excessive salty concentrations. Salty water will corrode metal (particularly ferrous) parts more rapidly than fresh water and in these instance pumps with wetted parts of plastic (PVC) will be

useful. Many wells of the study woredas have been built with no protective features. Thus still, yield water rather poor quality. The presence of silt and sand in high concentrations can be a major problem in certain instance due to erosion of the bottom or receiving run off from the land. Sediment in the water will wear down moving parts of the pump.

There are three routs by which, the water in a well may be contaminated: through the wellhead, through the lining, and through the water entering the intake (1989 Peter Morgan). As discussed earlier in chapter two, the simplest and most important improvement to a hand dug well is the construction of a head wall rising sufficiently high above ground surface to prevent any thing from washing into the well. In addition, an impervious apron 2 meters wide, sloping away from the shaft in all directions has to be provided. The top 3 meters at least should be made water proof by lining to prevent seepage from the surface soil layers, which are the most likely to carry dangerous contaminations. When a well is lined with material other than concrete, e.g. brick work masonry or similar substitute. Particular care must be given to ensure the water tightness of the top 3 meters and its junction with the wellhead. The space between the walls of the dug well and the lining should be sealed with puddle clay, or better with cement grout. The upper parts of the lining should be water tight preferably to a depth several meters below the lowest draw down level.

The water in the aquifer may become polluted before it reaches the intake. A source of pollution such as a pit privy or animal pen will produce contaminated water that will sock downwards into the soil. Usually the polluted drainage will become filtered and purified within a short distance as to travel downward, but if the water table is too close to the surface purification may be incomplete before the water enters the intake. A well should there fore be located as far away from potential sources of pollution as possible (certainly no nearer than 50 meters) and at a higher level of the water table.

In many of the hand pumps reported the locations of alternate water sources were more convenient. Inconvenient locations of public supply points are a discouragement of beneficiaries. It is found that a number of households continued to depend on unprotected sources of water due to inconvenient location, frequent breakdowns, longer waiting time, low yield, and bad quality of water, etc.

4.2.2. Spring development

There are 148 communal used springs in the study Woredas. During the field survey, 18 springs were visited to give a field inventory of the existing springs and their general conditions. All the springs are protected. In south wollo the service level of protected spring, vary greatly in size ranging from spot spring, serving many

consumers to elaborating distribution system with house connections and public water point. Four springs are used as gravity supply system for people living down stream of the spring due to the good topography with public fountain and small house connection. In the rest of the cases, taps are fitted on masonry tap stand or on the wall spring boxes and discharging with galvanized iron pipe with out faucet.

In the eighteen sample schemes, questionnaires were discussed with community. The existing situation, major problem encountered and the remedial measure that should be taken to improve the service of the eighteen schemes are discussed below.

4.2.2.1. Abo Corchow

Existing situation

Spring development in Abo Corchow is found in Kalu woreda 07 Keble located about 1769 m elevation. The scheme have cattle trough constructed interlinked with the tap stand .The tap stand has 1 1/2” galvanized steel open flow out let pipes installed on the wall of the spring box. The yield of the spring is estimated on average 0.171 liter per second with seasonal variation. The spring serves 120-house hold. Water from the spring is used for all domestic purpose and cattle watering.

Major problems

- I. As the community claimed and I observed, the spring tapping is not done exactly on the eye of the spring. This poor tapping of spring causes large amount of water loose and result insufficiency of the water source. On the dry, season the spring dry up leaving the community with acute water shortage. The spring box has much leakage at its base. Regular blocking of the out let pipe by rubbish and frog. Water from the scheme becomes more turbid and silt delivery increases time to time.
- II. Location of cattle trough is next to the out let pipe. Cattle drink water and stand on the tap stand while people filling jerry can. Allowing animal near water area may cause faecal and parasitic larvae being carried in to the water source.
- III. Because washing slab is not provided people wash their clothes on the wall of tap stand and on the top cover of spring box. The surrounding of water point is covered with rubbish, cattle drops, algae growth, and standing water that creates more comfortable conditions for fly and mosquito breeding. There is no physical protection work done like provision drainage for the surface runoff and spillage water. Therefore, Surface run off directly flooded to the spring source and spring box with its impurities. There is no fence to keep away animal and unauthorized entry.
- IV. Poor collaboration between users and water bureau. There is no mechanism for regular clearing and application of disinfections in spring box. Maintenance is carried out at emergency break down there is no preventive maintenance. At present

the responsibility to carry out minor maintenance is entirely left to the community, even if they are not capable to do it.

- v. High frequency of break down, like blocking of out let pipe, total change of spring course and silt build up of box, difficulty to obtain spare parts and material, lack of trained man power, and length of time required for repair all these drives the users to use unprotected source like river with its health hazards. People, especially children less than five cited to diarrhea consistently.
- vi. There was a water committee created at the time of construction phase but they are not play the role given to them. This is because they have not yet get any training to carry their intended work. There is no revenue collection mechanism to meet the cost of Operating, maintaining, repairing, and upgrading the scheme.

Remedial measures

- i. This poor functioning of spring is often caused by poor construction and maintenance. The area around the spring has to be dug out in order to capture all available flow. Then loss stone and gravel should pill against the eye. This serves to filter suspended soil and prevent the spring water from washing soil away from the area. The spring tapping structure should be located exactly on the spring eye and it should be cleaned and inspected regularly. Caution must be taken not to disturb ground formations when digging out around the spring. The area must, however, be dug out enough so that the spring box fits in to impermeable material. In the cases where the box dose not reaches impermeable material, puddle clay should be used to seal the area around the sides of the spring box.
- ii. Drawing of silt shows silting of spring box or presence of erosion in the spring tapping. Then regular clearing of spring box and filling of the source surrounding with gravel and sand is required.
- iii. The cattle trough should be relocated at least 8 m away from tap stand and provision of washing basin near the source result health benefit of improved personal hygiene.
- iv. Spring contamination may result from poor spring development construction or from direct flow of surface water into the shallow groundwater feeding the spring. Spring water should be tested before and after heavy rains each year and on regular base for bacteria, pH, turbidity, and conductivity.
- v. Physical protection of the spring and the spring surrounding is required. Like provision of fence, removing deep-rooted trees, regular cleaning the area and keep animal away from it. Surpluses and spillage water from tap stand has to be avoided safely to cattle trough or vegetable garden .To keep surface run off away and to avoid erosion of the source area provision of proper drainage required. Draining the

standing water and back filling it with gravel and pebble stone requires reducing breeding of fly and mosquitoes.

- VI. The spring box and spring tapping structure has to be watertight in order to avoid ingress of spillage water and surface run off pollution.
- VII. Discouraging people from spilling water off on the concrete structure and its surroundings and washing clothes on the structure.

4.2.2.2 Assa Erbata

Existing situations

Spring development in Assa Erbata is found in Kalu woreda 06 Keble located about 1778m elevations. The scheme consists of tap stand, washing basin, shower, and fishpond made of concert and masonry wall. The spring serves approximately 80 families. The water from the spring used for all domestic purposes.

Major problems

- I. Improper tapping of spring, which lead change of spring flow course. The amount of water supplied by the tap stand is much less than the expected yield after development. Water bureau had started to rehabilitate the scheme but not yet finish the work with in three years. This is due to financial constraint and conflict between the users. Dwellers near the spring sources would like to use leakage water for their vegetation garden. They are relieved about the occurrence of leakage from the tapping and considered it as their natural right. Because of water shortage, the shower and the fishpond are not functional. The water in the fishpond is covered by algae growth that cause animal death and create comfortable conditions for fly and mosquitoes breeding.
- II. There is no physical protection work done for the spring source like provision of drainage, fence, and removal of deep-rooted trees. Due to excessive leakage and lack of drains the surplus water pounded on the area and cause high health risk, like malaria.
- III. The upper part of spring catchments is as grazing land.

Remedial measures

- I. It should be dug back in to the hillside to the water-bearing layer where the water is flowing from the “eye” of the spring. Then loss stone and gravel should be piled against the eye. Gravel and stone will serve as filter media that reduces intrusion of silt to spring box and reducer erosion of the surrounding. To increase the amount of water reach the spring box ensures that all the water tapped from the source is channeled to the spring box.

- II. Conflict between the communities should be resolved. Dweller should be convinced to use the surplus and spillage water for their farm.
- III. The surrounding area has to be cleaned adequately .It can be disinfect at least once in a year and sediment has to be cleaned out the spring box. Sediment removal will prevent clogging and build up which cause the box to fill up more quickly.
- IV. It is noticed that runoff from the catchments area directly flooded to the source carrying with its impurities and polluted soil. Construction of diversion ditch above the spring source at least 8m above the source to divert surface water from the area. Fence has to be provided to keep effectively animals away from the4 surrounding.
- V. Animal grazing in water catchments area should be avoided because it causes faecal and parasitic larvae being carried in to water source.

4.2.2.3 Chefe Mesendy

Existing situation

Spring development in Chefe Mesendy is found in Kalu woreda, 06 Keble located about 1844m elevations. The scheme has 11/2” galvanized steel out let pipe installed on the wall of spring box and washing basin made of concrete. The yield of the spring is estimated around 0.24 liters per second with seasonal fluctuation. The spring serves approximately 310-house hold. The water from the spring is used for all domestic purposes

Major problems

- I. As user claimed and I observed the spring, tapping is not done exactly on the eye of the spring. Therefore after development the yield decrease and so many small springs start to flow out of the spring tapping.
- II. Water shortage occurs through out the year, especially on months April, May and June. Women and children spend much time each day queuing for water because of much number of users and spring dose not deliver enough water quickly. The water become more turbid, silt delivers increase after rain, and worms occasionally present in water. People especially children become sick of diarrhea consistently.
- III. There is no cattle trough provided there for people allowed their cattle to drink and stand on the tap while filling jerry can. In addition, the location of washing slab is at distance less than 1meter from the tap stand that is more dangerous from the sanitary point of view.
- IV. Spring box and spring tapping structure are covered with debris, bushes and algae growth. The wall of the spring box has cracks that lead much leakage, easy entry of frog, insect and debris in to the box. This result much amount of water lost through

crack. At the time of break down (i.e. blocking of out let pipes) traditional leaders open the manhole and clear the box. After clearing the manhole is not properly sealed using concrete because of lack of cement due to this cover of the inspection hole is not sealed properly.

- v. There is no physical protection work done in the area like, provision of drainage for surface runoff, surpluses water, and wastewater, fence to prevent entry of animal and unauthorized entry.
- vi. Water is provided free. There is no revenue collection mechanism. There is no any mechanism for the preventive maintenance, application of disinfections and regular clearing of the scheme and it's surrounding.
- vii. Lack of tools, materials, trained manpower, and lack of collaboration between users and water bureau.

Remedial measures

- I. Improper tapping of spring leads to insufficiency of the spring therefore, proper tapping has to be done and channeling all the water to the spring box is required. Silt delivery, either arise from improper tapping which leads erosion of the area around the spring eye or there is a place where surface run off join the spring box. Therefore, the tapping should be done exactly on the eye and back fill the area with gravel and pebbles. The wall of the spring box needs to be plastered with watertight material. The inspection manhole has to be completely sealed.
- II. Spring water should be tested before and after heavy rain and on regular base for bacteria, pH, turbidity, and conductivity.
- III. A drain has to be dug around the spring source to take surface runoff away from it and to prevent pollution of the spring water. Regular clearing of spring box and the surrounding area, regular application of disinfection, provision of drain for the spillage water, cattle trough and fence is required.
- IV. The water bureau must recognize and fulfill its commitment to provide continuous technical and non-technical support and ensure the availability of necessary materials, tools and manpower. Duties and responsibility of the water bureau and users need to be clearly defined.
- v. Villagers should raise sufficient fund at least enough to cover minor repair and maintenance.

4.2.2.4 Checorty

Existing situation

Spring development in Checorty is found in Kalu woreda 06 Keble located about 1787 m elevation. The scheme has a concrete tap stand, cattle trough and washing basin. The tap stand has four out let pipes with faucets the yield of the spring-estimated around 0.4866 litre per second with seasonal fluctuations. The spring serves approximately 120-house hold. The water from the spring used for all domestic purposes.

Major problems

- I. Spacing of different components of the scheme has not taken in to account the recommended standard spacing. Cattle trough is located at a distance less than 4m which is not recommended from the sanitary point of view. Also the dimensions of cattle trough not allowed more cattle at the same time.
- II. Spring box and spring tapping structure are totally covered by bushes and trees. There is no access for clearing and disinfections application. There is no sanitary protection to prevent contamination of the spring water. No drainage facilities available to divert surface runoff away from the spring box and spring tapping.
- III. The community hired system operator. He is simply appointed by the community with out considering his ability to operate the system and perform minor repair and maintenance. He has not yet received any training from any organization, even he do not know where to get help for major repair. He has no access to tools, spare parts, and manual.
- IV. There was a water committee created at the time of project implementation. But the member of the committee have not yet received any training on operation, maintenance, and other topics to manage the system therefore they are not capable to perform their intended work.
- V. There is no system to carry out preventive maintenance. Maintenance and repair are carried out only when the scheme breakdown. Whenever breakdown occur there is no an immediate measures taken. It takes on average 10-15 days.

Remedial measures

- I. Physical protection of recharge area of spring by removing deep-rooted trees and providing proper drainage facilities for runoff and water split. Clearing all the bushes

and trees around the spring tapping and spring box and fencing the recharge area. Manhole of the spring box should be inspected and cleaned regularly .Any algae growth or polluted materials should be completely removed.

- II. Relocation of cattle trough is required.
- III. Preventive maintenance and repair program should be arranged.
- IV. Personnel who do not have training should be given the relevant training.

4.2.2.5 Chorisa

Existing situation

Spring development in Chorisa is found in Kalu woreda 05 Keble located about 1732 m elevation. The scheme has a masonry spring box with 1” diameter galvanized steel open flow out let pipes installed in its wall and washing slab. The yield of the spring is estimated around 0.3942 litres per second with seasonal fluctuation. The spring serves approximately 160 families and one soldier camp. The water from the spring used for cooking, drinking and washing.

Major problems

- I. The spring box, which is made of masonry not completely sealed. It has crack on its wall, open space on the cover slab and half of which is covered with vegetation, which leads easy enter of frogs, insects and rubbish. The wall of the spring box is not properly anchored to the sidewall therefore large amount of water leaks through it. There is no regular application of disinfections and clearing of spring box. People, especially children cited to diarrhea regularly.
- II. Inconveniency of the water point and Water shortage is serious problem. Women and children have to walk long distance and wait long queue for water each day to collect minimum quantities of water. This is due to much number of users and out of four out let pipes two are non functional. In addition, the diameter of the out let pipe is very small to deliver enough water as needed.
- III. Clear distance between the out let pipes and bucket stand is around 400mm. which is not allowed jerry can and large containers to draw water. Users draw water with small bucket and transfer it to their Jerry can or larger container that causes long queue and increase the spillage water.
- IV. The washing slab is constructed at distance less than 1m from the out let pipe, at the same level as the surrounding ground floor. This is not comfortable to wash clothes and to dispose wastewater properly. The washing basins have four slab compartments of 800mm: 800mm dimension. Of which two are non-functional, filled with stagnant water, and rubbished. In addition, the ridge in between the slabs

is around 50 mm that leads the flow of water from one-slab compartment to the other easily at the time of washing. Most of the Users travel extra distance to nearest river to get water for their cattle but still few of them allow their cattle to drink in the spring. Therefore users washing pollute water, laundry and allowing their cattle to stand in the water while filling Jerry cans.

- v. There is no protection work done like provision of drainage for surface runoff, and surplus water. Runoff from the catchments area carrying with its impurities and polluted soil flooded to the spring box directly, No fence is provided and in the area, there are deep-rooted trees and bushes.
- vi. Lack of responsibility both from users and water bureau, lack of preventive maintenance, lack trained man power, lack of coordination, relatively low income of villagers and limited contribution, lack of local capacity, lack of tools and materials, all this are the problem noticed in the scheme.

Remedial measures

- i. Spring box wall has to be sealed with clay or concrete, the cover slab of spring box has to be water tight and completely sealed to reduce the chance of surface pollution, and anchorage of the wall of the box firmly to the side is required. Regular application of disinfections and clearing required.
- ii. Repair the nonfunctional pipes and increase the diameter of the out let pipes. Increase the clear distance between the out let pipe and bucket stand. Repair drainage facilities for the surplus water and provide drain ditches for surface run off.
- iii. The washing slab has been constructed by raising it from the surrounding and away from the tap stand. The dimensions of washing slab, the height, and the width of the ridge have to be increased. Proper drain has to be provided to dispose safely the wastewater. Cattle trough has to be constructed to reduce the extra time and energy for cattle drinking. Fence has to be constructed to keep cattle away from it and to prevent unauthorized entry.

4.2.2.6 Derek Woyira

Existing situation

Spring development in Derek Woyira is found in Dessei Zuriya woreda 012 Keble, Located about 2278m elevations. The scheme has 1" diameter galvanized steel out let pipe installed on the wall of spring box and washing basin made of concrete. The yield of the spring is estimated 0.124 liter per second with seasonal fluctuations. The spring serves approximately 110-house hold. The water from the spring used for all domestic purposes.

Major problems

- I. Poor construction of spring tapping and spring box leads to leakage of much amount of water. As the users claim and I observed, the spring tapping is not done exactly on the "eye" of the spring. In addition, it is noticed that the spring box have crack on its wall and it is not anchored with the ground on which it is build up. Due to this large amount of water lost and the source become insufficient. The inspection manhole of the spring box is not properly sealed and has openings, Children play on it animal stand on it. Insect, Frog, Snake, Mosquito, and garbage easily enter to the box & block the out let pipe frequently.
- II. There is no drainage facility provided to divert surface runoff, spillage and surplus water from the surrounding. The vicinity of the spring is muddy, full of rubbish, algae growth, and animal drop with bad smell. The upstream of the spring source is a grazing land. The spring area is not fenced cattle drink and stand in the outlet pipe while filling Jerry can. Also the washing slab located next to the out let pipe is not provided with drainage. Thus all the water from it stands on all around it.
- III. There is no means for regular application of disinfections. As users claim people, especially children are cited to diarrhea consistently and worms occasionally present in water.
- IV. Long walking distance (i.e. more than 2km) and Long queue (i.e. more than 1.5houre) is the biggest problem of the system. Women and children spent a lot of time each day for water because the well dose not delivers enough water quickly (i.e. too small diameter out let pipes)
- V. There is no protection work done around the spring like removing of deep-rooted trees.

Remedial measures

- I. It should be dug back in to the hillside to the water-bearing layer where the water is flowing from the "eye" of the spring. Then loss stone and gravel should be piled against the eye of the spring. Gravel and stone serve to filter intrusion of silt to spring box and reduce erosion of the surrounding. To increase the amount of water reach the spring box ensures that all the water tapped from the source is channeled to the spring box.
- II. To set the spring box firmly the area must be dug out enough so that the spring box fits in to impermeable material. In the cases where the box dose not reaches

impermeable material, puddle clay should be used to seal the area around the sides of the spring box.

- III. The spring box has to be made of watertight material and should be anchored tightly with the ground and the inspection manhole has to be completely sealed. Provide screen on the over flow pipe to prevent entry of mosquitoes and frogs. In addition, discourage children playing on the box.
- IV. Standing water around source will result in mosquito breeding; attract flies and animals, which are potential health hazard, to some extent negating many of the benefits of improved water supply. Clear the area and the spring box then surrounding swampy area has to be drained, cleaned and back filled with stone or gravel and provided with proper drainage. Provide drainage facilities around the spring catchments to divert the entire surface run off away from it. Also, channel the surplus and spillage water with proper drain to cattle watering pond or vegetable garden.
- V. Animal grazing in water catchments areas are also a cause of fecal and parasitic larvae being carried in to the water source. Fencing the water catchments is important to keep animal away from the source. That reduces compaction of the source and possible contamination.
- VI. Arrange a regular clearing and application of disinfections in spring box

4.2.2.7 Endode Bere

Existing situation

Spring development in Endode Bere is found in Dessei Zuriya woreda 014 Keble, Located 2250m elevation. The scheme consists of cattle trough, washing basin and tap stand with 2”galvanized steel out let pipes pipe. The yield of the spring is estimated 0.506 liter per second with seasonal variation. It serves 675 people .The scheme water used for multiply purposes including drinking, bathing, laundry, and animal watering.

In this scheme there is no significant problem noticed. The spring intake consists of covered collection box built to reduce the chance of surface pollution. Tap stand consists of galvanized steel pipe supported on masonry back wall. The floor is made of concrete and stone slab. Surpluses water is drained safely to the down stream-cultivated field.

There is some indication that the villagers do care for their scheme. It is noticed that, they use guard, lock the fence for certain period of the day. The implementing agent arranges a six-month visit for preventive maintenance and application of disinfections.

This positive trained of users and water agency to care for their scheme could be turned in to full-scale village level maintenance with proper training and back up services in spare parts, tools, and occasional major repairs.

4.2.2.8 Font Nina

Existing situation

Spring development in Font Nina is found in kalu woreda 06 Keble, Located at 1705m elevations. The spring is used as gravity piped supply system for people living down stream of the spring. This is due to the good topography of the source with 3000-litre storage tank made of masonry. Water distribution is through four stand post and eight house connections. It serves 270 families. The water from the spring is used for all domestic purposes.

Major problem

- I. Pipe lying are not properly done. Pipe trenches were shallowly or poorly dug. As the top cover is very little in many place it has been washed away and rain leaving many pipes unprotected.
- II. Inconveniency of public stand post, much number of users per stand post, long queue, long walking distance, limited working time of guards are major problems noticed.
- III. There are no other facilities like washing slab and cattle trough. Due to this, people travel extra distance to wash their cloth and watering their cattle.
- IV. Insufficient physical protection of spring catchments i.e. provision of drainage ditch to divert surface runoff away from the Spring Box removal of deep-rooted trees and fence to prevent animals entry to the area.
- V. There is no metering of consumption. For the stand post and the house connection charged at a flat rate. The flat rate is 1Birr per house holed. The revenue is far from covering the operation costs let alone the recovery of capital cost.

Remedial measure

- I. Pipe lying has to be done properly. Trench should be deep enough to protect pipeline from damage of large truck, falling trees, and animals. Piped supply keep functioning only when pipes, valves, taps are regularly maintained, leaks are promptly repaired and on suitable drainage facilities being provided and maintained to dispose of extra wastewater.

- II. It is needed to assign local people for such tasks checking and repairing taps, tracing and repairing leakage pipes. Guidance will be needed on appropriate management and finance system to ensure that spare parts and tools are available.
- III. Proper drainage has to be provided at the spring source and storage tank to divert surface runoff away from it, to avoid erosion of surrounding area and to prevent ingress of floodwater with its impurities and polluted soil to the water point and vicinity. Also drainage has to be provided for the stand post to dispose safely spillage and surpluses water to a cattle watering pond, village garden or cultivated land.
- IV. Supplies of tools, spare parts will have to be organized, as well as bureau assistance for the more major repairs
- V. Cost recovery mechanisms have to be arranged.
- VI. The storage tank and the water point have to be fenced to prevent entry of animals and unauthorized entry. Well distributed additional stand posts are required at convenient place and for the maximum number of users to be served. That also minimizes the frequency of breakdown of pipe joint, faucet. In addition, reduce the pressure.
- VII. Additional feature like bathing, laundry and cattle watering facilities have to be provided near to the stand post, but separate.
- VIII. Schemes are better maintained; less abused and has higher level of financial performance when the number of users is small.
- IX. Responsibilities of users and water bureau have to be clearly defined. Villagers should be encouraged to nominate a person or committee to be responsible for looking after the village scheme, metering water, collecting charges and perform similar tasks.

4.2.2.9 Gida

Existing situation

Spring development Gida is found in Kalu woreda 08 Keble, Located about 1937m elevations. The spring development consists of cattle trough, shower, washing slab and tap stand made of concrete. It serves 180-house hold .The scheme water used for multiply purposes including drinking, bathing, laundry, and Animal watering. It is constructed by Ethiopian Red Cross organization. After the construction completed the scheme is handed over to the community to be operated and maintained. Water committee with three members is formed at construction time the water committee and traditional leaders are now responsible to control and manage the system. The project arranges a six-month visit to the scheme for preventive maintenance and application of disinfections. The spring intake consists of covered collection box made of concrete,

built with raised out crop to reduce the chance of surface pollution. The over flow and the out let pipes are anchored to the wall and looks strong enough. Spacing of cattle trough, washing basin, tap stand, and shower are excellent.

Major problems

- I. There is no protection work done around the spring. Drainage facilities are not provided for surface runoff, surpluses water, and wastewater. The area is swampy and full of rubbish which create a comfortable condition for mosquitoes and fly breeding
- II. The shower is non-functional. Due to this people wash their body at the stand post.
- III. There is no training provided for the community member on any aspect of the system.
- IV. The dimension of compartment of the washing slab and the ridge dividing them is small and there is no mechanism provided to control cross flow of water from one compartment to another.
- V. There is no effort made to prepare the community for operation and maintenance of the system. No village level maintenance is practiced.

Remedial measures

- I. Proper diversion drainage ditches should be provided on the upper part of the spring box and also for the tap stand and washing basin. Then surrounding swampy area has to be drained, cleaned and back filled with stone or gravel and provided with proper drainage to prevent breeding of flies and mosquitoes in the area.
- II. The fence around the spring source and stand post has to be repaired to effectively keep animals away from the area.
- VI. The community should understand cost recovery as an obligation to meet its share of cost of the project.

4.2.2.10 Kedida

Existing situation

Spring development Kedida is found in Kalu woreda in 07 Keble, Located about 1889m elevations. The spring has a concrete spring box with a 1" diameter galvanized steel open flow out let pipe installed at the box wall. The yield of the spring is approximately 0.35 liter per second with seasonal variation. It serves around 650 people. The spring water is used for all domestic purpose.

Major problems

- I. As people claim the spring flow direction change, and so many small springs starts flow around the tapping structure
- II. The spring box and spring tapping are totally covered with bushes, debris, and algae growth. There are a lot of leakages in spring box. The over flow pipes are completely covered by soil, vegetation and water which leads easy enter of frogs and insects to spring box. Clear distance between out let pipes and bucket stand is very small which is not allowed jerry can and large containers to draw water. Users fetch with small bucket and transfer it to the larger one that increases the spillage of water and time consuming.
- III. There is no protection work done around recharges area and spring structures. There are no proper drainage facilities to divert runoff and spillage water. Even the manhole of the spring box is not properly sealed.
- IV. Yield of the spring is reduced and water shortage occurs through out the year, especially in months April, May, and June the community face severe shortage of water. Long queue (1.5-2 hour) is the biggest problem of the system. Women and children spend a lot of time each day queuing for the water because of the spring doesn't deliver enough water quickly and one of the out let pipes is not functional.
- V. The quality of water not good, after rain it become more turbid and sand delivery increase.
- VI. There is no cattle trough and washing slab provided. Therefore, users pollute the water by, laundry, and allowing their cattle to stand in the water while filling jerry can. The area is swampy full of animal waste and has bad smell. This condition facilitates disease spread by insects, which either breed in water or bite near water. People consistently suffer from diarrhea.
- VII. Water is provided for free.
- VIII. There is no a water committee created to manage and control the scheme. Shortage of trained manpower, non-participation of the users during any stage of implementation.

Remedial measures

- I. The area around the spring must be dug out so that all available flow is captured and channeled in to the box. The spring tapping structure should be located exactly on the spring eye and it should be cleaned and inspected regularly. Caution must be taken not to disturb ground formations when digging out around the spring. The size of the out let pipes have to be increased.

- II. The reduction of yield of the spring may arise from silt up of the spring box, the eye of the spring and at the out let. Therefore silt, clay and sand deposits, and other material washed down from the slope by surface runoff, must be cleaned away. When these materials are removed water flow increases. Clearing away vegetation from the spring effluent will also allow better flow.
- III. The manhole of spring box should be sealed. The spring box should be cleaned, inspected & disinfected regularly and any algae growth or pollutant material should be completely removed from the area.
- IV. Drain should be dug around side of the spring box to take surface water away from it and prevent pollution of the spring water. A fence around the area will keep animals from getting near the spring box and help in preventing contamination and destruction of the area.
- V. The end of the out let pipe and over flow pipe inside the box should be covered with screen fine enough to prevent stones rubbish and mosquitoes from entering to the box.

4.2.2.11. Kelem Myda

Existing situation

Spring development in Kelem Myda is found in Dessei Zuriya woreda 03 Keble, located at about 2536m elevations. Two Open flows galvanized steel pipe of 1” diameter out let pipes are installed on the wall of the spring box, of which one is out of order for more than 6 month the yield of the spring approximately estimated 0.067 liter per second. It serves 300-house hold. The water from the spring is used for drinking only and at the rainy season it also used for cooking. In the scheme, it was noticed that the community hired guard to protect unauthorized entry, to lock the fence and care for it.

Major problems

- I. The most sticking feature of Kelem Myda spring is long queue stay more than four days and long walking distance. User spends a tremendous amount of time to get 40-50 liter of water because the spring dose not delivers enough water. The long walking distance, the time wasted on queuing and the price charged all contribute to make people use alternative unprotected sources during the rainy season with its health risk.
- II. The scheme becomes insufficient to cover all the demand due to frequent failure and the size of the out let pipe is very small.
- III. The spring tapping and spring box are totally buried in the ground, there is no access to clean and disinfect.

- IV. Operating and maintaining the scheme is the task totally carried out by the villagers with out the assistance of trained person from water bureau. After the implementation water bureau have not yet contact the community.
- V. There is no any physical protection work done around the spring source. Runoff above catchments area carrying with its impurity and polluted soil in to the spring tapping and box. In addition the surrounding area is grazing land, which may cause faecal and parasitic larvae being carried in to water sources and droppings are being washed off.
- VI. There was a water committee created at construction time with eight members but they have not yet received relevant training to carry out managerial and technical work. At present traditional leaders carry out the task of the committee.
- VII. No cattle trough and washing slab are provided. Users travel extra distance to wash clothes and cattle watering.
- VIII. Each family contributes 1 Birr per month for the salary of guard and minor repair. Because of poor financial management and frequent system failure for each system unit breakdown users are called up on help to meet the cost of purchase of material, spare part and for the person how did the repair task.

Remedial measures

- I. The reduction of yield of the spring may arise from silt up of the spring box, the eye of the spring and at the out let therefore silt, clay and sand deposits, and other material washed down from the slope by surface runoff, must be cleaned away. When these materials are removed water, flow increased. Clearing away vegetation from the spring effluent will also allow better flow.
- II. The size of the out let pipe has to be increased. The top of the spring box has to be raised at least 300 mm above the surrounding ground to reduce the chance of surface run of pollution.
- III. Provision of cattle trough and washing slab at the water point encourages people for personal hygiene and reduce the extra time and energy wasted for cattle watering.
- IV. There shall be trained services attendant at the scheme so it is operated and maintained properly. The maintenance services have to be greatly improved. Provision of preventive maintenance, more frequent inspections and repairs, training of water committee, water point rehabilitation is required.
- V. Additional new scheme has to be constructed to reduce the load on the scheme and to provide adequate water for consumer. The scheme is properly maintained, operated and less abused if the number of users is small.

4.2.2.12 Negadras Chefee

Existing situation

Spring development Negadras Chefee or Wortaya is found in Dessei Zuriya woreda 014 Keble, Located about 2230m elevations. The design of cattle trough, washing basin and tap stand are the same as that of spring development in Tsebelow .All noticed problem in Tsebelow on spring box and placement of different component of scheme are also seen in this spring. The yield of the spring estimated around 0.167 liters per second with seasonal variation. It serves 1700 people .The scheme is water used for multiply purposes including drinking, bathing, laundry, and animal watering.

4.2.2.13 Shembeko Wuha

Existing situation

Spring development in Shembeko Wuha is found in Kalu woreda 01 Keble located about 1795 m elevation. The scheme has had a spring box with 1" galvanized steel open flow out let pipes installed in its wall, cattle trough and washing basin made of masonry head wall. Now a day the scheme facilities are failed due to natural disaster, lightening since 1992 E.C. The spring was serving approximately 100 families.

The head wall of the spring box is not in good condition with crack, poor anchorage to the upslope wall side and foundation and there is a sing of wearing of the wall by erosion. Water becomes more turbid after rain. The out flow water is not properly drained. The splash base slab is not also in good condition. Thus, there is a pool of stagnant water due to the poor drainage. In the upper part of the spring, catchment's there are deep-rooted trees like eucalyptus. The water behind the wall head is exposed and thus runoff floods the outcrop of the spring. Although the source is unsafe and inadequate, people still continuing using it.

The wall of the spring box crack needs to be sealed with concrete and has to be properly anchored with the upslope hill. The manhole of spring box should be sealed. The spring box should be cleaned, inspected, & disinfected regularly and any algae growth or pollutant material should be completely removed from the area. To protect erosion of the wall add additional backfill of topsoil, clay, or gravel. Build up the hill with stones and plant grass to help control erosion around the spring box. The increase in turbidity after a rainstorm, indicate that surface run off reaches the source. Therefore identifying the source of the runoff and improve the protection of the spring. The trench above the spring source should be improved. The diversion ditch has to be lined

with gravel or stone to increase flow and to prevent erosion of the side. Construction of cattle trough and washing slab at the water point encourage people for personal hygiene and reduce the extra time and energy wasted for cattle watering.

4.2.2.14. Titta Genfoch

Existing situation

Spring in Titta Genfoch is found in Dessei Zuriya woreda 02 Keble, Located about 2509 m elevation. The spring is gravity piped supply system and with 1000 liter volume storage tank composed of masonry made head wall. Distribution of water is through two stand post. The stand post in Titta Genfoch with four taps as separate open flow out let pipes and stand posts in Agowa Ber with two taps. The yield of the spring is estimated around 2.589 liters per second. It is serve 3500 people. The scheme water is used for multiply purposes including drinking, bathing, laundry, and animal watering.

Major problems

- I. System failure due to break down of pipe joint, blocking of out let pipes are the most frequent one. At the beginning, the out let pipes were constructed with controlling mechanism with faucet, however because of excessive pressure the faucet wears and fail, now a day the system become open flow.
- II. The difference in elevation or the insufficient diameters of pipe make it very difficult to fill water pots easily because of excessive water spraying. There is no mechanism to reduce pressure sufficiently at the out let pipe. That also causes frequent failure of faucet.
- III. The wall of the stand post is totally covered with algae growth. In addition, the area is covered with rubbish, and has bad smell due to animal drop and stagnant water. The number of stand post is not enough.
- IV. Although the yield of the spring is sufficient, due to much number of users and inconveniency, women and children spend much of their time by waiting long queue and traveling long distance for water. Due to this at rainy season people use unprotected source with its obvious health hazards.
- v. There is no cattle trough and washing slab provided. Users wash their clothes and bath children on the bucket stand of stand post, which cause wearing of the concrete wall. Awareness of health and hygiene link is poorly developed. Water users fined it convenient to bath and wash clothes at same time as collecting water.

- VI. There is no protection work done around the spring and proper drainage facilities provided for the tank and stand post for surface run off and spillage water. All the spillage and surplus water from the stand post stands around it.
- VII. Standing water around the scheme will result in mosquito breeding, attract flies and animals and be a potential health hazard, to some extent negating many of the benefit of improved water supply. Furthermore the risk of standing water getting back in to the spring sources, particularly if the box has crack and thus polluting the water is greatly enhanced. People, especially children cited to diarrhea consistently.
- VIII. There is no responsible body from the sides of the users as well as the water bureau to carry out regular preventive maintenance and to keep the scheme and its surrounding clean, dry, and free from rubbish. Of course, water committee was created but they have not yet get relevant trainings to carry out the intended work.
- IX. There is no revenue collection mechanism. At the time of break down the traditional leaders start to collect money from users. Because the users are unable to pay the charge, it takes long time to collect enough money to carry the maintenance work. Even after the collection over leaders face a problem to get tools, spare part, material and trained person. All this delays stay the users with out water for so many days.

Remedial measures

- I. Stand post should be enough in number and well distributed. So that all the people can use at walking distance 200-400m which also minimize the frequency of break down of pipe joint, faucet. Schemes are better maintained; less abused and has higher level of financial performance when the number of users is small.
- II. Proper drainage has to be provided at the spring source and storage tank to divert surface runoff away from it, to avoid erosion of surrounding area and to prevent ingress of floodwater with its impurities and polluted soil to the water point and vicinity. In addition, drainage has to be provided for the stand post to dispose safely spillage and surplus water to cattle watering pond, village garden or cultivated land. It is important to minimize standing water to eliminate the health hazard. In addition, discourage people from spilling water on the surrounding and ensure that excess water is channeled away and spread over a garden.
- III. The storage tank and the water point have to be fenced to prevent animals and unauthorized entry. Additional feature like bathing, laundry and cattle watering facilities have to be provided near to the stand post, but separate.
- IV. Water committee has to be formed to manage and control the system. The committee member should receive relevant training to carry their responsibilities. The water

committee should appoint caretakers for the developed scheme. Caretaker should have access to continual training, spare part, tools, and material.

- v. As finance is the big problem then the community should be convinced to pay for the services they get. To increase the services level water bureau has to supply basic material and tools at the completion of each scheme for initial operation and maintenance requirement. And the bureau has to be arranging regular visit for operation and maintenance until villagers attain capability to run the system.

4.2.2.15. Titta town

Existing situation

Spring in Titta Town is found in Dessei Zuriya woreda, Titta town is a small rural town with 2886 people located about 7 km from Dessie town on the main road Addis to Mekele Located about 2518m elevations. The spring is used as gravity piped supply system for people living down stream of the spring. This is due to the good topography of the source with 2500 litter storage tank made of steel. Distribution of water is through four-stand post and small house connection. The spring serves all the people of the town and one soldier camp.

Major problems

In the two stand post found in village Fate Gendda and Mehal Ketema there is some indication that villagers do care for their stand post. Users hired guard to prevent unauthorized entry, to keep the stand post and its surrounding clean, dry and free from rubbish, to lock the scheme and fence for certain period of the day and to collect charge of water i.e.10 cent per 100 liters. The selected water committee at the time of construction with seven members is more or less doing their intended job. When required the committee organize the users to provide additional money and labor for maintenance and repair work. The members of the committee have not yet received any training on managerial and technical aspect of the system. One of the major problems noticed in the stand post is limited working time of operator/guard. Only one person is assigned for the two-stand post. She works eight hour per day, four hour at Fatte Genda and four hours Mehal Ketema. Therefore long queue more than one hour, of water container are observed until the next on time of stand post. The second major problem is the water bureau did not supply basic material and tools and spare parts at the completion the scheme. Therefore it is difficult to get spare parts and tools and trained manpower. Spare parts like faucet, pipe joint are caused of the frequent failure of the scheme because the qualities of the material are not standard one that is why

they cause frequent failure. There shall be sufficient service attendant at the stand post to increase the reliability of water.

This positive trained of users of the two schemes trying to care for their scheme has to be encouraged and supported. The water bureau has to supply basic materials, tools and spare parts, provide training, and arrange regular visit.

In one of the stand post found in village Sami Amenu Agere, all the problem notices are the same as that of Titta Genfoch. Like absence of cattle trough and washing basin, lack of proper drainage facilities, and lack of responsibility on both side of users and water bureau on operation and maintenance, lack of trained man power, materials, tools, and spare parts. All the remedial measures are also the same. Sources and location of spring is in forest reserves with low risk of contamination by human and animals. The storage tank is made of steel affected by corrosion and has high leakage. About House connection, around 165 families get this service. The major problems in the house connection are:

- I. Pipe lying are not properly done. Pipe trenches were shallowly or poorly dug. As the top cover is very little in many place it has been washed away and rain leaving many pipes unprotected. In many places, the distribution network is laid shallowly and exposed to the surface.
- II. There is no metering of consumption. The house connection charged at flat rate (i.e. rate is two Birr per house connection). The revenue is small to cover the operation costs let alone the recovery of capital cost.
- III. There are no people assigned from community or water bureau to regularly checking and repairing taps, training and repairing leakage pipes.
- IV. Few of the consumers get the supply for 24 hour of a day and mostly with high pressure due to their geographical location. More of the consumer get water for the part of the day especially when the stand post are off.
- V. There are many leakages in the distribution system. Although repair work is done to reduce the leakages, it is not very effective. Repair work is faced with many problems like spare parts and materials are not readily available.

Remedial measures

- I. It is vital to recognize that proper provision for wastewater disposal is necessary when any piped system is to be constructed. There are many instance of wastewater from piped systems causing public health and environmental damage. The

encouragement of mosquito and fly breeding and water borne disease transmission are example.

- II. For piped water supply continuous technical and non-technical support, ensure the availability of necessary materials, tools, and spare parts. Two or more care taker have to be selected and trained to carry out minor repairs and protection works, the water bureau have to provide continuous technical and non technical training for the selected care taker.
- III. Piped supply keep functioning only when pipes, valves, taps are regularly maintained, leaks are promptly repaired and on suitable drainage facilities being provided and maintained to dispose of extra wastewater.
- IV. It is needed to assign local people for such tasks checking and repairing taps, tracing and repairing leakage pipes. Guidance will be needed on appropriate management and finance system to ensure that spare parts and major repair are available and can be paid for when needed.
- V. As well as equipping the users to meet their maintenance commitments, the water bureau must accept commitments of its own. Any initial training will need to be followed up with refresh courses and regular monitoring and advice for local caretakers or mechanics and management organization. Supplies of tools, spare parts will have to be organized, as well as bureau assistance for the more major repairs
- VI. Cost recovery mechanisms have to be arranged and organizing water user associations, provision of local labor, material for maintenance and repair is required. In addition metering of water is essential to fix tariffs and collect the charge.

4.2.2.16 Tsebelow

Existing situation

Spring development Tsebelow is found in Dessie Zuria woreda, 015 Keble, located about 2256 m elevation. The scheme have a concrete tap stand with 1 1/2" galvanized iron outlet open flow pipe, washing basin constructed with two slabs interlinked with the tap stand on both sides. Cattle trough placed at distance less than 5 m from the tap stand. The yield of the spring estimated 0.462 lit/sec with seasonal variation. The spring serves 700 people. The water from the spring is used for all domestic purposes.

Major Problems

- I. The spring box and spring tapping are totally buried in the ground. Frog, Snake, Mosquito, and garbage easily enter to the box and block the out let pipe frequently. Worms occasionally present in water

- II. The washing slab is constructed interlinked with the tap stand on both side. There is no proper drainage provided to dispose safely wastewater from washing slab. Therefore, the wastewater become stagnant all around the area with bad smell and closes all the entry to the water point. Also facilitates disease spread by insects that either breed in water or bit near water likes malaria.
- III. There is no means for regular clearing & application of disinfections on spring box.
- IV. The upper part of the spring catchments is grazing land that is fully covered with animal drop and garbage's. At rain time all this are directly flooded to the spring box. After rain the water has bad smell and become turbid.
- V. The cattle trough is not functional. Animals use stagnate water.
- VI. Insufficient physical protection of spring i.e. provision of drainage ditch to divert surface runoff away from the Spring Box removal of deep-rooted trees and fence to prevent animals entry to the area.
- VII. There is hardly any preventive maintenance. Emergency type of maintenance and repair are carried out at the time of unit break down. It often out of operation for several weeks, because of communication problem with the water bureau. If break down occurs at the beginning of the rainy season the delay could be particularly severe repairs may not be carried out until dry season.
- VIII. There is no mechanism to collect charge from users.
- IX. There are no people, who receive relevant training about operation, maintenance and managerial aspect. Lack of material, tools, trained person, and lack responsibility from both side of user and water bureau are major problem encountered.

Remedial measures

- I. The surrounding of the spring box should be dug to bring top of the box at least 300mm above the surrounding ground to prevent surface water running in to it. In addition, has to be covered with a concrete slab, with an access hole to facilitate cleaning. Over flow has to be provided. The end of over flow and outlet pipes inside the box need to be covered with screen to prevent entry of stones, rubbish, frog, and mosquitoes to spring box and blocking the pipe. Seal the leak with clay or concrete so that all flow is diverted in to the spring box.
- II. Then surrounding swampy area has to be drained, cleaned and back filled with stone or gravel and provided with proper drainage to prevent breeding of flies and mosquitoes in the area. Proper diversion drainage ditches should be provided on the upper part of the spring box and also for the tap stand and washing basin. Spring contamination is result from poor spring development construction which result direct flow of surface water into the shallow groundwater feeding the spring. Water

quality should be tested before and after heavy rains each year for bacteria, pH, turbidity, and conductivity to determine surface water contamination is a problem if bacteria are found at any time in the water, properly disinfect the system.

- III. The washing slab should be relocated away from the tap stand. The fence around the spring source and stand post has to repair and effectively keep animals away from the area.
- IV. Water committee has to be formed from the community include women as well as men. The member of the water committee has to get relevant training to carry out their job. The water committee
- V. Villagers have to be encouraged to pay adequate fee for the service they received. That covers at least operation and minor repair and maintenance cost. Community must contribute to the improvement of their scheme. The contribution includes monetary, materials and labor.
- VI. The water bureau must recognize and fulfill its commitment to provide continuous technical and non-technical support and ensure the availability of necessary material, tools, and spare parts.

4.2.2.17 Wefku

Existing situation

Spring development in Wefku is found in Kalu woreda 08 Keble, Located about 1861 m elevation. The spring is a gravity system has two stand posts with 200-liter storage tank made of masonry. Distribution of water is through two stand post one for the community and one for elementary school. It serves 1200 people. The scheme water is used for all domestic purpose, bathing, laundry and animal watering.

Major problems

- I. There is a lot of leakage from the service pipe .In one point near the stand post water gets out like fountain. Due to this, water reach to the scheme is insufficient.
- II. The over flow pipes are completely covered by soil, vegetation and water which leads easy enter of frogs and insects to spring boxes. There is no means for regular clearing and application of disinfections of spring box. The spring box is totally buried in the ground. Children plays on it also animal stand over it. Even the cover slab is not totally sealed insect; frog, snake, mosquito, and garbage easily enter to the box and block the out let pipe frequently.
- III. Insufficient physical protection of spring i.e. provision of drainage ditch to divert surface runoff away from the Spring Box removal of deep rooted trees and fence to prevent animals entry to the area.

- IV. The upper part of the spring catchments is grazing land that is fully covered with animal drop and garbage. At rain time all this are flooded to the spring box directly after rain.
- V. Location of standpipe, cattle trough is very close to each other.

Remedial measures

- I. The surrounding of the spring box should be dig to bring the top of the box at least 300mm above the surrounding ground to prevent surface water running in to it. And has to be covered with concrete slab which an access hole to facilitate cleaning.
- II. The spring box should be inspected, cleaned and disinfect regularly. The increases in turbidity after rainstorm indicates surface runoff reach the source and contaminate it. Therefore the spring box wall and cover slab has to be properly sealed with watertight material. Over flow pipe has to be provided. The end of over flow and outlet pipes, inside the box need to be covered with a screen to prevent entry of stones, rubbish, frog and mosquitoes to spring box and blocking the pipe.
- III. The washing slab has to be constructed.
- IV. Proper diversion drainage ditches has to be provided on the upper part of the spring box and also for the tap stand. The fence around the spring source and stand post has to repair and effectively keep animals away from the area.
- V. User have to be encouraged to pay adequate fee for the service they receive, that covers at least operation and minor repair and maintenance cost. Community must contribute to the improvement of their scheme. The contributions include monetary, materials and labor.
- VI. The water bureau must recognize and fulfill its commitment to provide continuous technical and non-technical support and ensure the availability of necessary material, tools, spare pares.

4.2.2.18 Yelemulu

The entire problem noticed in this scheme is the same as that of scheme in Chorisa. Lack of responsibility from uses side and water bureau, there is no revenue collection mechanism and preventive maintenance. Lack of tools and material, lack collaboration of users and water bureau, leakage through spring box and spring tapping, no regular clearing of box and surrounding, no regular application of disinfections, lack of capacities are the major problem which cause deteriorations of the scheme. In addition, lack of finance is the problem of early maintenance of break down before it growth to complex one. In addition, in Yelemulu spring there is no washing basin provided users

wash their clothes and bath their children on the wall of the tap stand therefore users pollute water at the water point.

4.2.2.19 Discussion

Majority of people living in the hilly tracts all over the zone are still dependant much more on natural springs, although many of developed springs are at the verge of failure. Hence, today the first step in spring development is to regenerate the springs (inventory report, 2005). Protecting them from sources of contamination is another important consideration. Protected springs can provide safe and potable drinking water to a small community on a sustainable basis.

In the sample Woredas, many facilities are not operating well due to minor technical problems that occurred after a few years of use. In some cases, minor repairs, including fixing leaking spring boxes, tapping, and pipes, could not be done because the water community lacked one or more of the following tools, skills, or funds. Several facilities were abandoned due to unanticipated failures that required major repairs and rehabilitation. In most cases the water users do not have the funds or technical skills to face these situations.

At the time of field visit, it is noticed that the local communities were not aware that the upper catchments of their own sources of water, including the spring sources, must be protected to ensure long-term water availability and quality at that source. Water output decreased in some sites may be due to the very dense plantations of eucalyptus trees on the hills immediately above the springs. While protecting upper watersheds through forestation and other measures is necessary to avoid land degradation, situation of watercourses downstream, and landslides, dense tree plantations are not advisable. Certain varieties of eucalyptus trees demand a lot of water and cause serious imbalances in water availability. There are needs to implement awareness programs on the interrelationship of the different components in the environment and to empower communities to take appropriate action to avoid depletion of water resources.

In the study Woredas, many springs are designed for open flow. This did not create supply problems because projects are smaller and sources are adequate now. However, for the future project population will have increased in size, therefore there will be a need for more water than the present. At that time to reach, the demand sources have to be provided with controlling mechanisms and storage tanks. Yet an open flow system is an attractive option because it is very reliable and safest possible. However, an open flow system requires attention to the safe disposal of large quantities of wastewater.

Alternative solution to the problem of drainage could be to dig a very long channel or to spread water on land to maximize evaporation. This latter options obviously lead to

the conclusion that the most satisfactory solution would be to encourage villagers to channel all wastewater straight in to small garden at the out let of the drain. There by solving the water disposal problems and providing some horticultural produced through out the year.

Spring water is generally pure and may only be contaminated at spot where it emerges however; springs are susceptible to contamination by surface water, especially during rainstorms. Contamination sources include livestock, wildlife, crop fields, forestry activities and septic systems, located upslope from the spring outlet. Changes in color, taste, odor, or flow rate indicate possible contamination by surface water. To protect springs one can take the following measures.

- Divert all surface water away from the spring as far as possible. Do not allow flooding near the spring. Construct a U-shaped surface drainage diversion ditch or earthen drains at least 15m uphill from the spring to divert any surface runoff away from the spring. Be careful not to dig deep enough to uncover flowing groundwater. Prevent ponding in the diversion ditch.
- Construct an earth drain adjacent to the spring or a second U-shaped diversion ditch lined with concrete tile for added protection.
- Fence an area at least 30 meters in all directions around the spring box to prevent contamination by animals and people who are unaware of the spring's location.
- Avoid animal and human activities over the uphill water-bearing layer to prevent compaction that may reduce water flow.

For piped supply continuous technical and non-technical support and ensure the availability of necessary materials, tools and spare parts. Two or more care taker have to be selected and trained to carry out minor repairs and protection works, the water bureau have to provide continuous technical and non technical training for the selected care taker.



Figure 4.2-spring development in Gida



Figure 4.3-spring development in Kelem Myda



Figure 4.4 Spring Box in Kelem Myda



Figure 4.5 spring development in Chafe Mesendy



Figure 4.6 Improper spring tapping in Assa Erbat



Figure 4.7 Water points in Titta Genfoch



Figure 4.8 Exposed pipe in Font Nina spring development



Figure 4.9 Spring development in Derek Woyira

4.2.3. Shallow well

In the zone, 26 are not functional out of 54 shallow wells (inventory report, 2005). Consideration has been made on the wellhead status and lifting devices in describing the physical status of shallow wells. Because there is no any design, construction, or other document reports to deal with all the component of schemes. Out of 54 shallow well, two were visited to give a field inventory of the existing wells and their general conditions. All shallow wells are fitted with different types of pump. the depth and the diameter of each specific well is not known.

In the two sample schemes, questionnaires were discussed with community from the result of the finding the existing situation, major problem encountered and the remedial measure that should be taken to improve the service for each of the two schemes are discussed below.

4.2.3.1 Jemme

Shallow well in Jemme is found in Dessie zuria woreda 012 Keble located about at 2338 m elevation. It is fitted with diesel pump; water distribution was done through two public fountains. Water from the well was used for all domestic purposes. It was serving 150 household .It was constructed by an investor. Now a day the scheme is failed due to landslide. As it is known, the area is prone to landslide; it is obvious stability of shaft may not achieve unless especial treatment is done. There are many causes of well failure like casing and screen failure, collapse of well wall, and excessive fluid velocity. If the wrong materials are installed, if the screens are incorrectly located, or if the grout is bad, all these problems are the problem of the well itself. The problem in Jemme well can be especially difficult to treat since they can occur many feet far from the well with in all the area of the aquifer. But there is no alternatives water sources and site, and the village have been using the borehole and wish to continue using it, a full rehabilitation is required. It should be treated with provision strong lining casing, grouting, and screen with proper screen size and placed on proper place. Physical protection of the area also reduces such problems like Avoid heavy trucks, animals and human activities over the surrounding of water bearing layer to prevent compaction.

4.2.3.2 Mitikolo

Existing situation

Shallow well Mitikollo is found in Dessie Zuria woreda 08 Keble, Located about 1968mm elevation. The well is used as gravity piped supply system. Water lifting is

done with electric driven pump and 10,000 m³ volume storage tanker located at 2001m elevations. Water distribution is through three stand post and 236 house connections. It serves 16000 families. The water from the well is used for all domestic purposes.

Major problems

- I. All of the water points have problems like, the platform and the wall of stand post has crack, blocking of ditches and surrounded by standing water and rubbish, and the faucets are removed and the out let pipes are plugged with wood.
- II. The water utility uses electricity as its sole source of power. The electricity supplied by Ethiopia electric power corporation is reliable although sometimes there are power cuts.
- III. The presence of only one pump attendant, leads to frequent break down. Management of the operation is not efficient. It is common to take up to three hours to get ready for work. Spare parts are barely kept in stock. Often fresh purchase has to be made when a break down occurs. As the purchasing process is long especially when the item is expensive, repair work can be delayed even for a week with the fore going situation, it is impossible for the system to operate satisfactorily. Preventive maintenance appears to be almost unknown.
- IV. Operation and maintenance activities are filled with breakdowns especially the machinery. It is common to have a pump or motor break down within three days. This is a result of equipment being very old, few personnel and unsystematic operation and maintenance practice. A pump or motor break down causes an acute shortage of water. It is common for repair to take a few days.
- V. The expansion in the water system had not considered the town's rapid population growth. The distribution system is inadequate with greater part very old and may the conveyance capacity reduced due to deposits and much leakage. Pipe laying also not properly done. Pipe trenches shallowly and poorly dug. As the top cover is very little, in many places rains leaving many pipes unprotected have washed it away. Poor Water Quality, as a result, the incidence of waterborne diseases like diarrhea and typhoid is found among city dwellers. Also in the well sites, there are two toilettes at a distance less than 8 m.
- VI. Few of the consumers get the supply for 24 hour of a day and mostly with high pressure due to their geographical location. More of the consumers get water for the part of the day or no water at all for long day. At certain time, a specific area is supplied with water while the supply is shut for other areas and vise versa. This is so many households get water for only part of the day. Frequently reduced water production due to breakdowns of machinery and pumps, In general, the shortage is

felt in almost all areas and there is almost no area in the town where the supply is not reliable.

Remedial measure

- I. Properly fenced public fountain, regular tightening of fittings would help to reduce damage of faucet. Structural failure of stand post has to be maintained by plastering the crack. The standing water has to be drained and provision of proper drainage is required.
- II. To minimize the problem of water shortage at the time of power failure increasing the storage capacity or diesel pump alternatives is required.
- III. Forming community level water users association and building capacity for improving the association skills should come first from actual construction of the facility. Community organizations responsible for the O&M of the well should first be legally constituted and registered. The tariff collection should be regular, and tariff levels should be set according to the level of service and cover expenses for regular and periodic maintenance. This is a prerequisite for the sustainability of the facilities.
- IV. Preventive maintenance used for the identification of frequency and location of tasks to be performed and the allocation of the responsibility to under take these tasks. Preventive maintenance aims at prolonging the life of the equipment, reducing operational and maintenance costs and improving the reliability of a water supply system. An organization that dose not practice preventive maintenance looses money and probably gives unreliable services.
- V. Corroded pipes would lead to leakage and subsequently contamination of the water. Hence, where severe corrosion is observed in the pipeline, new pipes should replace corroded section. In case of leakage due to loose connection, the joint should be retightened with the help of appropriate jointing material.
- VI. The pressure in the water system is generally low in most of the places. The topography of the town is very hilly. At present there is almost no pressure boosting in the distribution network. With such topography pressure, boosting would be required in the distributions network to produce adequate pressures in all areas. Replacing old pipes and equipment is required to reduce leakage, pollution, frequency of break down, and repair cost.

4.2.3.3 Discussion

In the shallow well facilities, the water committees were poorly organized to handle the daily operation and routine maintenance. The tariff collected (i.e. 2 Birr per meter cube for house connection and 1.2 Birr per meter cube for public fountains) was barely sufficient to pay for maintenance and the water committee are not well equipped to handle repairs. Many systems were abandoned, when the repairs cost much more than what the water committee collected every month. Water quality was not being tested regularly.

The number of wells fails to give the intended benefits in the zone is too much. To know the cause of insufficiency a detail study is required. The groundwater resources appear to be the key to the development of the rural water supply industry and should therefore be managed and utilized on sustainable basis to meet future challenges is required. However, it has to be emphasized that due to geological limitations it is not everywhere that groundwater is available or available in the required quantities.

Simply replacing the pump is not, however, sufficient to ensure that the existing borehole does play a full part in the project by providing an adequate and reliable supply that is of an equal standard to that of the new water points. The design and construction defect of the existing boreholes to be known. Poor screen and inadequate gravel pack mean that many of the existing wells continue to pump sand through out their lives. Unless this problem is rectified, the new pump may require much more frequent maintenance than the pumps installed on the new project water supply points. A procedure for clearing out the existing boreholes and where appropriate, installing an inner lining and gravel pack is required.

Table 4.1 Summary of problems in some of sample hand dug wells

Name	Problems			Remedial measures		
	Technical	Institutional	Social	Technical	Institutional	Social
Alidally I	Not utilized due to quality problem (i.e. odor and turbidity)	Poor implementation of water policies and lack of capacities	Lack of awareness and lack motivations of users	Rehabilitate the well and arrange regular maintenance	Water implementing bodies should full fill their commitment to ensure sustainability	Creating awareness and encouraging users to take responsibilities of schemes
Alidally II	Quality, quantity, seasonal variability of yield, defect on pump, absence of protection work & lack of maintenance	Poor implementation of water policies and lack of capacities	Lack of awareness and lack motivations of users	-Regular water monitoring, -Tightening & greasing of bolt & nuts of pump, -Provide fence & drainage facilities	Water implementing bodies should full fill their commitment to ensure sustainability	Creating awareness and encouraging users to take responsibilities of schemes
Derk woyira & Endode Bere	Non-functional	---	---	---	---	---
Kelem Myda	Quality, non reliability, absence of protections work & lack of maintenance	Poor implementation of water policies and lack of capacities.	Lack of awareness and lack motivations of users	- Regular water monitoring, - Provide fence & drainage facilities - Provision of maintenance	Water implementing bodies should full fill their commitment to ensure sustainability	Creating awareness and encouraging users to take responsibilities of schemes

Meawa	Quality, quantity, incontinence, seasonal variation, absence of protection work & lack of maintenance	Poor implementation of water policies and lack of capacities	Lack of awareness and lack motivations of users	- Regular water monitoring, - Provide fence & drainage facilities Provision of maintenance	Water implementing bodies should full fill their commitment to ensure sustainability	Creating awareness and encouraging users to take responsibilities of schemes
Tulu Abajibo	Quality, quantity, incontinence, seasonal variation, absence of protection work & lack of maintenance	Poor implementation of water policies and lack of capacities	Lack of awareness and lack motivations of users	Repair plat form, regular quality checking, provide fence & drainage, and carry out regular maintenance	Water implementing bodies should full fill their commitment to ensure sustainability	Creating awareness and encouraging users to take responsibilities of schemes

Table 4.2 Summary of problems in some of sample spring development

Name	Problems			Remedial measures		
	Technical	Institutional	Social	Technical	Institutional	Social
Abo corchow	Improper spring tapping, - Leakage from spring box quality, -Absence of protection work	Poor implementation of water policies and lack of capacities	Lack of awareness and lack motivations of users	Tapping the spring properly, seal the spring box, and provide proper drainage facilities and protection work.	Water implementing bodies should full fill their commitment to ensure sustainability	Creating awareness and encouraging users to take responsibilities of schemes
Chefe Mesendy	-Improper spring tapping, -Leakage from spring box -Quality quantity, -Absence of protection work and maintenance	Poor implementation of water policies and lack of capacities	Lack of awareness and lack motivations of users	Tapping the spring properly, seal the spring box, quality monitoring and provide proper drainage facilities and protection work, and regular maintenance of facilities is required	Water implementing bodies should full fill their commitment to ensure sustainability	Creating awareness and encouraging users to take responsibilities of schemes
Font Nina	-Improper pipe laying, -Inconvenience location of water points -Insufficient	Poor implementation of water policies and lack of	Lack of awareness and lack motivations of users	Proper pipe laying and provision of proper protection work and regular maintenance of facilities is required.	Water implementing bodies should full fill their commitment to ensure	Creating awareness and encouraging users to take responsibilities of schemes

	protection work and maintenance	capacities			sustainability	
Wefku	-Quantity -Improper pipe laying, -Leakage from pipe & tank, Risk of pollution, - Absence of protection work and maintenance	Poor implementation of water policies and lack of capacities	Lack of awareness and lack motivations of users	Tightening pipe joints, proper pipe laying, and provision of proper protection work and regular maintenance of facilities is required.	Water implementing bodies should full fill their commitment to ensure sustainability	Creating awareness and encouraging users to take responsibilities of schemes
Ylemulu	Leakage from spring box and tapping, and lack of protection work and maintenance	Poor implementation of water policies and lack of capacities	Lack of awareness and lack motivations of users	Properly seal spring box and provision of appropriate protection facilities and regular maintenance of facilities is required	Water implementing bodies should full fill their commitment to ensure sustainability	Creating awareness and encouraging users to take responsibilities of schemes

5. TECHNICAL SUSTAINABILITY AND PERFORMANCE EVALUATION

5.1 General

The technical issues relating to the design, construction, operation, and maintenance of rural water supply system are the most determinant of technical sustainability of water supply projects. Even if detailed study of sustainability is essential for any water supply project to judge whether it is sustainable or not, this study bases its analysis on qualitative indicators that measures the technical aspect only. In this section, using the indicators given in chapter three the technical aspects, like functioning, utilization and performance of sample project will be discussed.

5.2 Physical Status of Schemes by type

Functionality is one of the main key indicators to describe the physical status of a scheme as it expresses best the general condition based on the working condition of each component of the scheme.

The status of the schemes has been designated based on their current working condition, the type and extent of failure/damage & the possibility of reinstatement repair and maintenance requirement for future utilization.

Accordingly, the following terms were used to designate the status of the schemes.

- i. Functional schemes (F): are schemes, which are in good working condition, and all their components are functional.
- ii. Partially functional schemes (PF): are schemes, which are in working condition, but some of its components are defective that require repair and maintenance.

Schemes included in this group are;

- a. Springs with defective faucets or water that leak partially through the base of the intake or collection chamber; water that leaks through the pipe line or fittings; etc
- b. Some hand dug wells or springs that are reported to be seasonal.
- c. Cracked manhole covers or cover slab that allows dirt into the well; Hand pumps with broken base plate or wearing parts.

- d. Schemes that are located very far from users and do not serve the intended population size.
 - e. Schemes with poor quality or taste that serve for laundry and washing purpose only
- III. Non functional schemes (NF): are schemes which are currently not functioning due to failure on one or more part/parts of their system/system components that could be maintained and made functional.
- Schemes included in this group are;
- a. Springs eye changes the course of flow or flow beneath the intake structure that water is not tapped and hence require the reconstruction of the intake or collection chamber etc.
 - b. Schemes where hand pumps or motorized pumps are not functional.
- IV. Abandoned Schemes: Are schemes, which have been abandoned and cannot be reinstated, like dried up springs, wells, etc.

In order to provide clear and broader picture, based on the above designation, out of the total rural water supply schemes existing in the sample woreda, detailed description of the physical status, are discussed in the following table.

Table 5.1: physical states of schemes

Schemes by type	Functional scheme (%)	Partially functional schemes (%)	Non-functional scheme (%)	Abandoned scheme (%)
Hand dug well	--	Five out of nine, well (56%)	Two out of, well Nine (22%)	Two out of nine (22%)
Spring development	Four out of eighteen, spring (22%)	Thirteen Out of eighteen spring (73 %)	One out of eighteen, spring (5%)	--
Shallow well *	--	One out of two, scheme (50%)	--	one out of two (50 %)

* In the woreda out of 54 shallow wells 26 are non functional (Inventory report, 2005)

5.3. Functioning

5.3.1 Quality

Existing water-supply systems are in a poor state of repair because of maintenance constraints, and most often, the population has to rely on unsafe water sources. Major problems associated with quality of drinking water in the zone are turbidity, taste and diarrheas (presence of water bourn disease). I realized that there should be a permanent solution for this problem. No regular cleaning and disinfections have been carried out. During the fieldwork, it was noted that the water bureau did disinfections of the schemes on non-regular basis and this highly depends on the accessibility of the schemes. The water quality (physical requirement like taste, odor and colure) is unacceptable for drinking in almost all facilities. Chemical testing for coliform and other bacteria is not regularly conducted in many facilities. In addition, most of the schemes are located in a potential contamination sources, like farm (the use of pesticide and fertilizers) and latrine. In the study Woredas the percentage of schemes facing all this problems are summarized in Table 4.2.

Table 5.2: percent on schemes having quality problems

Schemes	Taste	Turbidity	Diarrheas	Application Of disinfections
Hand dug well	57 % *	14 %	28 %	15 %
Spring development	44 %	61 %	66 %	33 %

(* it considers seven schemes because two schemes are non-functional.)

5.3.2 Quantity

Existing water-supply systems are in a poor state of repair because of maintenance constraints, and most often, the population has to rely on unsafe water sources. Major problems associated with quantity of drinking water are too many users, seasonality and the scheme does not deliver enough water quickly. I realize that there should be a permanent solution for this problem.

It is not possible to judge the adequacy of the rural water supply scheme due to lack of information on the yield of specific scheme and per capita consumption. In most of the cases, the real number of users per pump or public fountain or spring development is

not known. In addition, the number of users at rainy seasons and dry season are different.

Only domestic uses of water are considered in this survey. Domestic uses of water include drinking, cooking, bathing, clothes washing, and dish washing. Water that is suitable for drinking is also used for cooking. In all the hand dug wells and piped supply spring users reported obtaining their drinking water from a well and public fountain, and for bathing, clothes washing and animal watering reported using different water source like, rivers, ponds and unimproved spring source.

5.3.3 Convenience

The distance that households travel to collect water are provided in the appendix II. The average distance that a household travels to a water source is 2 km, the closest is 500meters, and the farthest is 5 km. In most areas, 71 % hand dug well and 55 % springs, seasonal variation of yield exist. This in itself can be viewed as a seasonal inconvenience, since a large number of households are using public sources due to inconvenient location and longer waiting time. Only about 31 per cent of rural households reported having their source of water within their Premises, the rest had to go out to fetch their drinking water. About 16 per cent of the schemes are located in distance less than 1 kilometer, 40 % in distance between 1 and 2 km, and 44 % in distance greater than 2 km. Seasonal disruption of supply is common, especially in months April, May, and June Households still depended on supplementary sources, especially where hand pumps are the main source.

A number of households reported that the locations of alternate water sources are more convenient for them. Inconvenient location of public supply points are a discouragement for using such sources by some beneficiaries. It is found that a number of households continued to depend on unprotected sources of water due to inconvenient location, frequent breakdown, longer waiting time, low yield, and bad quality of water, etc.

5.3.4 Reliability

Of the nine hand dug well previously mentioned, only 29 % have water available year round, in the rest of the scheme users reported the need to use a secondary water source due to seasonality, and in all these cases the secondary sources are near than the primary source. Of the eighteen spring development previously mentioned, only 45 % have water available year round, in the rest of the scheme users reported the need to use a secondary water source due to seasonality. The most striking feature during the dry season is the long queue that is the biggest problem of water supply system. They

spend a tremendous amount of time each day queuing for water because the spring or well does not deliver enough water quickly and as a result of the limited working hours of the operators in some of the place.

- x. Almost the entire sample village reported breakdown of modes during each year. In 80% of these cases, the frequency of breakdown is more than two. In addition to the high frequency of breakdown and length of time required for each repair is one of the problems of reliability of schemes as people clam especially for hand pump on average five days is required for maintenance. The incidence of breakdown is much higher in hand pump. If break down occurs at the beginning of the rainy season the delay could be particularly severe repairs may not be carried out until dry season.

5.4 Utilization

5.4.1. House hold using water

In most of the cases, the real number of users per well, spring or public fountain is not known. In addition, the number of users at rainy seasons and dry seasons are different because at rainy season many people use alternative unprotected sources such as seasonal rivers, small ponds, and seasonal springs. However, as presented in appendix II the numbers of users are too much when it is compared to the user specified in table: 3.1 for each source. Population growth affects all dimensions of sustainability.

5.4.2. Volume of water use

There has been a scarcity of reliable data on the water consumption of the study woredas. However, as presented in appendix II average house holed consumption is 40- 50 liters per day per family. If one considers a family size of 5; per capita consumption will be 8 – 10 liters. This is by half less than fixed by world health Organization (WHO), 20 liters per person per day.

5.4.3. Affordability

In 66 % of spring and 43 % of hand-dug wells water is provided free. In the five-piped water supply system, except in one of the shallow wells, the tariff is at flat rate in the rest of the schemes. A common regular payment is also towards operations of a water supply system, and in most of the cases where these regular payments are made; the money is used to buy tools and material for minor repairs.

5.4.4. Participation

In 83 % of spring development communities are involved in construction, by both in supplying of building materials (bricks, stones, sand, and water) and voluntary labor. In the rest of the springs and all hand dug wells all the tasks are performed by the water agencies. In the study Woredas, there is no feeling of ownership and responsibility among users to carry O&M. This can be endorsed to the lack of awareness among the public about the importance of community participation, and lack of motivation and promoting courage on the part of water bodies. Lack of community participation, is one of the main reasons towards low performance of the scheme, leading to excessive expenditure and low cost recovery. However, during the field survey people have expressed their willingness to participate in O&M of the scheme and to pay O&M costs and capital costs.

The selected water committees to mediate the users and water agencies do not operate efficiently. They do not collect tariffs regularly; they could not handle major repairs; and they do not have adequate training or skills to manage the system. From the survey, it is found that in many of the schemes water committee were created and some of the committee received training once upon a time some not yet. Nevertheless, in a very few of the schemes the committee performs their duties properly (i.e. conducting maintenance at the time of break down and collecting tariffs or payment for repair). In some, place often, traditional leaders carry out the task of managing the water system.

Project formulation itself has generally been treated purely as technical exercise and the local bodies are seldom involved in the process. The local bodies are formally consulted only about the financing pattern. During project execution also, there is little interaction with the local body. These factors have resulted in the lack of a sense of ownership among the public and local bodies in the schemes.

5.5. Evaluation of design and cost

The technical designs for the construction of the point source systems are simple and generally appropriate. Considering the simple ness of the structures, the construction quality is not satisfactory in most cases, absence or improper platforms and drainage at several sites, improper tapping and leaking spring boxes. There are sites where cracked manhole covers or cover slab that allows dirt into the well; Hand pumps with broken base plate or wearing parts of pump, leading to perennial water wastage. The hydro geological assessments in selection of sites of project facilities are generally based on

on-site interviews. Moreover, the Project could not anticipate the widespread pollution of shallow groundwater through ingress of surface runoff or spillage water. In addition, the study found that construction material quality has a major impact on sustainability. While construction material quality is difficult to evaluate qualitatively, from visual observation much of structural defects are arise from poor construction and using of poor quality materials.

The study found that project rules for cost-sharing arrangement are poorly defined in most of the project. The study was informed that there was no budgetary commitment from the Government to support the facilities once they are completed and handed over to the community. As indicated above in most of the schemes there is no means to collect water tariffs. The financial performance of the water projects is poor and the financial internal rates of return are negative. Financial sustainability should be guaranteed by the operation of a fee system that recovers at least the operational, maintenance, and replacement costs. 44% spring and 55 % hand dug well of the operational facilities collect water fees. The level of fees collected is not based on the calculated O&M and replacement costs. Considering these institutional, technical, and financial factors affecting the sustainability, the Project is rated as less likely to be sustainable.

5.6. Evaluation of operation and maintenance

The finding from the survey indicate that many communities are not well organized to operate and maintenance their water system. In much of the hand dug well and springs with public fountain system operators are hired. Even if communities have, system operator they have not received training to operate the system and many lacked the necessary tools to operate and maintain their system.

In most of the cases, no normal provisions have been made to monitor the functioning of the system. This explains the limited data available on maintenance of system performance. There is a general agreement on training, operation and maintenance between the answer given in the questionnaires and what was observed in the visits. The need for proper operation and maintenances is ignored. Schemes are constructed with out any clear assessment of the funds and manpower needed to keep them running, or of the logistical problems involved. As a result, a high percent of water supply systems break down soon after having been brought in to service. To operate successfully, stores, technical assistance, etc...must be available locally.

In the zone, emergency type maintenance is practiced. Maintenance and repairs are carried out only when major schemes break down. When ever a break down occurs there is no an immediate measure taken. It takes in average 8-10 days. This delays the

maintenance work often for more than 15 days. As the questionnaires showed that, in some of the cases, when system break down the community member collect money and do the minor repairs of the system. During this time water is not available, people brought it from unprotected sources. Although repair work is done to reduce the leakage, it is not very effective. Repair by local people faced with many problems, quality spare parts and materials are not readily available.

In general, most of the questionnaires point at lack of capacities and lack of finance as major cause of maintenance problem. Other problems encountered are Lack of responsibility on the part of the users, lack of spare parts and material, lack of capable manpower, poor financial management by local bodies, lack of monitoring, feedback, control, poor operation, inadequate collaboration, lack of transport and insufficient revenues.

5.7. Evaluation of Performance

Coverage is the proportion of community with reasonable access to an adequate amount of drinking water from improved sources. “Reasonable access to an adequate amount of drinking water” is defined as availability of water at least 20 liters per person per day from a source within one kilometer distance (UNDP 2001) .The water supply coverage estimated by the ministry of water resource is 23%, which is not on track with the MDGs targets. However, the accuracy of such estimates is questionable as the reliability of actual coverage is suspect. As describe in previous section of evaluation of functionality and utilization of existing schemes much proportion of them need rehabilitation, more than 78% spring development, 50 % shallow well, and almost all hand-dug wells have quality and quantity problems, need major repairs and the rest of the schemes are not functioning to design capacity.

All of the village households have reasonable access, as defined in UNDP (2001), to an adequate and safe water source that provides 20 liters per person per day within one kilometer of the household’s compound, but not all households obtain their domestic water from an improved water source. The distance households traveled to collect water from any type of water source Ranged between 500metres and 5 kilometers and averaged 2.5 kilometers. Due to long walking distance and long queues each day, users draw water twice a day and the amount per capita consumption is estimated 10 liter per day. Based on the definitions of “coverage” and “improved” water supplies facilities from the WHO/UNICEF (2000) report, the schemes in the wordas are not said to be efficiently performing. Even it is not possible to accept the above figure given by the

ministry. As long as the systems have not full filled the safe and adequate water, criteria set by WHO/UNICEF (2000).

The other important performance indicators applied to water supply systems are water production, water consumption, frequency of break down, unit operation cost, and continuity of service. The amount of water produced in each schemes are reduced due to ageing infrastructure, much leakage, and through spring box, pipeline and poor design and construction also due to improper tapping of spring. In much of the schemes the frequency of break down are too many, especially on piped supply system the break down happen 3-4 times a month. In all most schemes at the time of break down a minimum of 5 days are required for repair. To decide on all this indicators, there are no enough information's. But from the previous discussion on physical condition, functioning, utilization and from observations made in the 29 schemes, it can be concluded that the majority of water supply facilities that were constructed are no longer functioning as intended and it is possible to say almost all the schemes are not performing efficiently.

6. COMMON AND MAJOR PROBLEMS OF RURAL WATER SUPPLY PROJECTS IN THE SAMPLE WOREDAS

6.1 General

This chapter presents the main problems related to non-sustainability of schemes in the sample woredas. As defined in the previous chapter, sustainability of water supply project is related to so many factors. Like, technical, institutional, and social factors. All factors rather than technical factors, affects the technical factors directly or indirectly. Therefore in the preceding section all problems related to each factors are listed.

6.2 Technical problems

Technical issues relating to the design and construction of a rural water system are the most obvious determinants of water system sustainability or poor construction quality or the use of low-grade materials may lead to the failure of the water system before the end of its design life. Similarly, design flaws including shallow well or spring developments, and overestimates of the water sources may cause a system to fail from the outset.

From the technical problems observed at the time of field visit, the major and common ones are listed below.

6.2.1 Hand dug wells

- Poor sit selection
 - Located near high potential source of pollution.
 - Inconvenient
- Poor design and construction
 - Sand intrusion
 - High turbidity and taste
 - Seasonal Variation of supply
 - Insufficient discharge (low yield)
 - The number of storks to get water is very much
 - Unusual vibration and noise of pump
 - Distortion and crack of platform
 - Absence of protection work.
 - Absence of apron and drainage facilities

6.2.2. Spring protection

- Insufficient spring protection. i.e. the spring tapping structures are not located properly and exactly on spring eyes.
- Poor construction leading to leakage of spring boxes, pipes and reservoirs.
- The spring flow direction change, decrease of yield, sand delivery and so many small springs starts flow around the tapping structure
- There is no protection work done around the spring.
- The over flow pipes are completely covered by soil, vegetation and water which leads easy enter of frogs and insects to spring boxes.
- Location of standpipe, cattle trough, and washing basin are very close to each other.
- Lack of drainage facilities.
- In most of the spring point washing basins and cattle, troughs are non-functional.
- In most of the places water is polluted by users washing, laundry and allowing their cattle to stand in the water while filling jerry cans.
- There are many leakages in the spring tapping and boxes structures.
- In springs having house connections, pipe lying is not properly done. Pipe trenches were shallowly or poorly dug. As the top covers is very little in many place it has been washed away and rains leaving many pipes unprotect. In addition, intermittent supply due to low pressure.

6.2.3. Shallow wells

- Unsecured fuel supply.
- Poor site selection.
- Inadequate pump selection
- Inadequate reservoir capacity.
- For electric driven, pump shortage of water at the time of power failure.

6.3. Institutional problems

Even well constructed water system needs proper institutional arrangements to keep it functioning sustainably. Most systems required some sort of preventive maintenance. Hand pumps may require greasing of moving parts. Gravity systems may require sediment to be removed from storage tanks or repairs of leaking parts and cracked pipes. In addition, work is required to keep the water sources free from contamination. Because a number of families share most rural water systems, providing these inputs

requires some sort of community management structure, such as a water committee, to oversee O&M and collect money to convert the costs of these services.

The major institutional problems are:

- poor implementation of water policies
- Lack of coordination between users and water utility administration
- Lack of capacity to keep the system running after project completion.
- Lack of village level organization, like water user association and water committee.

6.4. Social problems

The sustainability of rural water supply system depends on the willingness of users to provide the necessary time, money and labor to keep the system functioning. This willingness may be affected by socioeconomic factors such as income level, or willingness of villagers to work together. More commonly, however, the willingness depends on consumer satisfaction with the service, usually compared to the previous water sources in a community. When communities perceive a significant improvement in water services, they are usually more willing to pay for O&M willingness-to-pay is also affected by community perceptions of ownership or sense of entitlement to free services from the government.

Main problems related to social aspects are:

- People are not satisfied with the service they get due to long walking distance and long queue each day, seasonal variation of service.
- People in the study wordas are very poor, who earn their cash income only once a year, at the time of harvest. They are not capable to generate revenue on monthly base.
- People are not aware of the benefits of improved water supply.

6.5. Environmental problem

There are a number of environmental issues to be taken into accounts that do not feature prominently at policy or implementation levels. The low environmental risks can be avoided with careful planning and design. Potential problems include possibility of landslides from gravity schemes; drainage problems around artesian wells; pollution of aquifers due to poor quality wellhead construction and the sitting of latrines close to well points; ponded wastewater around water points as breeding grounds for mosquitoes and water borne and water related diseases. In addition, it is absolutely necessary to ensure that safe water both bacteriologic ally and chemically

are delivered to the rural communities. The wastewater from washing slab stands flows on the surface of the source due to lack of drain.

6.6 Ranking of problems

Over all sustainability of rural water supply system can be measured using different parameters of sustainability. The problems related to each parameter are ranked below with the degree at which they cause failure in the study woredas.

6.6.1. Environmental problems

The first problem that deserves urgent attention in south wollo zone is environmental problem. Potential problems include, digging well in the center of farm land, locating of latrine close to a well point, etc... All this and other noticed problems result deterioration of ground water quality.

6.6.2 Institutional problems

This is the primary parameter to be considered in any water supply program but it is the most ignored one in the study area. Water supply system needs proper institutional arrangement to ensure sustainability. The problems significantly notices in the zone are:

- poor implementation of water policies
- Lack of coordination between users and water utility administration
- Lack of capacity to keep the system running after project completion.
- Lack of village level organization, like water user association and water committee.

6.6.3 Technical problem

The technical problems noticed in the sample woredas are also significant. That includes O&M, construction, and design respectively put in the order of causing considerable failure.

Summing up, O&M take the first rank as a technical failure. All water supply infrastructures need sort of preventive, routine and emergency maintenance and repair like any other engineering structures.

- In the zone there is no defined responsible body for carrying out this task..
- Lake of capacity on both sides of users and implementing bodies.

Poor construction reflected in the form of absence of apron, drainage facilities, insufficient spring protection and use poor quality construction materials also significantly contribute to failure.

Design takes almost a small proportion of technical problems. Avoiding over estimation of yield and inconveniency could solve this problem.

6.6.4. Financial and social problems

- poor implementation of financial policies in regard to water supply
- Limited budgetary support for keeping the schemes sustainable once they are handed over to communities.
- People are not well aware of the benefits of improved water supply.
- Lack of user motivation to pay for the service they get due to poverty.

7. TECHNOLOGY OPTIONS

7.1. General

In terms of service level, the technology options can be divided in two to groups, according to the way in which water is conveyed to the user's homes. Communal supplies from which the users carry out the water and pipes transport in to individual homes.

The service provided by communal supplies varies according to the amount of time it takes to travel to and from the source, to queue, and to fill containers: it depends too on the reliability of the supply at the source. Stand pipes are more convenient than hand pumps in that water is drawn from a tap rather than manual pumping.

Ground water is usually preferred over surface water sources, because it avoids the need for special, often unreliable measures to safe guard water quality or improves It through treatment. However, it needs some lifting or pumping devise. Many water-pumping systems have been constructed in different countries some systems work satisfactory whereas others stand abounded with in a few years because of insufficient maintenance or lack of spare parts.

If the selection is right, the schemes can be expected to provide the desired service level for many years, and may latter be upgraded to or replacing with, a technology giving higher service level.

In this section, different kinds of water pumping system suitable for small villages are discussed as option, like VL0M for manually operated hand pump and renewable energy sources like sun and wind for motor pumps.

7.2. Hand pump

7.2.1. The VL0M approach

This section describes the rational behind village level operation and maintenance (VL0M) approach to community water supplies. It then summarizes the various engineering solutions, which have been developed to fulfill the need for hard ware, which is suitable for (VL0M) management systems.

Rational

Traditional rural water supply schemes have been characterized by the use of expensive and sophisticated imported equipments. This has been operated and maintained under a centralized system using skilled personnel who rely on considerable engineering back up. Usually the full recurrent costs have been borne by government departments. Often, community themselves have had no involvement in the planning and implementation process, such schemes have generally proved to be unsustainable, due to high cost and other logistical problems inherent in carrying out centralized maintenance over widely dispersed rural community. The lack of community involvement in the planning, implementation and financing process has resulted in communities not feeling a sense of ownership, therefore responsibility, for the supply. These factors together with the need to import spare parts, have led to unacceptable long equipment downtimes, with significant proportions of equipment out of action at any given time (WRC, 1989)

7.2.2 New concepts of VLOM Hand pumps

- Availability
- Wearing parts /non wearing parts
- Pump design for VLOM maintenance systems
- Local manufacture-of complete pump is desirable-of spare parts are essential.
- Single, relatively small cylinder diameter-reduces pump internal forces-reduces number of spare parts-reduce down hole components, simplifying installation and maintenance. Pump water output is not reduced.
- Adjusting handle to optimize operating force and water delivery.
- Easy connect/ disconnect pump rods.
- Extractable plunger and foot valve without removal of rising main.
- Rationalize pump components and spare parts.

Lever action/ direct action

Direct action pump can be used at water level down to around 12 -15 meters. They are simpler, cheaper than lever action pumps, and easier to maintain. Training of pump caretakers is therefore simplified. The main difference between the two pumps is that in direct-action pumps the operators apply the pumping effort directly to the pump rod. Usually by means of a 't bar' handle and the pump lever with its associated hanger and fulcrum bearing assemblies is eliminated. In other respects direct action pumps, down hole components are extractable without removing the rising main, maintenance is straight forward using few tools, and spare parts are cheap, locally available and easy to fit.

Direct action pumps have a further important advantage. Unlike suction pumps, which are limited by the atmospheric head and can only pump from the water levels of around 7 meters maximum, direct action pumps can work down to 12- 15 meters. Further more, because direct action pumps have their cylinders below the water level. They do not required priming. They offer the same levels of sanitary protection as lever- action pumps.

Direct-action pumps should be considered for installation on hand dug wells or boreholes wherever water levels permits and should form parts of the technical strategy for all rural hand pump program.

7.2.3. New VLOM Hand pump production

The UNDP/World bank program has carried out development work on hand pumps and worked closely with other agencies such as UNICEF. On hand pump suitable for village level operation and maintenance. The following hand pump are now in production and available commercially.

Tara

This direct action pump was developed in Bangladesh and is suitable for users group where pumping requirement do not exceed around 1.5 cubic meters per day. The pump is cheep, simple to maintenance.

Afradiy

This is a deep well, community hand pump suitable for water level from 10 – 45 meters. It features May innovative design features including the uses of plastic bearing bushes for the handle bearing assemblies.

Afradive direct action

This pump is designed for community use and prototypes are currently being tested in Kenya and Malawi with encouraging results. The Afradive direct action uses the same down hole component as the Afradive deep well pumps, giving a use full rationalization on components and spare parts. It shares other features such as the flange mounting and rising main suspension system.

Indian MK III

This is a deep well community hand pump developed from the India MK II. Modifying the pump head and making the plunger and foot valves extractable with out the

necessity of removing the rising main have considerably simplified maintenance. It has been field tested in India and have recently gone in to production.

7.2.4. Standardization

Most countries with hand pump schemes use a variety of different types of pump. Using of different types of pump cause spares parts and methods of fixing the above ground parts on boreholes or dug wells different for each type. This means that spare parts have to be imported from the country of origin for each type of pump and that it is not possible to remove one type of pump and replacement it with other.

Several of the design concepts incorporate to the latest generation of VLOM hand pumps are intended to rationalize as far as possible. Pump components and spare parts. The use of in the Afradive of a single cylinder diameter for all pumping applications and a standard fixing flanger for direct, action and lever action pumps is an example of this approach. Standardization on pump hard ware can have significant advantages with in a country. As well as reducing the number of different spare parts and permitting pumps to be replaced with different ones, it has important benefits in reducing the cost of stocking and distributing spares. It also simplifies the training of caretaker and pump mechanics, and production quality control during local manufactures.

Ideally, section an agencies should settle on a limited number of hand pumps for a country water programmers. When different pumps are in use efforts should be made to standardize dimensions and spare parts wherever possible.

7.3. Energy sources for water pump

For water pumping in rural areas, renewable energy sources such as sun and wind or water offer a competitive alternative to the traditional diesel or petrol. Pumping systems driven by renewable energy normally have a lower operation and maintenance cost than diesel powered systems but required higher investment cost. Reliability depends on the metrological conditions. There fore a correct understanding and interpretation of meteorological data is of greatest important when designing pumping systems.

7.3.1. Solar energy

Water pumping can be powered by solar energy in most regions. The solar radiation can be converted to electricity in photovoltaic systems. Photovoltaic systems are reliable and inexpensive to run. There relative high investment costs make this unit most suitable for areas with more than five to six daily sun hours or for isolated areas

where reliability is imperative. Photovoltaic-pumping systems are available for normal flow head conditions. The power range is between 0.4 and 2 KW. Photovoltaic systems are most economical at low power demand and high solar radiation.

7.3.2. Wind energy

Wind energy is largest potential is in coastal and desert regions, where the wind is strong and regular windmills for water pumping requires a relatively low investment and in good wind conditions can lift water at a low operating cost. Windmill can pump water or produce electricity for a motor and pump. Windmills are very sensitive to variations in wind speed. The diurnal, monthly and annually variation of wind speed must be measured and considered carefully before construction. Windmills are available for normal flow head conditions some windmills can also be built or produced locally (Sam and Roy, 1985).

8 CONCLUSIONS AND RECOMMENDATIONS

In the study area Projects were formulated through supply-driven approach and with out consultation with representatives of communities. The supply of water facilities to rural populations like Kalu and Dessie Zuriya often presents difficult in technical and organizational issues. This applies to both project implementation and operation of facilities. When rural communities do not express a clear demand for such services, are not part of the planning, design and implementation process, are not trained, and are not willing to pay for a major part of the investment and recurrent operational costs, then efforts are likely to fail. In the study areas the local bodies are formally consulted only about their contribution on labor and some materials only. During project execution also, there is little interaction with community. These factors have resulted in lack of sense of ownership in the study area communities.

Project design should recognize the need for community involvement in planning, design and construction to guarantee sustainability. Effective O&M, including cost recovery, will take place only when the community accepts full ownership of the facility. Project formulation itself should be treated purely as a technical exercise and the communities have to be involved in the process. To increase the level of ownership of future project, appropriate measures should be incorporated in the project design, such as capacity-building program for sector agencies and communities, and clear delineation of responsibilities among central, local agencies and communities. Appropriate organizations need to be built up and strengthened before, or alongside, project implementation

There is no effort made to train and capacitate the community to take responsibilities of their schemes. Provision of adequate training for rural water personnel and villagers should be included in village water program. Carrying out a training program will ensure proper and continuing O&M of water supply components.

From the survey it is noticed that O&M is by far the weakest aspect of most of the sample projects. Poor administrative and technical support and lack of operating fund

are cited as the most frequent cause of failure. Improvement would not be achieved unless the improved source is properly maintained and used. Proper operation and maintenance should therefore be central to the remedial measures to be taken.

Failure of Projects to involve the community and to successfully complete the institutional capacity-building component has a key impact on the success of the Projects. Water bureau is responsible for community mobilization but was insufficiently involved, and have insufficient fund and manpower for full interventions. Institutional weakness is the most significant problem in the study woredas. Stated objectives are no set for the utilities. The water bureaus are not also supporting the utilities efficiently. NGOs and donors are the primary implementing bodies of rural water supply projects but they are reluctant to do O&M. They allocate funds for construction of new schemes with out any assessment of the cost and manpower requirement for running completed projects. Therefore all governmental and non-governmental bodies should share certain responsibilities to reduce maintenance problem and to ensure more reliable functioning of facilities. To undertake such a responsibility integration of efforts under the woreda water supply, sanitation hygiene team composed of all stakeholders is required.

Quality is a crucially important parameter to be monitored in water supply. Though it looks that water quality monitoring is neglected in the study areas. Water quality checks and control (i.e. physical, chemical and bacteriological) before putting the system in to use as well as on a regular basis should be considered in the future.

The problems I have seen in the sample schemes are problems associated to the utilization system as a whole but not on water production as most of the schemes are springs. Therefore In addition to using Water for basic needs such as drinking, cooking and hygiene, a wide range of productive uses should be promoted. These uses empower rural women economically and help in changing the livelihood of the poor.

The villagers should be motivated to take over routine O&M activities and contribute funds for repair and maintenance, as it is not possible for the Government agencies to handle routine O&M responsibilities.

Although technical sustainability depends largely on design and construction, it also depends on economic, social, political, cultural, financial, technological, and management aspects. Addressing these aspects calls for a well-designed, long-term, water supply monitoring and evaluation program complemented by all stakeholders.

There are insufficient data on the magnitude and nature of drinking water system problems. Lack of information and documentation are possibly one of the main reasons why so far sustainability is not assured. Since a large number of households were found not to regularly use the public taps, due to inconvenient location, longer waiting time and seasonality of flow, it would be advisable to make adjustments on the number of beneficiaries per scheme.

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Appendixes

Appendixes I

Questionnaires

For The community

The following questionnaire is part of a research work, which is being conducted to know the technical sustainability of rural water supply project in the Amhara regional state, case study south Wollo. Answer to the questions will be used as a part of the efforts to find a solution to technical problems of scheme. You are kindly requested to fill the questionnaire as truly as you can and your answer will be taken in confident.

- Woreda -----
- Keble -----
- Place -----
- Date -----

1. Source of water for household -----

- Hand dug well
- Spring
- Bore hole
- Shallow well
- Other (specify)

2. Source of project initiative -----

- Inside community
- Local government
- Project
- Other (specify)

3. What do you think about the taste, odor, and color? -----

- Very good
- Good
- Fair
- Not good
- No

4. Estimated walking distance. -----

- Less than 100m
- 200m
- 500m

- 1km
- More than 1km

5. Are you satisfied with the distance from previous source? -----

- Yes
- No

6. Do you get water for all 24 hour of the day? -----

- Yes
- No

7. House hold members mainly transport water -----

- Mother
- Children
- Other (specify)

8 .Water containers -----

- Jerry can
- Bucket
- Metal barrel
- "Insera"
- Other (specify)

9. Is there frequent queues? -----

- Yes
- No

-If yes, for how long? -----

10. Do you have other option to meet your water requirements? -----

- Yes
- No

- If yes, what water source is that? -----

11. List all of the current water use -----

12. Source of water other than drinking and cooking -----

13. Do you pay for the water? -----

- Yes
- No

- If yes, how much is it? -----

- Are you willing to pay more than what you pay now to improve the service? -----

14. Is there a water system operator? -----

- Yes
- No

- If yes, are these employees paid? -----

15. Do you think that the operators are sufficiently trained their job. ----

- Yes
- No

16. Are there people appointed for maintenance? (Caretaker) -----

- Yes
- No

17. Are the caretakers sufficiently trained? -----

- Yes
- No

18. Do caretakers have access to tools, spare parts? -----

- Yes
- No

19. Dose the caretaker has adequate access to spare parts? -----

- Yes
- No

20. Does the caretaker have operation and maintenance manual? -----

- Yes
- No

- If yes, how often they are updated? -----

21. Is there any activity for preventive maintenance? -----

- Yes
- No

22. What step do you follow at emergency break down? -----

23. When the system breakdown how many days dose it take on average to repair? -----

24. What part of the scheme regularly breakdown? -----

25. How many times has the system failed in the last year? -----

26. How is the annual operation and maintenance cost covered? -----

27. Are you satisfied with the existing operation and maintenance statues of the water supply facilities? -----

- Yes
- No

- If No, in what respect are you not satisfied? -----

- Water quality is not good

- Water is not available most of the time
- Facilities are deteriorating
- Amount of Water is not enough
- Water price is expensive
- Others (specify)

28. Is there a registered water committee? -----

- Yes
- No

- If yes, how many people? -----

- What is the role of the water committee? -----

29. Are these water committee members paid? -----

- Yes
- No

- If yes, in cash or in kind -----

30. How much expense does Water committee have?

- For the caretaker -----.
- Operation -----
- Maintenance -----

31. Are women chosen as a member of the water committee? -----

- Yes
- No

32. What was the community role at the time of planning, design and construction of the water System? -----

33. Can you suggest some ways to improve the scheme? -----

34. What additional resource do you need to keep the system running and looking like it should? -----

35. Is water available year round? -----

- Yes
- No

36. Are there problems with the water source(s)? -----

- Yes
- No

37. What is the water used for?

- Yes
- No

For the official

The following questionnaire is part of a research work, which is being conducted to know the technical sustainability of rural water supply project in the Amhara regional state case study , case study south Wollo. Answer to the questionnaire will be used as a part of the efforts to find a solution to a technical problem of scheme. You are kindly asked to fill the questionnaire as truly as you can and your answer will be taken in confident.

- Woreda -----
- Keble -----
- Place -----
- Date -----

1. Source of project initiative -----

- Inside community?
- Local government?
- Project
- Other (specify)

2. Source of water for household -----

- Hand dug well
- Spring
- Bore hole
- Shallow well
- Other (specify)

3. Did the community participate on the choice of source, location of water point and technology?

4. What limitation did you face to implement other types of scheme? -----

5. Did you conduct detail hydro geological investigation study? and what was that -----

6. Did you properly collect and analyze the obtained data and information? -----

7. Did you apply appropriate drilling technique? -----

8. Did you utilize local materials? -----

9. How many people served by your water system? -----

10. How much is the estimated water consumption? (Lt/day/capita) -----

Out of this how much water (Lit/day/capita) is used for? -----

- Cooking and drinking-----
- Personal washing and bathing-----

- washing clothes -----
11. What type of problem did you face at the time of design & construction? -----
12. What was the contribution of the community at all stage / or project cycle? ----
13. Are any programs currently in place to give support on operation and maintenance? -
- Yes
 - No
- If No, who is responsible to carry it? -----
14. Are there a registered water committee? -----
- Yes
 - No
- If yes, how many people?
- What is the role the water committee? -----
15. How do you communicate with the consumer? -----
- In an emergence-----

 - When maintenance is performed -----

 - When improvement are planned -----

16. Do you have schedule of training for the water committee and users? -----
17. Do you provide operation and maintenance training for the water committee? -----
- Yes
 - No
18. What steps are being taken at the time of emergence? -----
29. How many times has the system failed within a year? -----
- Hand dug well
 - Spring
 - Bore hole
 - Shallow well
20. When the system breakdown how many days dose it take on average to repair? -----
21. Do operators have access to tools, spare parts and manual? -----
22. Does the community have operation and maintenance manual? -----
- Yes

- No

- If yes how often they are updated? -----

23. In what kind the beneficiaries are expected to contribute to wards the operation and maintenance of their water supply

- Labor (percentage)
- Cash (Birr)
- Material (kind)

24. How is the annual operation and maintenance cost covered? -----

25. Do you have adequate access to spare parts? -----

- Yes
- No

26. What part of the scheme regularly breakdown? -----

27. What additional resource do you need to keep the system running and looking like it should?

28. Please suggest any improvement to be done for technical sustainability-----

29. What is your career objective as a woreda water bureau? -----

Thank you very much for your answers

Appendix II

Summery of general conditions of schemes

1. Hand dug well

No.	1	2	3	4	5	6	7	8	9
Name	Ali dale I	Ali dale II	Derek woyiera	Endod bere	Gerado high school	Kelem meda	meawa	Tulu abajebbo	Wuha ambo
Woreda	Kalu	Kalu	Dessie zuria	Dessie zuria	Dessie zuria	Dessie zuria	kalu	kalu	Dessie zuria
Year of construction	1982	1982	--	--	---	1992	1982	1982	1992
Population	100 house hold	200 House hold	--	--	School community	150House hold	150 House hold	520 people	200 House hold
walking distance	1.5 km	1 km	Non functional	Non functional	-	1 km	500m	1.5 km	3 km
Water consumption	--	(40-50)litter /day/family (only for drinking &cooking)	--	--	--	it is not deliver more than 80-100 lit per day	(40-50)litter/ day/family drinking &cooking	(40-50)litter/ day/family drinking &cooking	(40-50)litter /day/family
Yield	--	0.111 liter per second with seasonal variation	--	--	Small with seasonal variation	80-100 lit per day	0.15 liter per second with seasonal variation	0.101 liter per second with seasonal variations	0.278 liter per second

Condition of pump	Good	Un usual noise and vibration	--	--	un usual noise and vibration and need much stoke to deliver water	Good	un usual noise and vibration	un usual noise and vibration and need much stoke to deliver water	un usual noise and vibration
Taste	Salty	Salty	--	--	Good	Good	Salty	salty	Good
Odor	Bad	Good	--	--	Good	Good	Good	Good	Good
Color	Not good	Not good	--	--	Not good	Good	Not good	Not good	Good
Turbidity	turbidity	turbidity & Silt intrusion	--	--	silt intrusion	Good	silt intrusion	Silt intrusion	Good
Queues	--	2 hour	--	--	--	>>>> 10 days	NO	2 hour	Yes, 3 hour
Alternative options	Unprotect ed spring and river	River	Unprotect ed spring and river	Unprotected spring and river	--	pond and unprotected spring	River	River	River
Revenue	NO	for operator 1 birt/ family / month	--	--	--	NO	For operator 0.30 birt / family / month	for operator 0.50 birt / family / month	for operator 0.60 birt / family / month
operator training	NO	Yes	--	--	--	yes	Yes	yes	Yes
Preventive maintenance	NO	NO	--	--	NO	NO	No	NO	NO
Disinfections	NO	NO	--	--	NO	NO	NO	NO	NO

Community contribution	Labor & material	Nothing	--	--	Nothing	Labor ,money & material	Labor & material	Labor & material	Labor & material
Health risk	NO	diarrheas	--	--	NO	NO	No	diarrhoeal	NO
Protection work	NO	no	--	--	Pollution risk at 10 m	NO	located at center of farm	located center of farm	Good
diversion ditch	NO	NO	--	--	NO	NO	NO	No	No
drainage Facilities	NO	Good	--	---	No	NO	NO	No	Fair
Apron and Plat form of	Distorted and cracked	good	--	--	Distorted and cracked	no	Distorted and cracked	good	no
conditions of the surrounding	--	Muddy, full of rubbish, and algae growth Good	--	--	Muddy , and full of rubbish,	----	Muddy ,full of rubbish, and algae growth	Muddy ,	Muddy , and full of rubbish,

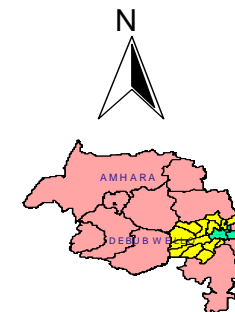
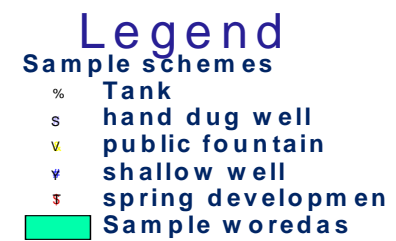
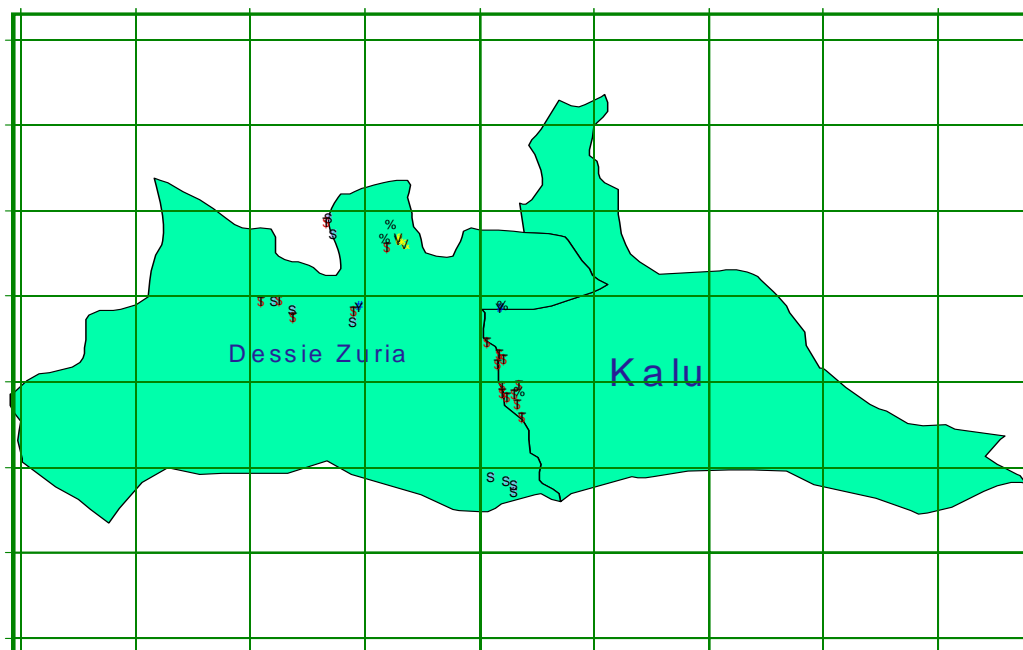
	Not Good	Not Good	Not Good		Not Good	Good	Good	Good	Good	Not Good	Good	Not Good	Not Good	Good	Good	Not Good	Not Good	Not Good
Turbidity	Turbid Silt Intrusion	Turbid	Turbid	Good	Turbid	Good	Good	Good	Good	Turbid	Good	Turbid	Turbid	Good	Good	Turbid Silt Intrusion	Turbid	Turbid
Queue	1- 2 Hours	>> 1houre Morning And Evening	>> 1houre Morning And Evening	>> 1hours Morning And Evening	3 Hours	>> 2 Hours Morning And Evening	No	Yes 3 -4 Hours	No	Yes >>1.30 Hours	>> One Week	>>2 Hour	Yes 30 Minute	Yes >>1.30 Hours	No	>> 1hour Morning	>> 1hour	Yes>> 1 Hours
Alternative option	No	No	No	No	Yes River	Yes River	No	No	No	Yes River	Pond	No	Yes River	No	No	No	No	Yes River
Revenue	No	No	No	1b/M/F** For Operator	No	No	0.50 B/M/F For Operator	1b/M/F** For Operator	1b/M/F** For Operator	No	1B/M/F** For Operator	1B/M/F** For Operator	NO	No	One Birr Per Meter Cube	No	0.50 B/M/F For Operator	NO
Operator	NO	NO	NO	YES	NO	No	No	Yes	Yes	No	Yes	Yes	No	No	Yes	No	No	No
Training	NO	NO	NO	NO	NO	No	Yes	No	No	No	No	No	No	No	No	No	No	No
Preventive maintenance	NO	NO	NO	NO	NO	No	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No
Disinfections	NO	NO	NO	NO	NO	No	Yes	Yes	Yes	NO	No	No	NO	No	No	No	NO	NO
Community contribution	Labor and material	Labor material & money	Labor material & money	Labor only	Labor material & money	Labor and material	Labor	Labor & material	Labor and material	Labor and material	Labor and material	---	---	Labor only	Labor only	Labor material & money	Labor and material	Labor and material
Health risk	Malaria, diarrheas and Alket Cattle case	Malaria Alket Cattle case	Malaria, diarrhea, Alket Cattle case	NO	Malaria	Malaria, diarrhea, Alket Cattle case	NO	NO	Malaria	Malaria,& diarrheas ,	No	Malaria,& diarrheas ,	Malaria,& diarrheas ,	NO	Malaria,& diarrheas ,	Malaria, diarrheas , Alket Cattle case	NO	Malaria & diarrheas
Protection work	No	No	No	NO	NO	NO	NO	NO	No	NO	NO	No	NO	NO	NO	NO	NO	NO
Diversion ditch	No	No	No	NO	NO	NO	NO	NO	No	NO	NO	No	NO	NO	NO	NO	NO	NO
Drainage Facilities	No	No	No	NO	No	NO	Yes	Yes	No	NO	Yes	NO	NO	NO	NO	NO	NO	NO
Conditions of the surrounding	Muddy ,full of rubbish, animal drop, and algae growth	Muddy, full of rubbish, & animal drop,	Muddy ,full of rubbish, animal drop, and algae growth	Good	Muddy , full of rubbish , animal drop, and algae growth	Muddy ,full of rubbish, animal drop, and algae growth	Good	Good	Swampy	Muddy ,full of rubbish, animal drop, and algae growth	Muddy and ,full of rubbish,	Muddy and ,full of rubbish	Muddy ,full of rubbish, animal drop, and algae growth d	Muddy & ,full of rubbish,	Muddy ,full of rubbish, animal drop, and algae growth	Muddy ,full of rubbish, animal drop, and algae growth	Muddy & ,full of rubbish,	Muddy ,full of rubbish, animal drop, and algae growth

* Litter per family per day (lit/day)

** Birrper family per month (B/M/F)

Appendix III
Location of schemes

Location of schemes



Appendix IV

For sustainable rural water supply systems, key conditions and key issues to be considered are summarized in the table below.

key conditions	key issues
<p>1. <u>Technology choice</u></p> <p>Technology selection must be primarily based on identified maintenance requirements and local resources. User involvement in technology choice and selection of services level increases the possibility of adequate maintenance and better use of the facilities.</p> <p>Technology has to be affordable, which means that, users can pay for maintenance and possibly construction costs. Alternatively, a system of cross subsidies must be adopted.</p> <p>technology must be technically feasible which means that the quality of the system must be acceptable and suit the local conditions</p> <p>Standardization of technology simplifies maintenance. It facilitates developing national and regional capacities for maintenance, and the introduction of quality standards.</p>	<p>Service level, technology type, maintenance tasks, caretaker training, community organization, finance, control.</p> <p>Total annual costs, per capital costs, annual maintenance costs, cross-subsidies, service levels, technology level, willingness to pay, control of funds.</p> <p>Level of available expertise, quality of systems and components, availability of spare parts, tools and materials, environmental and geo-hydrological conditions.</p> <p>Choice of suppliers, manpower development and training, local production of spare parts, workshop management, price control, quality control.</p>

<p>2. <u>Institutional arrangement and legislation</u></p> <p>The maintenance system needs to be formalized. Tasks, responsibilities and rights of all parties have to be clearly identified, agreed up on and authorized.</p>	<p>Task analysis ,control powers, sanctions, legislation, contractions, overall management ,preventive maintenance, repair, spare parts supply revenue collection, personnel management, and training, monitoring.</p>
<p>3.<u>Logestics</u></p> <p>The supply and distribution of spare parts should be guaranteed and organized before project implementation starts. Short-term solutions do not suffice.</p> <p>Immediate repair of facilities is essential. In case local conditions prevent maintenance team to travel, alternatives are required such as VLOM options or installing additional facilities.</p> <p>Replacement of system components combined with repairs in well equipped workshops will allow for better quality control and improve reliability of repairs.</p>	<p>Impact regulations, local production system, and price competition, role of private sector, quality control, stock keeping, monitoring, and standardization.</p> <p>Access roads, transport costs, local storage of spares, caretaker selection and training, community organization.</p> <p>System components, workshops equipment manpower, transport quality control.</p>
<p>4. <u>Financial viability</u></p> <p>Financial assessment should include all costs, and all available revenues, including taxation by local governments.</p> <p>Revenue collection mechanisms need to be developed and agreed upon prior to</p>	<p>Direct maintenance costs, total system costs, depreciation, revenues, service level, Subsidies.</p> <p>Tariffs, community based financial management, budgeting for maintenance,</p>

<p>construction.</p>	<p>control, training, and bookkeeping.</p>
<p>5. <u>Man power development and training</u></p> <p>Training efforts need to be based on care full assessment of required skills and long term man power requirements. Acquired knowledge should also be applied.</p> <p>Job satisfaction is very important to keep safe and villagers motivated. This requires flexible organizations and personnel management.</p>	<p>Task analysis, manpower planning (decentralized) training, selection of trainee's formal status, operation working relations.</p> <p>Salary, income generation personnel management, career planning, job rotation fringe benefits, side jobs, accountability, sanctions.</p>
<p>6. <u>Monitoring and control</u></p> <p>Monitoring on the bases of selected information is a basic requirement for management of available resources.</p> <p>Control of the quality of equipment that installed and spare parts that are provided is needed and should meet agreed standards.</p>	<p>Monitoring criteria, indicators, data collection, records, standards (number of users, water consumption, break-downs, and costs), user's satisfaction, feed- back, corrective measures.</p> <p>standards, legislation , local manufacture , sanctions m quality codes</p>