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Assessment of Non-Functionality of Rural Water Supply Schemes The Case of Lailay Maichew Woreda, Tigray Region, Ethiopia

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A Thesis Submitted to the School of Graduate Studies of Addis Ababa University in Partial Fulfillment of the Requirements for the Degree of MASTERS OF SCIENCE in Civil and Environmental Engineering

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Certification

This is to certify that the thesis prepared by Haftom Yalembrhan , entitled: **Assessment of Non-Functionality of Rural Water Supply Schemes : The Case of Lailay Maichew Woreda, Tigray Region, Ethiopia** is submitted in partial fulfillment of the requirements for the degree of Master of Science in Civil and Environmental Engineering (major in Hydraulic Engineering).

As member of the board of examiners of the MSc. thesis open defense examinations, we certify that we have read, evaluated the thesis and be accepted as fulfilling the thesis requirement for the degree of Master of Science in Civil and Environmental Engineering (major in Hydraulic Engineering).

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DECLARATION

I, the undersigned, declare that this thesis is my original work performed under the supervision of my research advisor Dr.-Ing. Geremew Sahilu and has not been presented as a thesis for a degree in any other university. All sources of materials used for this thesis have also been duly acknowledged.

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ABSTRACT

Assessment of the main causes of non-functionality of rural water supply schemes in Lailay Maichew Woreda has been the main objective of this research. To assess the major causes of non-functionality primary and secondary data was collected from 407 rural water supply schemes (RWSS) of the woreda. Secondary data was collected from respective governmental and non-governmental organization at federal, state and woreda level. Primary data was collected through questionnaire, key informant interview, focus group discussion and observation.

The secondary and primary data sources have been useful to assess all non-functional schemes in the woreda. All types of rural water supply schemes include hand dug well, shallow well, spring development at spot and deep well have been studied and analyzed for their main cause of non-functionality in the woreda.

The average non-functionality period of schemes in the study area is seven years. Most non-functionality occurs much lesser than expected design periods. Two third of water schemes failed lower than a minimum design period, which is 10 years. Compare to scheme type spring development at spot becomes the best scheme of the study area.

The main causes of non-functionality are technical problems including construction, yield, quality, site selection problems, management of operational and maintenance problems including mechanical and management problems, financial problems, institutional problems and others including social, cultural, gender, health and education problems. Among those individual causes of non-functionality, financial problems score high (18.02%). Generally, management of operational and maintenance problems score high (35.27%) and technical problems scores 33.02% which is the second main cause of non-functionality of RWSSs.

The researcher strongly recommended that community participation should be in all stage of scheme development not only during construction, local well train construction and supervision firm should be available during scheme design and construction with standard design and construction manuals, technical training for community water committee and care takers should be continuous throughout scheme design period and monitoring of schemes through the coordination of different institutions should be develop for functional sustainability of RWSSs.

Key words: *Non-Functionality, Rural Water Supply Schemes, Technical, Management*

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ACRONYMS AND ABBREVIATIONS

ASA	American statistical association
DPW	Deep well
DTH	Down the hole
FGD	Focus group discussion
GI	Galvanized iron
HDW	Hand dug well
HH	House holds
HHS	Households survey
MDG	Millennium development goal
MoWR	Ministry of water resources
MoWE	Ministry of water and energy, Ethiopia
MWRI	Ministry of water resources and irrigation, Sudan
NGO	Nongovernmental organization
NWI	National WASH inventory
O&M	Operational and maintenance
PE	Polyethylene
PRV	Pressure reducing valves
PVC	Polyvinyl chloride
REST	Relief Society of Tigray
RWSN	Rural water supply network
RWSS	Rural water supply scheme
RWSSHP	Rural water supply scheme sanitation and Hygiene program
SHW	Shallow well
SNNPRS	Southern nation nationality peoples regional state
SPR	Spring development at spot
TWRDE	Tigray water resources, mines and energy bureau
UN	United nation

UNDP	United nation development program
UNICEF	United nation children fund
WASH	Water Sanitation and Hygiene
WATSANCO	Water and Sanitation Committee
WWRDO	Woreda water resources development office
WOPF	Laelay Maichew Woreda office of plan and finance
WHO	World health organization
WPF-IF	Water point functionality intervention framework
WSSCC	Water Supply and Sanitation collaborative council

- Kushet: Lowest local administrative body equivalent to sub of sub-district.
- Kebele or Tabiea: Lowest administrative body in Ethiopia equivalent to sub-district.
- Woreda: Administrative body in Ethiopian next to Kebele equivalent to distric

1. Introduction

1.1. Background

Wise utilization of water resources is becoming very important as world faces water crises which could hold back human development. According to Millennium Development Goal (MDG) summit Report UNDP (2010), progress on the MDG 7 target "to reduce by half the proportion of people without sustainable access to safe drinking water and basic sanitation by 2015" is presently on pathway. However rural areas in developing countries across the world remain severely underprivileged, with eight out of ten people not having access to safe water supply.

Despite unprecedented progress, 768 million people still drew water from an unimproved source in 2011 and 83% of the population without access to an improved drinking water source (636 million) lives in rural areas. Furthermore, concerns about the quality and safety of many improved drinking water sources persist. As a result, the number of people without access to safe drinking water may be two to three times higher than official estimates (MDG, 2013).

Most people around the world aspire to piped drinking water supplies on their premises. Yet 38 per cent of the 6.2 billion people globally using an improved drinking water source do not enjoy the convenience and associated health and economic benefits of piped drinking water at home. Instead, they spend valuable time and energy queuing up at public water points and carrying heavy loads of water home, often meeting only minimal drinking water needs (MDG, 2013).

As per WHO and UNICEF (2014) 87% of the world population could have access to safe drinking water, a progress of 10% within the last two decades. The report also pointed out that about 884 million people worldwide, out of which 37% living in Sub-Saharan Africa, still utilize drinking water from unsafe supply spots.

Africa is lagging behind the attainment of the MDG as 340 million Africans lack access to safe drinking water (Habtamu, 2012). The proportion of the African population who had access to safe drinking water accounted for only 60% by 2010, which is about 11% increase compared to the situation in 1990 (UN World Water Development, 2009).

In Africa, the best way to get clean water is by using boreholes, but there is a big question mark on their functionality as the non-functionality rate of these boreholes is very high. The system functionality may be affected by inappropriate technology like poor construction, unavailability or high cost spare-parts, missing professional support services, drying-up of the source or the theft. In addition, there are some other factors affecting the sustainability, like social and institutional ones such as community participation and sense of ownership (WSSCC, 2012).

Water's crucial role in accomplishing the continent's development goals is widely recognized. Africa faces endemic poverty, food insecurity and pervasive underdevelopment, with almost all countries lacking the human, economic and institutional capacities to effectively develop and manage their water resources sustainably. Thus, a large number of countries on the continent still face huge challenges in attempting to achieve the United Nations water-related MDGs (International Decade for Action, 2014).

Northern Africa and Sub-Saharan Africa even though in one continent, have made different levels of progress towards the MDG on water. North Africa has 92% coverage and is on track to meet its 94% target before 2015. However, Sub-Saharan Africa experiences a contrasting case with 40% of the 783 million people without access to an improved source of drinking water from the region. Sub-Saharan Africa is off track from meeting the MDG on water with just 61% water coverage and with the current pace cannot reach the 75% target set for the region (International Decade for Action, 2014).

As per urban-rural disparities concerning access to safe drinking water, out of the world population who lacked access to safe drinking water, about 84% were living in rural areas (UNDP, 2010). Accordingly, urban safe drinking water coverage for Africa was estimated to be 85% (281 million people) while the rural coverage was about 51% (294 million people) by 2008 (WHO and UNICF, 2008). In this respect, Ethiopia has made an encouraging progress as access to safe drinking water has increased from 35% and 80% in 2005 to 65.8% and 91.5% in 2010 for rural and urban areas respectively (UNDP, 2010).

As a result of the National WASH Inventory (NWI), rural water coverage has been revised downwards significantly. Combined urban and rural coverage is now determined to be 54 per cent, compared to the 68.5 per cent that was reported for 2010 on the basis of earlier data. Rural water supply coverage is now known to be only 49 per cent compared to the 65.8 per cent reported earlier. While it is not so encouraging to learn that more Ethiopians lack access to water and that the challenge of reaching universal access is even greater than earlier realized, Sustainability of rural water supply services is a critical area. Functionality rates for rural water supply schemes (RWSS) vary between 66-80% between regions and average 74% nationally (John et al, 2013).

The main reasons for very low level of performance in the supply of safe drinking water, and the quandary for not efficiently utilizing the water resources potential of the country towards realizing sustainable water supply, is attributed to lack of articulate and holistic water policy and insufficient investment for safe drinking water supply (UN World Water Development, 2009). In addition to this, communities lack capability in managing RWSS. Such problems indicate the need of in depth studies to assess the RWSSs in the country and finding out the factors to improve the functionality of RWSSs.

1.2. Statement of Problem

Most people around the world aspire to piped drinking water supplies on their premises. Yet 38 % of the 6.2 billion people globally using an improved drinking water source do not enjoy the convenience and associated health and economic benefits of piped drinking water at home. Instead, they spend valuable time and energy queuing up at public water points and carrying heavy loads of water home, often meeting only minimal drinking water needs. The most affected are the poorest and most marginalized people in society many of whom, especially in urban areas, pay high prices for small amounts of often poor quality water. It is encouraging to note that the share of people relying on untreated surface water as their main drinking water over 180 million people rely on rivers, streams, ponds or lakes to meet their daily drinking water needs(MDG,2013).

Every day 1800 children die from unsafe water, lack of basic sanitation and poor hygiene. Many adults suffer from waterborne disease and ill health, making them less economically productive and straining already weak health systems. Women and girls who trek miles for drinking water miss out on productive work or school education. For those children who do attend school, about 443 million school days are lost each year due to water-related illness. Lack of investment in sanitation and water costs countries in Asia and Africa 2–6% of Gross Domestic Product (GDP) annually (http://sanitationandwaterforall.org/about). Two out of five people without access to an improved drinking water source live in Africa (MDG, 2012)

Table1.1Numbers of peoples without access to an improved drinking water source

S.No.	MDG Region	Number of people (in millions)
1	Sub-Saharan Africa	325
2	Southern Asia	149
3	India	92
4	Eastern Asia	114
5	China	112
6	South-eastern Asia	67
7	Latin America & Caribbean	36
8	Western Asia	20
9	Northern Africa	13
10	Caucasus and Central Asia	11
11	Developed regions	9
12	Oceania	5

Source: WHO and UNICEF Progress on Drinking Water and Sanitation update 2014

Most countries in sub-Saharan Africa are not on track to meet the MDG drinking water target. despite strong overall progress, 748 million people still did not have access to improved drinking water in 2012, 325 million (43%) of whom live in Sub-Saharan Africa. 9% of the global population, or 748 million people, continue to rely on unimproved drinking water sources, of whom almost a quarter (173 million people) still rely on direct use of surface water. Between 1990 and 2012, 2.3 billion people gained access to an improved drinking water source: access to a piped supply on premises 1.6 billion gained, and 700 million gained access to an improved supply, which could range from a public tap to a hand pump, protected dug well or protected spring. Within Southern Asia, India increased access for 534 million people, and within Eastern Asia, China increased access for 488 million people, greatly contributing to both their subsequent regional and global increases in coverage (WHO and UNICEF, 2014).

The best way to get clean water in rural is by using boreholes and springs, but there is a big question mark on their functionality as the non-functionality rate of these boreholes and springs are very high. In Ethiopia 33% of RWSSs are non-functional at any time, owing to lack of funds for O&M, inadequate community mobilization and commitment and a lack of spare parts (MoWR, 2007).

As a result of NWI rural water coverage has been revised downwards significantly. Combined urban and rural coverage is now determined to be 54 per cent, compared to the 68.5 per cent that was reported for 2010 on the basis of earlier data. Rural water supply coverage is now known to be only 49 per cent compared to the 65.8 per cent reported earlier. While it is not so encouraging to learn that more Ethiopians lack access to water and that the challenge of reaching universal access is even greater than earlier realized, Sustainability of rural water supply services is a critical area. Functionality rates for RWSSs vary between 66-80% between regions and average 74% nationally fig1.1 (John et al, 2013).

In Tigray region the functionality rate of RWSSs (67.12%) is less than the national average (74.48%) and in Laelay Maichew Woreda 25% of schemes which accounts 56.25%, 39.57%, 16.22% and 50% for spring development, hand dug wall, shallow well and deep well respectively are non- functional fig.1.1.

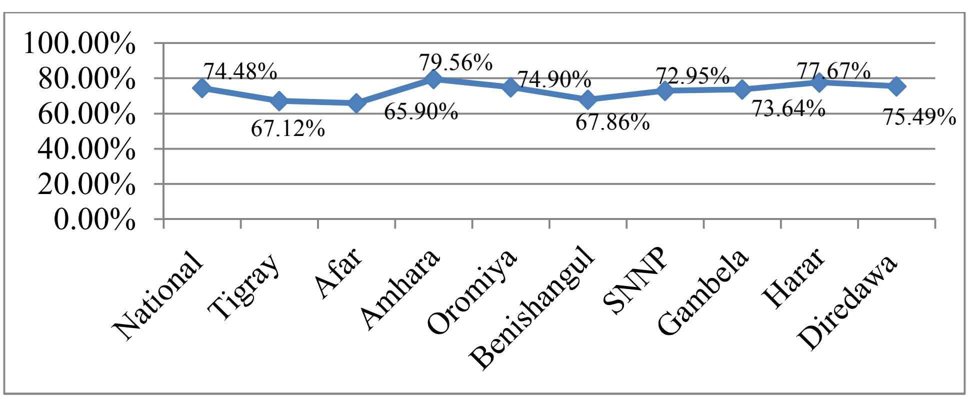


Figure1.1: Functionality of rural schemes (source MoWE.2013)

As water is important to every sector of development different civil society association, governmental and non-governmental organizations (NGO's) are emphasis on how to use water for different purpose especially rural water supply as the coverage is less than urban water supply. Assessing of non-functionality of rural water supply schemes of pre construction, during construction and post construction phases within different aspects of non-functionality of RWSSs is critical to Ethiopia in general particularly to the study area.

1.3. Objective of the Research

1.3.1. General Objective

The primary objective is to assess causes of non-functionality of RWSSs and provide remedial measures in Laelay Maichew Woreda.

1.3.2. Specific Objective

The specific objectives listed below are specific to Lailay Maichew Woreda.

1. To assess non-functional rate and give an over view of current RWSSs.
2. To identify the main problems related to non-functionality of RWSSs.
3. To assess design period, cost and duration of non-functional RWSSs.
4. To identify the best scheme from the existing RWSSs.
5. To provide possible remedial measures of non-functionality of RWSSs.

1.4. Research Questions

1. What is mean non-functionality of RWSS?
2. What are the main problems that cause non-functionality of RWSSs?
3. How is the community organized to operate and maintain RWSSs?
4. Which scheme type is accepted and best practice by the beneficiary?
5. What remedial measures can be providing to solve non-functionality of RWSSs?

1.5. Significant of the Research

In the development policies and strategies of the country RWSSs have crucial role in sustainable health and education for Ethiopian rural people. Hence, this research accounts almost all factors that affect functional sustainability of RWSSs such as technical, management, finance, institutional, economy, social, institutional, gender, health, education and community participation of the users and different water sectors. The result of this study will serve as base line information for those who are interested to conduct research study in depth of those factors individual to discover the problems of rural water supply schemes, especially, in the study area.

This research will help full to understand the causes of non-functionality of RWSSs which is series problem now days and come with solutions in Ethiopia in general and specifically in Laelay Maichew Woreda thereby Improve rural water supply schemes coverage, health, education and reliable water to rural community and increase the functionality rate of RWSSs.

1.6. Scope of the Research

This study focuses on assessing the causes of non-functionality of RWSSs in rural area of Laelay Maichew Woreda such as hand dug well, shallow well, spring development at spot and deep well.

1.7. Organization of the Research

This study contains five chapters. Following this chapter the second chapter incorporates literature review. Chapter three comprises methodology that includes: description of the study area, sampling design, data sources, type and methods of data collection. Chapter four deals with: analysis of collected data result and research findings of non-functionality of RWSS in study area. Finally, chapter five incorporates conclusions and recommendations.

2. Literature Review

2.1. Introduction

RWSSs have been assessed within different scholars throughout the world especially in rural African countries for their failure from miner to very complex problems. The researcher tries to review supportive literatures to assess non-functionality of RWSSs in the study area. Similar research's, published and none published papers, journals, books have been reviewed to collect enough information related to non-functionality of RWSSs.

2.2. Functionality and Non-Functionality of RWSSs

According to various studies conducted to RWSSs, scholars have produced definitions concerning to functional sustainability or non-functional in the context of RWSSs.

According to Lockwood and smith (2011) functionality refers to the percentage of water points working at any given time and is normally measured by a one-time check on a water facility or water point to determine whether the system is working at the time, and is normally a binary condition (yes/no). Functionality is percentage of improved water sources that are functional at time of spot-check (Ssozi et.al, 2012). Functional schemes are schemes, which are in good working condition, and all their components are functional (Selamawit, 2007).

Functional schemes were identified as the schemes, which met the following primary criteria according to Matji (2003) the water supply system should not have more than 7 day's interruption in supply to any consumer per annum, response to breakdowns approximately two weeks, frequency of breakdowns being once every three months in addition to the above criteria, the scheme should meet the following secondary criteria include: effective communication between the water service provider or water services authority and the community, effective institutional arrangement and community involvement in all aspects of the scheme.

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. Water quality, water quantity, reliability of water supply and convenience are four indicators of the functioning of the water supply facilities (Issays, 1988).

Non-functionality of schemes is one of the challenges affecting the sustainable provision and coverage increase in rural water supply. “In the case of water supply, if the water supply continues to be available for the period 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 which are required for sustainability must have been in place”(Mohan et al, 2005). According to this definition, the achievement of functional sustainability is interdependent to the elements of functional sustainability before construction, during construction and post construction of rural water supply schemes

Non-functional schemes are schemes which are not giving service at all due to various reasons or are repeatedly breaking down and do not give service as required most of the time (Gebre, 2012). Non-functional schemes were defined as schemes, which have collapsed completed (Matji , 2003). According to Selamawit (2007) Non-functional schemes are schemes which are currently not functioning due to failure on one or more part(s) of their system components that could be maintained and made functional

2.3. Causes of Non-Functionality of RWSSs

Causes of non functionality of RWSS can be at different stage of scheme development or sustainability practice includes design, construction, operational and maintenance or management. The researcher revised some literatures to develop understanding on the main causes of non-functionality with different aspect of rural water supply studies.

Functionality is now one of the two top government priorities for action in Nepal. Functionality was assessed in 785 villages, and the hard evidence has led government to address functionality in the policy and increase training of implementers and scheme managers. The challenge was to create incentive and conductive environment for improved performance of implementers and scheme managers (Wandera et al, 2011).

According to Jackson (2011), Non functionality of the water systems was established to be attributed to low water table 6.6 %, technical faults 10 %, poor operation and maintenance 40.7 %, lack of trained and active water committees 30 %, community initiative 3.3 %, literacy and sensitization 3.3 % and poor sitting 6.6 %.

According to WPF-IF (2012) one major reason for the declining access to clean and safe water in rural areas in Tanzania were the sustainability challenges facing rural water supply. As revealed by the results of the water point mapping and the validation and inquiry process, the major reasons for non-functionality of many water points were not technical problems but poor management of water sources caused by accountability issues among actors in the water sector.

One of the key challenges contributing to non-functionality of rural water sources is the time lag between the identification of faults and the rehabilitation (Nabunnya et al, 2012). The causes of scheme breakdown were include: lack of regular follow-up and supervision during the design and construction of schemes, installation of inappropriate technology use of mono-lift pumps , lack of trained operators and absence of timely servicing of motors.

According to SNV (2013) in rural Zambia, non-functional water points further reduce access to safe water supply. Problems include lack of an effective maintenance system for community water supply facilities, lack of incentives and spare parts for WASH artisans to undertake repairs, lack of accurate data on status of water points, inadequate capacity of local authorities to plan, implement and maintain water facilities.

According to Migbar (2013) the main reasons for non-functionality rate were inadequate operation and maintenance skills and knowledge at the water scheme committees and Woreda levels, poor access to spare parts, less water committees legal, inappropriate technologies scenario, low sense of ownership and absence of frameworks to foster preventive maintenance of the schemes. Complete non-functionality was caused by unproductive wells, breakage of the hand pump, failure of the spring box and a malfunctioning pump (Seifu et al, 2012).

In Alaba special woreda out of total 65 water points, 62% are not providing a service to the community. The major reasons for the non-functionality of water points include (Fig2.1): scheme breakdown (70%), technical problems (18%), closure by the WWRDO owing to WATSANCo management problems (3%) and closure by the WATSANCo to save the money paid to tap attendants (8%). A total of 3% were still under construction (Israel et al, 2008).

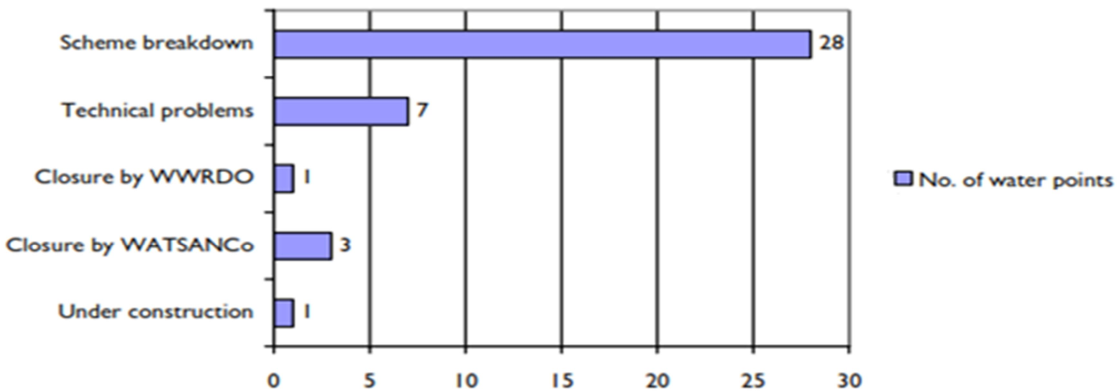


Figure 2.1: Major reasons for non-functionality of water points (Israel et al, 2008).

According to Gebre (2012) non-functionality in Southern Nations Nationalities Peoples Regional State and in Amhara Regional State causes of non-functionality were because of mechanical, yield quality and construction problems fig.2.3 for SNNPRS and mechanical, institutional and financial and yield problems for Amhara Regional State fig2.2.

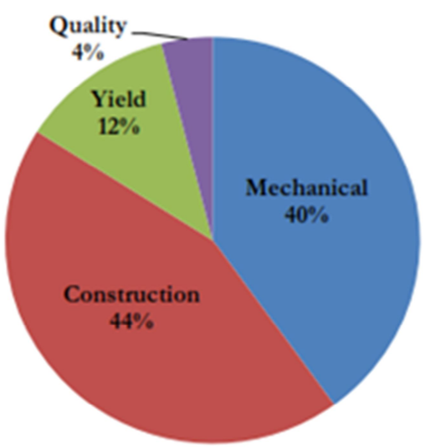


Figure 2.3 Causes of non-functionality of RWSSs in SNNPRS (Source Gebre, 2012)

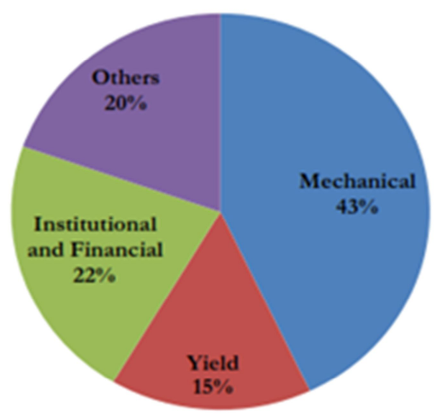


Figure 2.2 Causes of non-functionality of RWSSs in Amhara region (Source Gebre, 2012)

2.4. Sustainability of RWSSs

2.4.1. Introduction

The concept of 'sustainability' is used liberally in the sector, and there are numerous Interpretations of what this may mean in a wide variety of literature. In the more specific context of the rural water sector, many organizations define sustainability as the maintenance of the perceived benefit of investment projects (including convenience, time savings, livelihoods or health improvements) after the end of the active period of implementation. Hence, this definition may be closer to one that simply describes sustainability as: 'whether or not something continues to work overtime' (Abrams, L.; Palmer, I., and Hart, T. 1998); meaning, in this case, whether or not water continues to flow over time. Sustainability of the service is affected by a range of factors. These factors include not only the technical or physical attributes of the system, but also the financial, organizational (support functions) and managerial capacities of the service provider Lockwood and smith (2011).

Sustainability has been defined as: The maintenance of an acceptable level of services throughout the design life of the water supply system. A number of studies have identified various determinants of water system sustainability, including technical, institutional, and social aspects. These determinants are described below (Sara and Katz, 1997).

Technical Aspects: Technical issues relating to the design and construction of a rural water system are the most obvious determinants of water system sustainability. 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 wells or boreholes, and overestimates of the water sources may cause a system to fail from the outset. Most of these factors may be identified through examinations of the system and interviews with system operators.

Institutional Aspects: Experience has shown that even a well-constructed water system needs proper institutional arrangements to keep it functioning over time. Most systems require some sort of preventive maintenance. Hand-pumps may require grease for moving parts. Gravity systems may require sediment be removed from storage tanks or repairs for leaky taps and cracked pipes. In addition, work is required to keep the water source free from contamination. Because most rural water systems are shared by a number of families, providing these inputs requires some sort of community management structure, such as a water committee, to oversee O&M and collect money to cover the costs of these services.

Social Aspects: The sustainability of a rural water system depends on the willingness of users to provide the necessary time, money and labor to keep the system is functioning. This willingness may be affected by socio-economic factors such as income level, ethnic homogeneity, or the willingness of villagers to work together. More commonly, however, the willingness will depend on consumer satisfaction with the service, usually compared to the previous water source 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.

2.4.2. Sub-Indicators of Sustainability

Physical Condition: The physical condition indicator measures the overall functionality of the water system and construction quality. A perfect physical condition score indicates that a water system is free of contamination and has high quality construction without visible defects in the wells, catchment or masonry. For piped systems, it must have sufficient pressure in all points of the system and no leaks in exposed pipes, standpipes or house connections. Hand pumps or wells should provide abundant flow water at the first pump.

Operations and Maintenance: The O&M score measures how well a community is performing on the institutional and organizational aspects of system maintenance. A perfect score indicates the community has a trained system operator, who was hired based on ability and knows how to perform basic maintenance procedures. The operator must have access to tools, spare parts, manuals, and blueprints for the system, and know where to get help for major repairs. Finally, a perfect-scoring community will not have experienced a decrease in water flow since the construction of the system, and must have sufficient water flow to meet community needs.

Consumer Satisfaction: This indicator measures people's perceptions of how well their system works they would be satisfied with their water pressure, the number of hours water is available, and the quantity, color and taste of the water. They would no longer use other sources of water, and would report increased water consumption and use of water for new purposes.

Financial Management: Community would have a designated treasurer or accountant and employ a tariff structure that covers O&M and generates savings for future repairs and system replacement. In addition, these communities would charge people for connecting to the system, sanction people for non-payment, and would have tariff collection rates over 90 percent.

Willingness to Sustain the System: The indicator measures the degree to which community members feel responsible for maintaining their water system. A perfect score in this category would mean all members of the community believe that the water system belongs to them. Community members would express satisfaction with the management of the system and willingness-to-pay monthly fees for service. In addition, people would expect the community to finance future maintenance, repair, and system replacement. They would express a willingness to pay for improvements, and report health improvements since the system's construction.

2.5. The Importance of Functional Sustainability of RWSS

The importance of sustainability may appear obvious, but four aspects are worth highlighting: (Richard et.al, 2006).

First, however successful an intervention may be in the short-term, if its beneficial impact is not sustained over a long period of time, it cannot be deemed cost-effective. Funds have been invested by users and by donors, and a few years later there is nothing to show for the investment.

Second, progress toward the MDGs or any other service coverage targets is undermined by non-sustainable interventions. If services are falling into disrepair as others are being newly constructed, the net progress toward full coverage decelerates the antithesis of the drive toward scaling-up of service delivery. Third, non-sustainable interventions serve to discourage the households, communities and local government, NGO institutions which have seen some short-term benefit, only to be disappointed as hard-won gains are snatched away. On the other hand, sustainable outcomes build confidence, self-reliance and self-esteem.

Fourth, as confidence and self-esteem grow among communities and supporting institutions, possibilities for further self-help or locally initiated undertakings can emerge, creating a multiplicative effect.

2.6. Design and Construction of Rural water supply schemes

A number of global technology options are available for improved rural water supply systems. However, not all can be applied everywhere. In rural Lailay Maichew Woreda, the common RWSSs are boreholes equipped with hand pumps or motorized pumps, hand dug wells with hand pumps and spring development.

2.6.1. Hand Dug Well

Hand dug are Wells excavated and lined by human labour, generally by entering the well with a variety of hand tools. They may be as small as 80 cm diameter, and in some traditional cultures, as large as 15 metres diameter.

Hand dug well Design: The design of the hand dug well aims to achieve the following (MWRI, 2009): **Well sitting**: The site of the hand dug well should be at least 30 to 50m away from latrines and from grave yards and other sanitary landfills (the latter to be determined by the community) fig2.4.

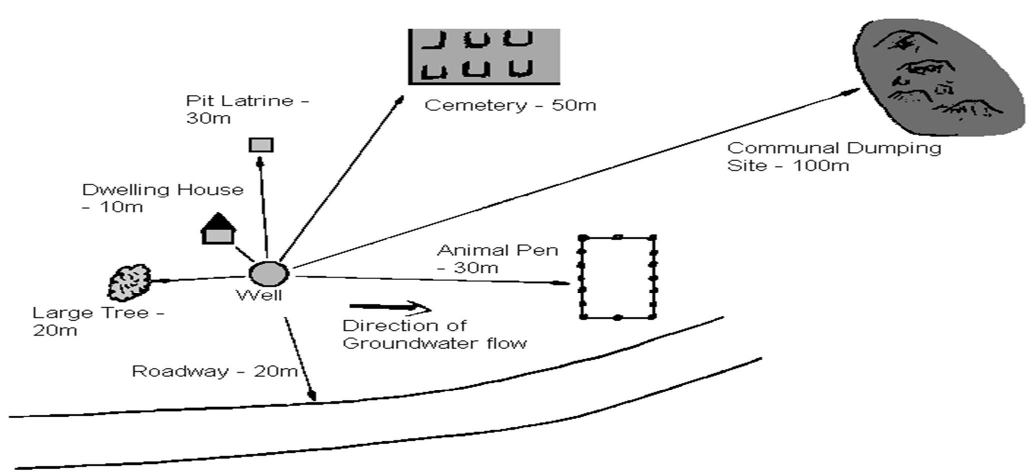


Figure2.4 Location of well (source: Seamus, SKAT, 2000)

Wall lining extension above ground level as a parapet or wall: The provision of 75 to 80cm extended wall lining will protect from the possibility of flooding from surface water during the wet seasons.

Cover slab on top of the well: The space between the spout and the cover slab should sufficient to allow easy water collection by the community with their water fetching container.

Hand pump to withdraw water: Water should be withdrawn from the well only through the hand pump

Extend apron/platform around the well (preferably at least 1.5 m to 2.0m from the wall (parapet) of the well.

Good drainage of wasted water: A proper drainage ditch that extends from the platform up to animal trough or soak away should be provided to allow proper drainage of wasted water from the well.

Well head area protected: The well head including the apron and the immediate surrounding should be protected with a fence to keep animals off the platform and apron and prevent pollution of the water with animal dung.

Diversion of surface water: Surface water diversion ditches should be dug upstream of the well at a reasonable distance from the well, to divert surface water away from flowing to the well site.

Well diameter: This should be large enough to allow well diggers and their equipment into the well for future deepening of the well in case the water table level drops and sufficient water cannot be drawn. The recommended diameter for a concrete ring lined well is 1.50m, whilst the minimum diameter recommended for a brick lined well is 2.0m

Hand-dug well construction General procedures: The important considerations with regard to the overall construction process are the participation of the community to the fullest possible extent, the assembly of the necessary equipment in good working order, the proper layout of the well site, adherence to safety procedures and the availability of the relevant survey report for consultation. (Seamus, 2000)

Equipment: The equipment needed will depend on the lining method adopted and the construction procedure to be followed. Formwork, a device for lowering materials and equipment into the well, dewatering device and method of lowering workers into the well are the equipment needed.

Intake Construction: In practice, the type of intake constructed will depend on the lining option selected, and on the construction sequence adopted. The possible variations may be summarized as follows:

The well is excavated and lined in-situ to the top of the water table. The intake lining is then prefabricated and sunk, through continued excavation, into the aquifer.

The well is excavated to below the level of the water table. A pump is used to keep the well dry while the intake is constructed in-situ.

The well is excavated to the top of the water table. A complete prefabricated lining is put in place, with porous elements positioned to eventually coincide with the aquifer. Further excavation is done to allow the lining to settle into the correct position.

Site layout: The layout of the construction site should allow for easy access to the well with the necessary materials, for the easy and appropriate disposal of the soil excavated from the well and for the rapid and safe dispersal of the water from the dewatering phase.

Safety precautions: In the excavation of hand-dug wells, the most common causes of injury are sub-standard equipment, collapse of the well, and equipment or materials falling down the well. On occasion, the excavation may liberate harmful gases which could cause asphyxiation. The following precautions should be taken at all times during excavation and construction of a hand-dug well:

Ensure that all equipment is in good working order, regularly maintained and checked, and replaced when necessary. When workers are down the well, there should always be somebody on the surface to attend to them. The diggers should always be assured quick access to an emergency escape (by ladder, rope, etc.) Well diggers should enter and leave the well in a safe manner. Well diggers should always wear safety helmets, which should be replaced after any impacts. Ensure that no objects or people can fall into the well. Provide guard rails and, at night, cover the well or make sure that someone is on guard to prevent animals or people from falling in. Do not excavate greater than 5m without temporarily or permanently securing the sides of the excavation.

Lining of hand-dug wells: The purpose of the lining is to ensure that the well retains its excavated shape, allowing access to the water in the aquifer while at the same time helping to prevent contamination of the aquifer. A variety of different linings may be used, and these may be used over the full depth of the well or only partially (Seamus, 2000):

Unreinforced Precast Concrete: Using specially-made formwork, concrete is cast in rings with an internal diameter of 1.2-1.3m and a thickness of 7.5-10cm. The height of the rings can vary from 50cm to 1m.

Reinforced Precast Concrete: As above, concrete is cast in special formwork, but using steel reinforcement and with a reduced thickness (5-7.5cm), depending on whether the ring is to be transported over long distances or rough terrain.

Reinforced Cast In-situ Concrete: Using one leaf of formwork, concrete is placed directly against the walls of the excavated well.

Cast In-situ Mass Concrete: As above, but with thicker walls to compensate for the lack of reinforcement.

Brick or Masonry Lining: Brick and masonry linings are also used, but the porosity of the materials in question impairs their suitability for this particular application. Any gaps between the pit wall and the lining should be filled with a plaster mix to develop some small degree of impermeability in the important top section of the well. The inside of the lining should also be plastered for at least the top 3 meters.

Common problems of hand dug well construction: During hand dug well construction there are a construction problems which lead to non functional scheme due to different reasons. But, according to (Seamus, 2000) common problems of hand dug well construction are**:**

Excavation in loose soils: Unlike firm soils, where the sides of a pit will more or less retain their shape during excavation, loose soils may assume an angle of repose of 30° or less. In such a situation, the construction of a hand-dug well would involve an enormous amount of extra excavation. Local experience and/or a site investigation should show whether a hand-drilled borehole or a tube well would be a better option. If this is not the case, and it is decided to go ahead with a hand-dug well, the use of a cast in-situ lining will not be feasible fig 2.5.

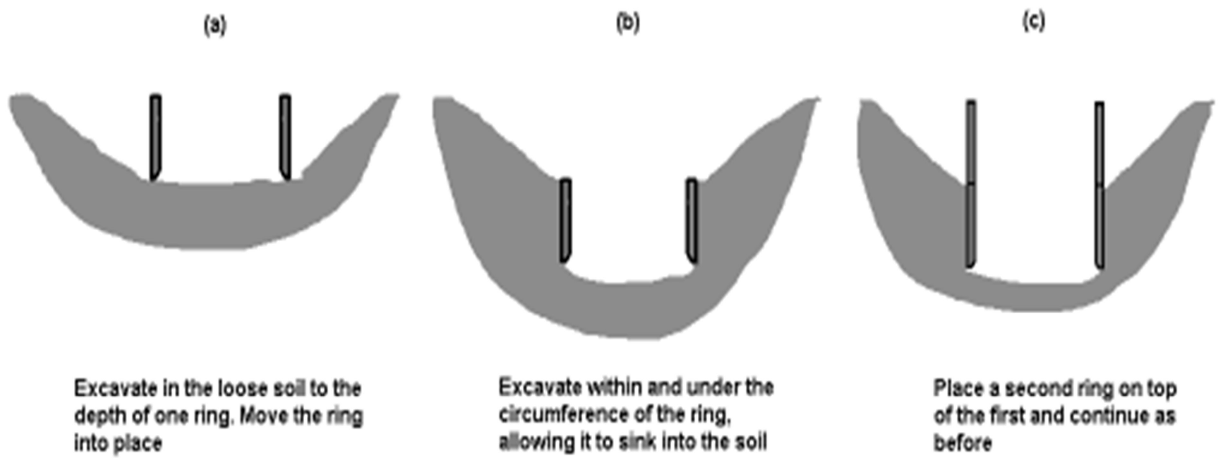


Figure2.5: Excavation in loose soil (source: Seamus, 2000)

Loss of vertical alignment: If the material being excavated is composed of different inclined layers, there may be some differential settlement of the lining rings, leading to a loss of vertical alignment

Arrested descent of lining rings: In certain soils, usually unconsolidated, it can happen that the column of lining rings will not descend under its own weight.

2.6.2. Borehole

Drilled wells or boreholes give access to deeper groundwater. They differ from hand dug wells in the small diameter, generally varying between 0.10 m and 0.25 m for the casing, which does not allow a person to enter for cleaning or deepening. Also, boreholes do not have storage capacity. Boreholes can be constructed mainly by machine or, sometimes, by hand-operated equipment. They have an expected life of 25-30 years, or even more (Basteiro and Salvador, 2003).

Three main parts of borehole:

At ground level: A concrete apron around the borehole with an outlet adapted to the water abstraction method; it prevents surface water from seeping down the sides of the well, provides a hard standing and directs wastewater away from the well to a drainage channel.

Below ground but not in the desired aquifer: These parts are usually lined with pipe material (mostly PVC and sometimes galvanized iron) to prevent it from collapsing, especially in unconsolidated formations. In consolidated formations, a lining may not be required.

Below water level in the aquifer sections: The pipe material is slotted to allow ground water to enter the well. A gravel filter layer surrounding this part facilitates groundwater movement towards the slotted pipes and, at the same time, prevents ground material from entering the well. In consolidated formations this gravel may not be required.

A proper combination of slot size, gravel filter and aquifer material, and extensive well developing before the well is brought into production can considerably improve long-term performance. If confined and low transitivity aquifer is drilled, a combination of hand dug well and borehole can be executed, thus improving storage capacity.

Drilling techniques: Several different well construction techniques exist and the most suitable method for constructing wells in a particular area should be selected carefully. One important factor is the type of geological formation to be penetrated. (Table 2.1) provides general guidance on well construction methods **(Basteiro and Salvador, 2003).**

Table2.1: Drilling techniques of boreholes

Method	Maximum depth (m)	Diameter (cm)	Geological formation	
			Suitable	Unsuitable
Hand dug	25-30 (exceptionally50)	120-200	Clay; silt; sand gravel; soft sandstone; soft, fractured limestone	Igneous rock
Auger-drilled	25-35	10-40	Chalk; gravel; soft sandstone soft; fractured limestone; alluvial formations	Igneous rock
Percussion-drilled (cable tool)	300	10-60	Clay; silt; sand; gravel; cemented gravel; boulders (in firm bedding); sandstone; limestone; and igneous rock	None
Rotary-drilled (fluid circulation)	250	10-60	Clay; silt; sand (stable); gravel; cemented gravel; sandstone; limestone, and igneous rock	Problems with boulders
Rotary-drilled borehole (down-the-hole air hammer)	250	10-50	Particularly suitable for dolomite; basalts; metamorphic rocks	Loose sand, gravel, clay, silt, sandstone

(Source: INTERMON OXFAM, 2003)

There are several drilling techniques (driving, jetting, sludging...), but Cable tool percussion drilling, Down-the-hole (DTH) hammer drilling, direct fluid circulation rotary drilling and Auger Drilling are the more suitable to Ethiopian highlands (Basteiro and Salvador , 2003)

Execution period and duration: according to Basteiro and Salvador (2003) the best execution period is during the dry season, in order to find the water table in its deepest level:

- Tigray, Gonder, Lasta region: May- Jun and
- Gurage, Rift Valley: February – March.
  The total duration of a borehole will be according to each technique

2.6.3. Spring Development

According to Different researchers spring development of rural water supply has been define as follow. A spring is a place where ground water emerges naturally from the earth's surface, usually along hillsides, at the base of slopes, or in low areas (RWSSHP, 2007).

According to AGRI-FACTS (2002) a spring or seep occurs when groundwater emerges naturally on the earth's surface by either gravity or artesian pressure. Springs are outcrops of groundwater that often appear as small water holes or wet spots at the foot of hills or along river banks (World Bank office Manila, 2012).

Springs occur wherever groundwater flows out from the earth's surface. Springs typically occur along hillsides, low-lying areas, or at the base of slopes. A spring is formed when natural pressure forces groundwater above the land surface. This can occur at a distinct point or over a large seepage area. Springs are sometimes used as water supplies and can be a reliable and relatively inexpensive source of drinking water if they are developed and maintained properly (Stephanie et al, 2007)

Types of spring's development: There are three main types of springs that occur in nature (RWSSHP, 2007)

Artesian springs are confined by two layers of impervious material. The water from artesian springs is likely to have been sufficiently filtered naturally through the ground, and typically has little to no chance of being contaminated with surface water that may infiltrate into the spring.

Gravity springs rest on a single impervious layer, and can be thought of as an underground river. The unconfined aquifer will add many "tributaries" or input from local water and rain that seeps into the ground. Any contaminated water that flows into the ground will only have the short flow distance before reaching the spring, giving the input water much less time to be filtered naturally.

Seepage springs occur where water simply seeps out of sand, gravel, and other porous material. Opposed to artesian and gravity springs where flow is directed to one point, seepage springs result from a somewhat unconfined aquifer, where an underground reservoir simply leaches out in different places. This gives seepage springs the highest susceptibility to contamination. Therefore seepage springs need periodic disinfection.

Spring development: According to AGRI-FACTS (2002) springs are highly susceptible to contamination and seasonal changes in flow rate. In addition to spring design assessment there are different factors that should be consider seriously while spring development is take place like water quality , quantity or yield and spring protection..

Water quantity: When considering using a spring as your source of drinking water, it is important to ensure that the rate of flow is reliable during all seasons of the year. Spring flow that fluctuates greatly throughout the year is an indication that the source is unreliable or may have the potential for contamination. It may be possible to learn about historical spring flow from the previous owner or a neighbor (Stephanie et al, 2007).

Water quality: Water quality is also important to consider before using a spring as a water supply. Before developing the spring, collect a sample of water and have it analyzed at a local water testing laboratory to ensure that it can be efficiently and economically treated to make it safe for human consumption. Springs are highly susceptible to contamination since they are fed by shallow groundwater, which usually flows through the ground for only a short period of time and may interact with surface water (Stephanie et al, 2007).

Spring Water Protection: The main objective of spring development and protection is to provide improved water quantity and quality for human consumption. 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 (Hart, 2003).

Basic Design Features of a Spring Box: Although there are many different designs for spring boxes, they all share common features. Primarily, a spring box is a watertight collecting box constructed of concrete, clay, or brick with one permeable side (Hart, 2003).

There are two basic spring box designs that could be modified to meet local conditions and requirements.

The first design is a spring box with a single permeable side for hillside collection (Fig2.6), In Fig 2.6; the outlet pipe should be at least 100 mm above the bottom of the box. To prevent stones, rubbish and frogs from blocking the pipes, the end of the outlet pipe inside the box should be covered with a screen. Moreover, a drain pipe is necessary for removing silt at the bottom of the spring box The second design has a pervious bottom for collecting water flowing from a single opening on level ground (Fig2.7) a spring box with a permeable bottom for springs emanating from ground level. In designing a spring box the overflow pipe should not be higher than the natural elevation of the spring. If subjected to back pressure from the stored spring water in the box, it is possible for a spring to divert its flow elsewhere. If a single spring eye cannot be located, a seep collection system is an alternative. In a seep collection system, perforated collection pipes are laid in a "Y" shape perpendicular to the seep flow in order to collect and concentrate water, which is then diverted to a spring box.

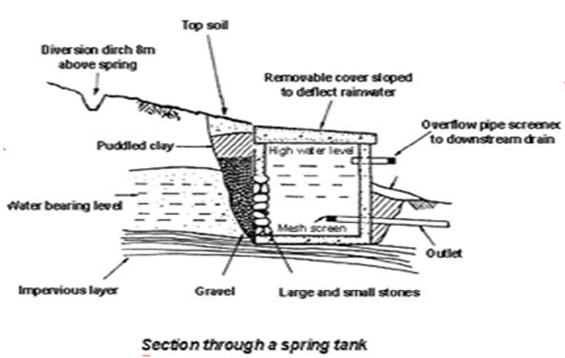


Figure 2.7 Spring box design with one side permeable (source: Hart, 2003)

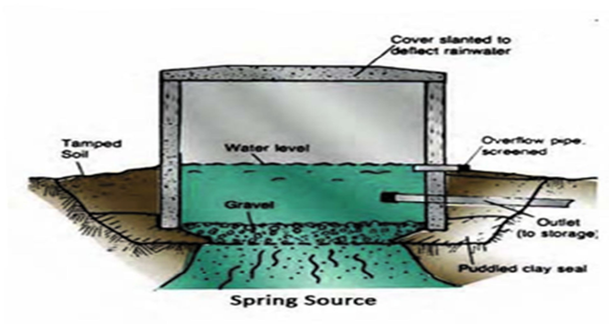


Figure 2.6 Spring box design with permeable bottom (source: Hart, 2003)

Designing the Structure Design chosen for any particular project will depend on local conditions spring yield, available materials, community knowledge and requirements.

The goal of design process is to generate a dimensional plan of spring box (fig2.9) and a map of the area, including the location of the spring, the location of houses in the community, distance from the spring to the community and elevation change as well as prominent features and landmarks (fig2.8).

Another useful resource to produce during the design process is a list of all labor, materials, and tools needed, as well as those that are available on site. Such a list will help ensure that all necessary tools and materials are available on site in order to avoid delays and setbacks

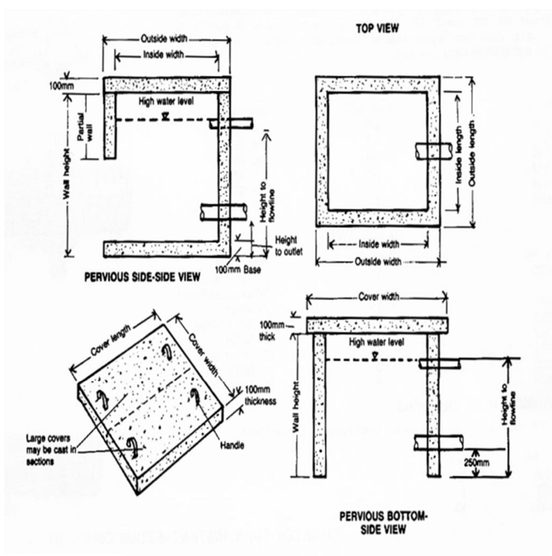


Figure 2.9 Dimensional plans of sprig box
(source: USAID, 1982)

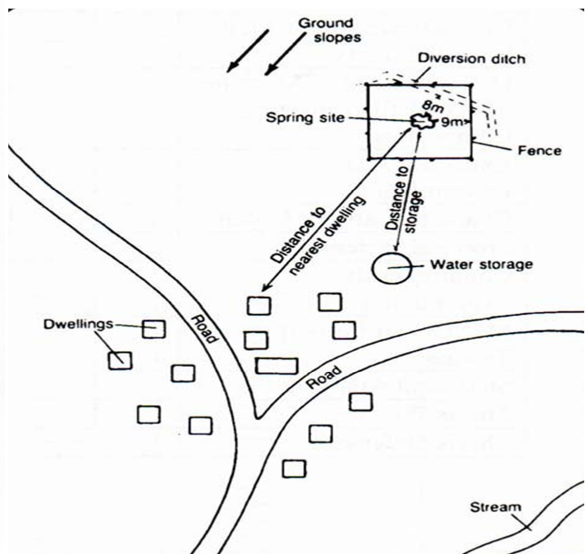


Figure 2.8 Location map of spring
(source: USAID, 1982)

General construction steps of spring development:

Locate the spring site with measuring tape, cord and wooden stakes, or pointed sticks, mark out the construction area as shown in fig2.10 (Water for the World, www.lifewater.org).

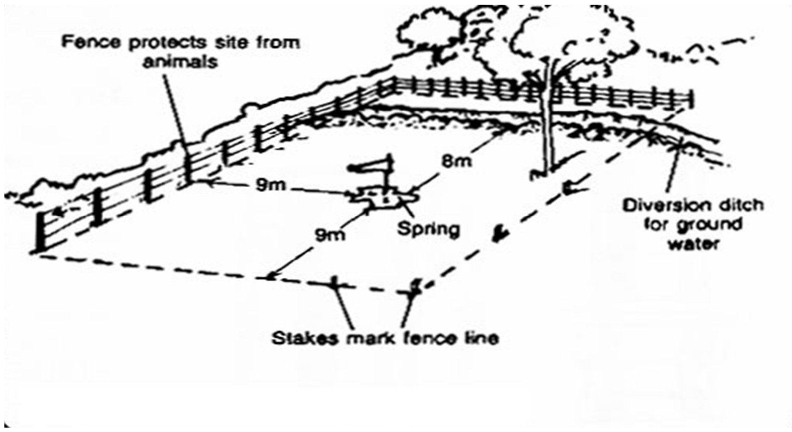


Figure 2.10 Preparation of spring box site (source: USAID, 1982)

Dig out and clean the area around the spring to ensure a good flow. If the spring flows from hillside, dig into the hill far enough to determine the origin of the spring flow.

Pile loose stones and gravel against the spring before putting in the spring box. The stones serve as a foundation for the spring box and help support the ground near the spring opening to prevent dirt from washing away.

Approximately 8m above the spring site dig a trench for diverting surface run-off. The trench must large enough to catch surface flows from heavy rains.

Mark off an area about 9m by 9m for a fence. Place the fence posts 1m apart and string the fence. A fence is useful to prevent animals from frequenting the spring site.

2.6.4. Pipe Line System

Transmission and distribution systems vary in size and complexity but they all have the same basic purpose, which is to deliver water from the source(s) to the customer. The design of the rural water system also needs to take into account the nature of operation. Most rural water utilities are remotely located and are operated and maintained by part time staff. Therefore, it is important that the systems be relatively simple to operate and maintain (World Bank office Manila, 2012).

Design considerations: The design considerations involve topographic features of terrain, economic parameters and fluid properties and peak flow factors include minimum and maximum pipe sizes, pipe material, and reliability considerations.

Pipeline materials selection:

1. **Factors in selecting pipeline materials**

Flow Characteristics: The friction head loss is dependent on the flow characteristics of pipes. Friction loss is a power loss and thus may affect the operating costs of the system if a pump is used.

Pipe Strength: Select the pipe with a working pressure and bursting pressure rating adequate to meet the operating conditions of the system. Standard water pipes are satisfactory usually only in low pressure water supply systems.

Durability: Select the type of pipe with good life expectancy given the operating conditions and the soil conditions of the system. It should have an expected life of 30 years or more.

Type of Soil: Select the type of pipe that is suited to the type of soil in the area under consideration. For instance, acidic soil can easily corrode galvanized iron pipes and very rocky soil can damage plastic pipes unless they are properly bedded in sand or other type of material.

Availability: Select locally manufactured and/or fabricated pipes whenever available.

Cost of Pipes: Aside from the initial cost of pipes, the cost of installation should be considered. This is affected by the type of joint (such as screwed, solvent weld, slip joint, etc.), weight of pipe (for ease of handling), depth of bury required, and width of trench and depth of cover required.

3. **Pipe Materials**

a. Galvanized Iron (GI) Pipes: GI pipes are available in sizes of 13, 19, 25, 31, 38, 50, 63 and 75 mm and in lengths of 6 m. They are joined by means of threaded couplings.

Advantages: Strong against internal and external pressure can be laid below or above ground. People in rural areas know how to install this kind of pipes.

Disadvantages: GI Pipes can easily be corroded, thus the service life is short. These have rougher internal surface compared to plastic pipes, hence, have higher friction head losses.

b. Plastic Pipes: Polyvinyl Chloride (PVC) and Polyethylene (PE) are commercial plastic pipes. They are available in different pressure ratings and sizes of 13, 19, 25, 31, 38, 50, 63, 75, 100 up to 200 mm. PVC is supplied in lengths of 3 m and 6 m while PE is available in rolls and, for diameters greater than 100 mm, in straight lengths. Suppliers have to be consulted with respect to the pressure ratings to be used. PE pipes are joined by butt welding. PVC pipes can be joined either through solvent cement welding or through the use of special sockets with rubber rings.

Advantages: Smooth internal surface, Resistant to corrosion. Extremely light and easy to handle, do not tuberculation

Disadvantages: Lose strength at high temperatures (500° C+), not suitable for laying above the ground, can deform during storage, require good and carefully prepared bedding materials.

Appurtenances for transmission and distribution mains

Valves: A valve is a device that can be opened and closed to different extents (called throttling) to vary its resistance to flow, thereby controlling the movement of water through a pipeline. Valves can be classified into five general categories as follows:

1. **Isolation Valves**: Perhaps the most common valve in the water distribution system is the isolation valve, which can be manually closed to block the flow of water. As the term "isolation" implies, the primary purpose of these valves is to provide means of turning off a portion of the system. Well-designed water distribution systems have isolation valves throughout the network. Isolation valves include gate valves (the most popular type), butterfly valves,

2. **Directional Valves**: Directional valves, also called check valves, are used to ensure that water can flow only in one direction through a pipeline, Any water flowing backwards through the valve causes it to close, and it remains closed until the flow once again begins to go through the valve in the forward direction.

3. **Altitude Valves**: Many water utilities employ devices called altitude valves at the point where a pipeline enters a tank. When tank level rises to a specified upper limit, the valve closes to prevent any further flow from entering, thus eliminating overflow. When the flow trend reverses, the valve reopens and allows the tank to drain or to supply the usage demands of the system.

4. **Air Release Valves and Vacuum Breaking Valves**: Most systems include special air release valves to release trapped air during system operation, and air/vacuum valves that discharge air upon system start-up and admit air into the system in response to negative gauge pressures. These valves are often found in system high points, where trapped air settles, and at changes in grade, where pressures are most likely to drop below ambient or atmospheric conditions.

5. **Pressure Reducing Valves**: Pressure reducing valves (PRVs) throttle automatically to prevent the downstream hydraulic grade from exceeding a set value, and are used in situations where high downstream pressures could cause damage. It can be used to separate pressure zones.

Fittings: Fittings are installed in the pipelines for the following purposes:

a. To connect the same type and size of pipe:

Union: Unions are provided in the pipeline for ease of repair. Unions are usually installed at 60-meter intervals on straight pipelines.

Coupling: Used in jointing 2 pipes of the same diameter, it is cheaper than unions.

b. To connect two pipes of different sizes:

Reducers are used when there is a reduction of pipe size and include bushings and elbows for galvanized iron pipes. Also available are reducing elbows, tees and crosses.

c. To change the direction of flow:

Elbow: To change flow direction.

Tee: To divide the flow into two.

Cross: To divide the flow into three.

d. To stop the flow: These are the caps, plugs and blind flanges.

Reservoir appurtenances:

1. Inlet Line: The size of the inlet line is determined by the supply and demand requirements. The inlet line on all reservoirs must have a shut-off valve located adjacent to the reservoir.

2. Outlet or Discharge Line: Like the inlet line, the size of the outlet line is determined by the supply and demand requirements. The upstream-end of the outlet pipe is usually installed at least 5 cm, above the floor of the reservoir to create a dead volume of water. This dead volume of water at the bottom of the reservoir acts as settling zone, where particles are allowed to settle and kept from entering the water distribution line. These dead volumes of water are drained via a drainage pipe. The outlet line must also have a shut-off valve located adjacent to the reservoir.

3. Drain Line: This is provided for draining and cleaning the reservoir. Draining could be done through the inlet–outlet line by shutting off the valve controlling the flow in the main line and opening the drain valve. To facilitate cleaning, the floor of the reservoir is sloped towards the drain.

4. Ventilation facilities: These are provided in reservoirs to allow the air to escape fast enough to prevent pressure from building up inside the reservoir during filling, and to prevent a vacuum from forming when water is being drawn out. The ventilation facilities should be designed to keep rain and surface water from entering, and they should be screened to keep out insects. Overflow and drainage pipes should be designed with a valve chamber to prevent rodents from entering the reservoir.

5. Overflow Line: Reservoirs should be provided with an overflow line large enough to allow the maximum anticipated overflow (pump or spring capacity) and should be properly screened and covered like an air vent.

6. Manholes and Covers: These are installed in reservoirs to serve as entrance during repair, cleaning and maintenance. To prevent the entry of surface water which may contain pollutants, manholes should be installed slightly raised above the roof level and must be equipped with an overlaying cover. The cover is also necessary to prevent the sun's rays from promoting algae growth.

7. Water Level Indicators: These are used to indicate the water level inside the reservoir. Depth gauges using a float and wires are usually used.

8. Control Valves: The use of reservoir control valves will depend on the type of controls and means of operation to be employed for the system. The flow into the reservoir may be stopped manually or automatically by a float valve, pressure switch or equivalent device.

2.6.5. Selection of lifting device

Selection of appropriate pump device is one of the most important factors that can ensure the reliability of a water supply scheme. There are different pump system options such as non-motorized system or motorized system. To determine the pump system which is suitable for given condition, the following questions have to be answered: (TWRDME, 1998)

Do the power ranges of a system fulfill the requirements for flow rate and head?, Is skilled staff available for installation, operation, maintenance and repair?, Is the supply of required spare parts ensured so that the system can be repaired without undue delays? Finally economical, social and institutional criteria have to be taken into account to make the final selection.

Considering the above criteria, the equipment reliability, degree of use in the region and the goal of standardization of equipment, the following types of pumps can be recommended in the Tigray Region. for hand dug well hand pumps, for shallow wells hand pumps or motorized pumps, for deep wells motorized pups. Motorized pumps can be submersible pumps or mono pumps (borehole shaft driven pump)

The energy sources for motorized pumps can be Electric motor (supplied by electric power supply or by diesel engines), diesel engine (direct without alternator), and solar energy or Wind energy

Hand pumps: Hand pumps are used for pumping water from wells which have a depth of not more than 60 meter. Hand pumps can be installed in dug wells or drilled wells of any depth and diameter, subject only to the practical limit that the pumping water level should normally not be more than 45-50m low.

Hand pumps can be divided in to four categories: (TWRDME, 1998)

High lift positive displacement pumps capable of pumping from depths of up to about 45m. These types of pumps are common in the Tigray Region due to the depth of water table. Pumps of type Indian Mark II, Afridev, Mono are examples of high lift hand pumps, Intermediate lift pumps up to 25m depth. Those are common in the Tigray Region, Low lift pumps up to 12m depth. These types of pumps are not common in Tigray Region except of a few. Type Tara is an example and Suction pumps up to 7m depth. Those pumps are not in use.

In Tigray most of rural people live in area, were the ground water table is around 15 to 20m below ground level. For this reason intermediate and high lift hand pumps are required. Of those pump types (Indian Mark II, Afridev, Mono and Tara) are in use in Tigray Region.

Main selection criteria for hand pumps are the sustainability for the intended maintenance system, durability and reliability of the pump, The lift capacity of the pump, discharge rate with respect to lifting depth, level of service and corrosion resistance.

Standardization of hand pumps: Standardization one or a few pumps type can facilitate considerably operation and maintenance as well as the storage of spare parts (if a pump is commonly used, local mechanic of the community are probably familiar with its maintenance and spare parts are likely to be readily available. (TWRDME, 1998)

According to experience got in Ethiopia hand pumps of type Indian mark II (modified) are not suitable for village level maintenance compared to Afridev type fig2.13. But they are more recommended for depth more than 45m. Taking into account all the selection criteria the community acceptance and technical capacity, Afridev hand pumps are recommended generally for use as a standard hand pumps for community water supply in Tigray Region.

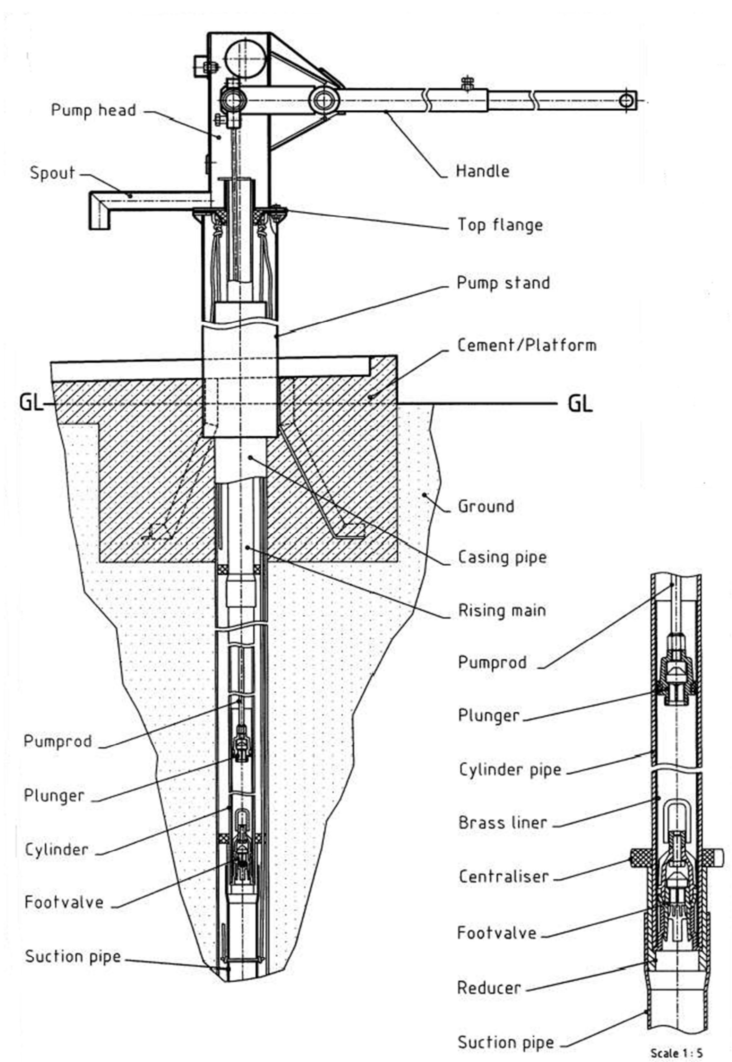


Figure 2.11 Afridev hand pump (source: SKAT, RWSN, 2007)

Motorized pumps: Pumps which operate through electric motors or diesel engines are called motorized pumps. Pumps driven by diesel or electric motors are used in case borehole, spring and surface water etc. two types of pumps are mostly used in Tigray Region to rise the ground water from shallow and deep wells: mono and submersible pumps. (TWRDME, 1998)

Selection criteria of motorized pumps are capacity of the pump depends on demand required for the community to be served, pump head required from the source to water point, maximum efficiency for required head and discharge, resistance to abrasion and corrosion, inner diameter of well, reliable public supply of electric power electrical pump, facilitate maintenance, operation and spare part supply, investment cost of pumping arrangement as well as cost for operation and maintenance.

2.7. Decision Support System and Rural Water Supply

According to Gebre (2012) one of the major global development agendas in MDG is the provision of sustainable access to improved water supply and improved sanitation. In order to have sustainable access, two steps are required**.** The first step is physical development of a scheme which includes planning, physical implementation and the second one is sustainable operation and management of scheme. Sustainable access to rural water supply depends on various factors such as:

Technical issues regarding planning, source development taking into account the required yield, quality and distribution to the end users

Capacity which includes: Funding of the scheme development, covering operation and maintenance cost and accumulation for replacement cost through cost recovery

Institutional issues at various levels from community to central government depending on a country's political structure including private sector, nongovernmental organizations, global institutions, existing policies and strategies of the sector

System or technology particular characteristics whether it is a spot, gravity, pressurized and gravity source, energy source, and its flexibility and reliability

Accessibility or proximity to spare parts and operation and maintenance services

Gender dimension which addresses involvement of women in the various stages

Social and cultural aspects of communities with regard to water use and willingness to pay Integration with relevant sectors such as health, education, hygiene and sanitation

The above factors have a peculiar nature from one scheme type to another that should be studied carefully before any decision is reached to develop a specific type of a scheme in the case of a new development or the evaluation of an already existing scheme.

2.8. Design of Questionnaires

In order to gather reliable data, questionnaires with simple, clear, easy to answer and personally relevant questions should be designed (ASA, 1999). As part of this study, a literature review was conducted to investigate better ways of designing questionnaires. According to ASA (1999),

It is the questionnaire designer's greatest challenge to take important topics and translate them into simple concepts, simple behaviors, and simple words two types of questionnaires could be designed (ASA, 1999):

Questionnaires with open-ended questions: These are the questionnaires in which the questioning becomes more of a formal interview with the opinions and the view of the interviewee being solicited. The main advantage of these questionnaires is that they can provide more complete and satisfactory information.

The disadvantages are a well trained and experienced surveyor, who would accurately record the opinions of the interviewee, is required, the questionnaires have to be administered by a well trained interviewer, and require much more skill and effort to be analyzed. this approach could be very expensive.

Questionnaires with closed-ended questions: These are questionnaires in which the questions require the interviewees to supply a yes/no answer or they are given a series of choices. The main advantages of this type of questionnaires are the relevant data can be obtained and analyzed quickly, less effort, time and money are required to train the surveyors. However, the interviewee is limited to selecting from a restricted set of choices.

In this research, questionnaires dominated by close-ended questions were designed to derive data from local communities, woreda and nongovernmental organization water experts on existing facilities, practices in terms of non-functionality of water points, perceptions, views and preferences with respect to RWSSs.

3. Materials and Methodology

3.1. Description of Study Area

3.1.1. Location of Study Area

Laelay Maichew Woreda is from one of the 12 Woreda located in Central Zone of Tigray Region that is Axum Town, center of the district is located at about 1000 km north of Addis Ababa. It lies between 14□07’00″and 14□09’20″ latitudes and between 38□38’ 00″ and 38□49′, 09″ longitude. The district is bounded in the north by Merbleke woreda, and east Geter-Adwa woreda and Werileke woredas, west by Thahitay Maychew woreda and southern by Naidier-Adiet woreda. The total area of the woreda is 538.33 sq km from this 145.52 sq km is set for agriculture. The total population of the woreda is 84679. The settlement pattern in the woreda is mainly dispersed fig3.1.

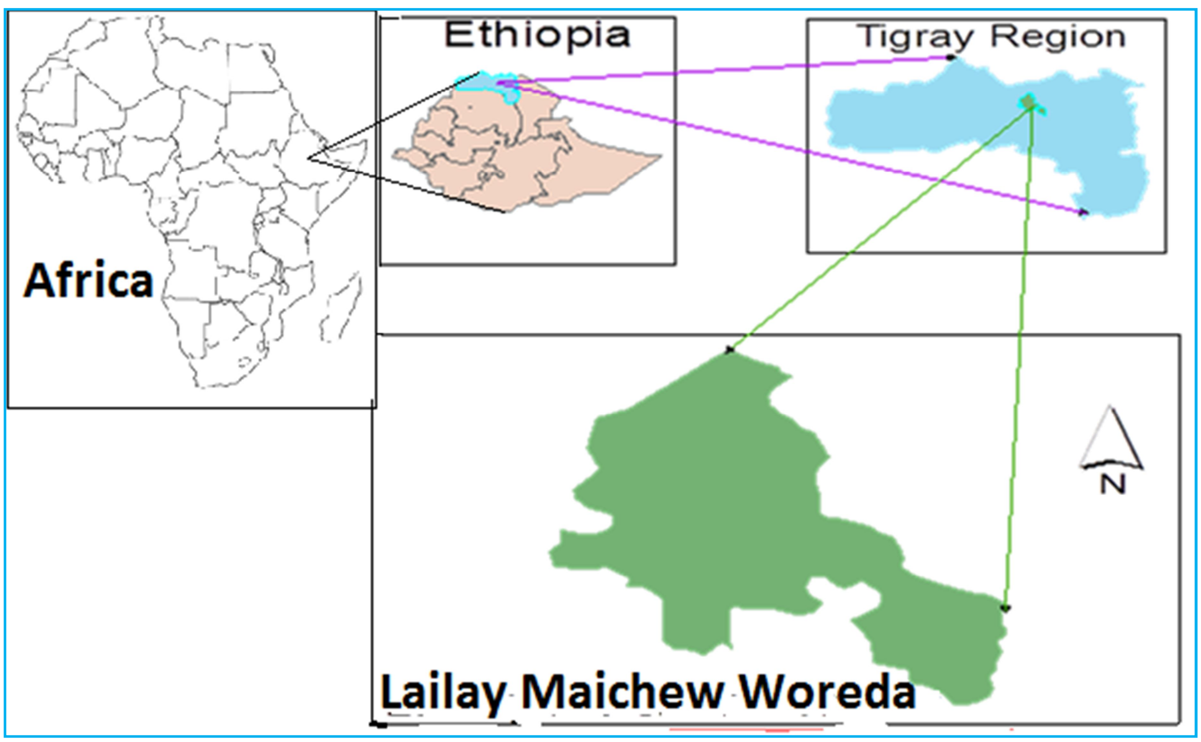


Figure 3.1: Location map of study area

3.1.2. Administration

Laelay Maichew Woreda has been divided in to 16 Peasant associations (locally known as tabias or Kebeles) and 49 Sub Peasant associations (also known as Kushets) for administrative purposes.

3.1.3. Physiographic and Drainage

The relative relief of the woreda Laelay Maychew is characterized by undulating topography on both the northern and east west border of the woreda, but undulating hills and in pacing mountains altering with plains characterize the central area. The elevation ranges from 1500 - 2500masl.

Physiographical Laelay Maichew Woreda is divided in to three broad divisions: i) the northern low lands ii) the central plateau and flat land and iii) south east escarpment. The northern low lands are exhibit undulating topography denuded hills and highly dissected topography covers the northern part of the woreda. The southeast escarpment exhibits denude structural hills, highly dissected undulating topography with sharp crested hills, deep gorges.

The woreda has higher elevation than the neighboring woredas. The woreda is drained in to two main river basins (Mereb and Tekeze) of the region. In the northern by Hino and Maykolal, rivers and its main tributaries like May-ayni, Hitsuy, May-argam and Machea. In the southern part of the woreda is drained by Maychew and Tahitayruba, and main tributaries like Haslo, Ayhida , Tenkete, and Mayagazien.

3.1.4. Climate

The woreda Laelay Maychew is in Dry Weyna-Dega agro-climatic zone. From the prevailing weather conditions, rainfall occurs during June to August. September is a transition rain between rainy and dry season and it represents the autumn. The period between December and February is characterized by cold and dry weather conditions. The period between Marchs to July is warmer. The annual rainfall of the woreda varies from 550mm to 700mm. February is the driest month as it contributes average rainfall 2.4mm and July is the wettest month with average rainfall of 233.96mm.

It is observed that the summer months (June to August) on average contribute more than 89.94% of the total rainfall. April to Jun is the hottest months in the woreda with average minimum and maximum temperature 12.4^0c to 29.6^0c, respectively. The coldest month is December where the average minimum and maximum temperature are 8.63^0c and 26.8^0c.

3.1.5. Farming System

People of Laelay Maichew Woreda are depending on agriculture for their day to day food and 95% (estimation) of people are leading their life by agriculture (WOPF, 2014). The study area has mixed (crop and livestock) farming system with emphasis on subsistence crop production. Rainfall is the most detrimental yield factor and influences largely the crop pattern.As it is largely determined by rainfall pattern cropping calendar is not fixed. During “spring”, the rains are very rare. Therefore, farmers use the rainfall for land preparation.

Livestock play an important role in economy of the area. The most important problem of livestock production in the area is shortage of feed. The different types and number of livestock in the Woreda are Cattle (40441), Sheep and Goat (72712), Donkey (12533), Camel (150), Poultry (57194) and Beehive (6496) (WOARD, 2001, 2011).

3.1.6. Soil

The geology of the study area is composed of uniform lithology of igneous rock, which is granite. The dominant soil types of the study area are locally known as Vertisols (Walka), Regosols, Cambisols, and Arenosols (Hutsa). The percentage area covered under each soil type is, 38.4 for Vertisols, 24.76 for Leptosols, 21.29 for Arenosols, and 15.55 for Cambisols.

Soil classification can be correlated with fertility and productivity based on farmers perception. The resulting ranking runs from; Arenosols (less fertile) followed by Regosols, Cambisols, and Vertisols (most fertile). Vertisols soils are the soils with the highest production potential. The soil mostly clay, dark brown in color, acidic in reaction with high water holding capacity has moderate to high organic matter content and nutrient (WOARD, 2001, 2011).

3.1.7. Natural Vegetation

The woreda claims to have relatively biggest forest reserves in the Tsaedat, Temen-Zewoo, Maychew, and Gobodura. The total area under forest in the Woreda Laelay Maychew is 1783ha, which is 3.3 % of the total area of the woreda (WOARD, 2001, 2011).

The large-scale unscientific land use practices have resulted in the depletion of primary forest and colonization of the degraded sites by Acacia Species, which grows well to develop in to secondary forests. Besides, the vegetation of the wereda is largely composed of scattered trees of Acacia species (Acacia lehi, Acacia albida, Acacia abyssinica, and Acacia etbaica) and bushes of Euclea racemosa. Schimperi, Senna singueana Lack. Dodonea viscosa, Jack Sapindaceae and Meytanus arbustefollia, and scattered cover of Carissa endulis, Cordia Africana, and Euphorbia abyssinica. There are also few trees like Eucalyptus camaldulensis, and Azanderacta indeca. Considerably large area of the bush land, especially where “Acacia lehay” and “Dodonea” are dominate in under area of closure with good recovery.

3.1.8. Rural Road and Electricity

In Laelay Maichew Woreda from 1987 to 2004E.C a total length of 112Km community road network was constructed. The community road network is at 2.9 road density (Km /1000Km^2) and constructed within different road standard Appendix I.

All districts have access to mobile network and 11 districts have access to telecommunication. But there was no enough access to electricity in the Woreda, due to this from 16 peasants in 7 peasants there was electricity service for 24 hours which is more than half of peasants were suffering from using rural electricity services (WOPF, 2014).

3.1.9. Health and Education

Lealay Maichew Woreda also have service to health and education within 15 health post and 4 health center, 42 educational center and one of those were secondary school (9-10th) and the rest were primary schools Appendix J and K.

3.1.10. Existing RWSS Conditions of the Woreda

There were a total of 407 water supply schemes in the woreda, from which 261 hands dug wells, 129 shallow wells, 16 springs development at spot and 2 deep boreholes. From the total water supply schemes, 305 are functional and 102 are non-functional which accounts 28.35% of hand dug wells, 13.95% of shallow wells, 56.26 of spring development at spot and 50% for deep wells. Thus implies that 75% were functional and the remaining 25% were non-functional. The water supply coverage of the woreda was 79.2%. In general, non-functionality was great problem in the woreda.

Table 3.1: Existing water supply conditions of Lailay Maichew Woreda

Scheme type	Non-Functional	Functional	Total	Percentage of Non-Functional
Spring	9	7	16	56.25
Hand dug	74	186	260	28.35249
Shallow	18	111	129	13.953488
Deep	1	1	2	50
Total	102	305	407	25.06

3.2. Methodology

3.2.1. Data Source and Type

The data type of the study was both qualitative and quantitative. Source of Primary data was households of the community water users, community water committees, woreda water resources experts and NGOs water experts. The main source of primary data was community individual households.

Secondary data was also collected to complement the primary data. The major sources of secondary data were government, NGOs, publications, non-published documents, websites annual reports, books and similar researcher done before etc.

3.2.2. Data Collection Instruments and Methods

Different data collection instruments and methods were employed to collect primary data. Since the main source of data for the study was individual households, structured households interview schedule which included close ended and open-ended questioners were employed. Focus group discussion and key informants' interview also employed to generate data from different actors.

The focus group discussion and key informants interview were conducted using structured and semi-structured check list. In addition, personal observation was also a handful instrument to directly observe the existing rural water supply problems within structured and semi-structured check list in the study area.

The researcher used three supporters to ease the work. The supporters had enough knowledge and experience in the rural water supply schemes. Water mechanic, one community facilitator per water point and Water resource engineer, were participated in the research work. The former two are diploma holders and the later is degree holder who was working in Lailay Maichew woreda water, mine and energy office during the research work.

Primary data was collected by implementing questionnaires. Questionnaires are formulated in such away to give clear picture about the non-functionality reason of water supply scheme in rural areas.

The concept of non-functionality was taken from the definition of Lockwood and smith (2011) and modified to non-functionality is the percentage of non-functional schemes from the existing functional schemes which does not give service to community because of technical, management, financial, institutional and other problems at the time of spot check. Questionnaire content and design system was taken from Gebre (2012) and formulated by the researcher. The following non-functional indicators were organized to five major causes of non-functionality to analyze the real picture of non-functionality reason of RWSSs.

Technical non-functionality reason indicators: Technical issues relating to the design and construction of a rural water system are the most obvious determinants of water system functional sustainability. 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 wells or boreholes, and overestimates of the water sources may cause a system to fail from the outset. Most of these factors may be identified through examinations of the system and interviews with system operators.

- **Construction**: Non-Functionality reason of RWSS can be during, before or after construction. During construction problem accounts for use of low-grade construction materials , absence of construction firm to perform the construction, not fence water point with firm gate, absence of collapse preventing during construction stage, absence of standard construction manuals and absence of consulting firm locally which able to take care of the design of the scheme.
- **Yield:** Yield problems were defined were yield assessment for spring during dry season and wet season. Schemes which does not give service throughout year, fetching time more than 30minute, distance of water point from their home more than 1.5km, community water consumption less than 20l /c/d, public health centre water consumption less than 50 l/ bed and school water consumption less than 15 l/person,
- **Site selection**: Appropriate Site selection of rural water supply scheme is important phase of planning and physical development of any water supply scheme. Site selection problems were defined by missing of spring eye, not considering upstream and downstream water shade of water point, less community participation in water point location, placing of water point near to river with no consideration of high flood level.
- **Quality:** Quality problems were defined more by the physical parameters like test, odor, color and turbidity of water sample from the water point, chlorination process and distance of water point from pit latrine, communal dumping of the community

Management of operational and maintenance non-functionality reason indicators: Under this indicator management and mechanical problems were sub indicators as explained below.

Management: Management problems were indicated by poor community management include less ownership fleeing, less work rate of water committee, conflict among water users, poor woreda water expert's management.

Mechanical (hand pump and pipe system components): Mechanical problems were assessed using the components of hand pump and pipe line system of spring and deep well which were sensitive for non functional reason include broken of hand pump, U-seal, bush bearing, pedestal cracked, plunger body damaged, cracking of PVC, break dawn of pipes, branched networks problems like Low reliability, which affects all users located downstream of any breakdown in the system, Accumulation of sediments at the system ends, Fluctuating water demand producing rather large pressure variation, spare parts problem and pipe fitting problems.

Financial non-functionality reason indicator: Financial problem were indicated by the willingness of the community to pay tariff on time for operational and maintenance, cost recovery of the scheme and community contribution during construction.

Institutional non-functionality reason indicator: Institutional problems were indicated by poor integration between different rural development sectors.

Other non-functionality reason indicators: Under this indicator social and cultural, Gender, Health and Educational problems were sub indicators as explained below.

- Social and cultural: Social and cultural problems were indicated by the acceptance of new technology and bad cultural problems by the community
- Gender: Gender problems were indicated by the activity of women to participation of water committee of their water point, man and boy's activity towards helping women to fetching water and women participation activity towards community issue.
- Health and education: Health and educational problems were indicated by the available of functional health facility, community health workers, formal education facility and informal education opportunities. Prevalent of water borne diseases, wither hygiene and sanitation education included in curriculum, and Sanitation and Hygiene education provided in the community.

Community participation towards their water point were indicated through different aspects of participation includes during design, construction, training (technical and non-technical) and management.

Composite programming model: Composite programming model were the tool to select the best and lowest scheme of the woreda evaluated by 157 questionnaires within 53 basic indicators which includes qualitative and quantitative data that can be primary and secondary data collected from community water users, governmental and nongovernmental organizations. The model were based on two major objectives which include planning physical development and sustainable operational and management of schemes within specified time. The following steps were conducted to indentify the best scheme of the study area.

- The first step were collection of primary and secondary data based on the questionnaire developed by the author (Gebre, 2012)
- Second, Determined the value of 53 quantitative and qualitative indicators
- Third, Set the best and worst values of these indicators
- Fourth, Normalized each indicator between 0 and 1
- Fifth, Assign weights for each indicator or group of indicators at every level (need very experienced water experts of woreda and NGO)
- Last, Get scores at every level and total evaluation level to meet the objective.

Household survey, focus group discussion, key informant interview and personal observation were techniques to collect primary data which helped to meet the research objectives.

3.2.3. Sampling Design

Sample frame: According to Laelay Maichew Woreda water resources development office, there were 407 public and institutional water points constructed by different governmental and NGOs water sectors REST, WASH, Food Security and others. sampling frame of functional and non- functional RWSSs constructed from 1990 to 2005E.C were only consider for the study as design period of most rural water supply is in the range of 10year to 15year therefore, 305 functional and 102 non-functional community water supply points were identified for the sample frame.

Sample size: In order to meet the objective of the study non functional water points were all taken as the result of the sample size computation and 10% of these were taken for functional water points as more emphasizes is given to non-functional water points. A level of significance of 5% and margin of error of 10% were used for the computation of the sample size water points, house hold population and number of kebele despite Laelay Maichew Woreda is topographically rugged and very difficult to access on foot and by vehicle. The sample of water points, house hold population and number of kebele computed using the sample size computation formula table 3.2 (Schweitzer, 2009).

$$SS^* = \frac{Z^2(P)(1-P)}{\epsilon^2} \text{..............Equation (1)}$$

$$SS = \frac{SS^*}{(1+\frac{SS^*-1}{POP})} \text{.................Equation (2)}$$

Where:

- SS^*= Unadjusted sample size for a very large or unknown population
- Z=Standardized normal deviate value at 5% level of significance ($Z_{0.05/2}$=1.96)
- P= Percentage population picking a choice expressed as a decimal (p = 0.5)
- □=Margin of error expressed as a decimal (□ = 0.1)
- SS=Adjusted sample size to achieve determined confidence level and interval (for finite population)
- POP=Population (water points sample frame) from which sample of water points are to be drawn

Using the above formula the sample size of the study were 50 and 5 for non-functional and functional schemes respectively (see table 3.2). But due to some additional resource supported from the woreda actual sample size water point were increased to 102 non-functional schemes and 15 functional schemes. As a result, all non-functional schemes were taken as sample size of water point Appendix A.

. Table 3.2 Sample size calculation

S.No	Item sample	Z^2	P	$\square^2$	SS^*	POP	SS	Actual SS
1	Water point	3.8416	0.5	0.01	96.04	102	49.7162	115
2	Kebele	3.8416	0.5	0.01	96.04	16	13.83862	15
3	HH	3.8416	0.5	0.01	96.04	2608	92.6632	115

Kebele Selection: According to the sample size computation table3.2 from 16 kebele 14 kebele were calculated and were selected purposely based on accessibility and feasibility factors those which have high non-functional rate and scheme type. Despite that laelay Maichew Woreda is topographically rugged and very difficult to access on foot and by vehicle, all non-functional schemes were assessed constructed in all kebeles of the woreda except schemes in kebele M/dego as there was no non-functional scheme table 3.3.

Table 3.3 Rank of Kebeles based on their non-functionality rate

S.No	Kebele	Functional Schemes	Non-Functional Schemes	Total Schemes	%age of Non-Functional	Rank
1	Welel	18	10	28	35.71	1
2	May-Weyni	20	11	31	35.48	2
3	Natk-Blae	12	6	18	33.33	3
4	Medego	21	10	31	32.26	4
5	Dereka	43	18	61	29.51	5
6	Awleo	14	5	19	26.32	6
7	Hatsebo	31	11	42	26.19	7
8	Edaga-arbi	20	7	27	25.93	8
9	Lesalso	20	7	27	25.93	9
11	Dura	19	6	25	24.00	11
10	Seglamien	4	1	5	20.00	10
12	D/Brhan	14	3	17	17.65	12
13	Adi-Tsehafi	13	2	15	13.33	13

14	M/Selam	30	4	34	11.76	14
15	Miha	20	1	21	4.76	15
16	M/dego	6	0	6	0.00	16
	Total	305	102	407	25.06	

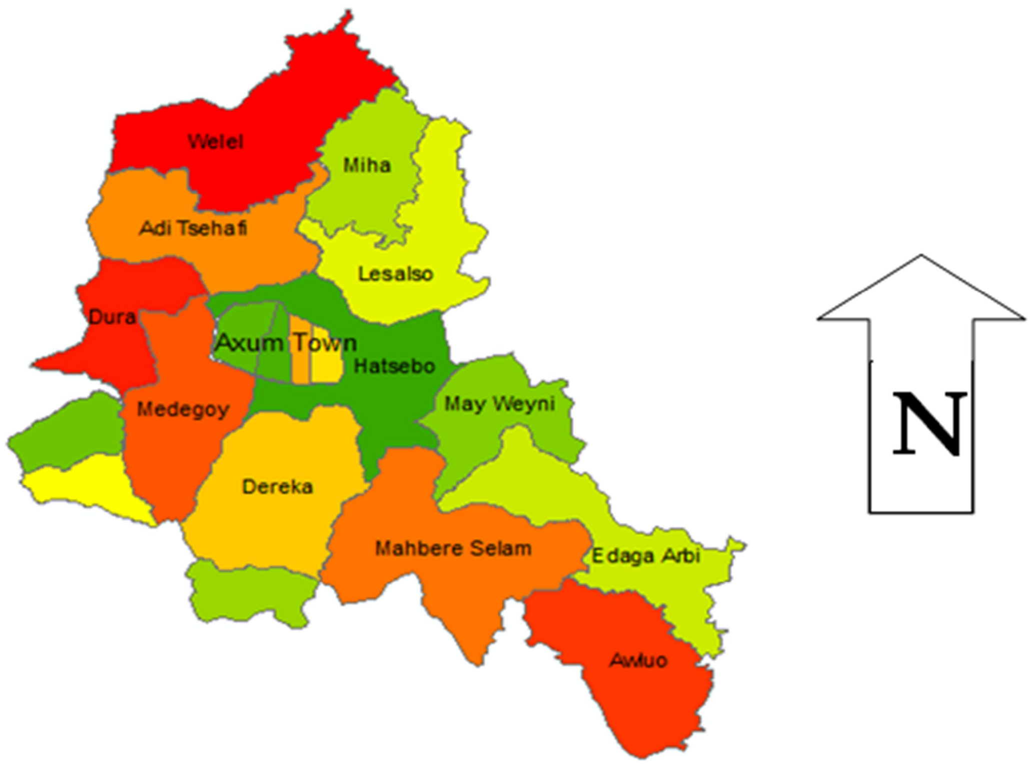


Figure 3.2 Location name of Kebele of the study area

Household Survey (HHS): As the objective of the research was to assess main causes of non-functionality of RWSSs, more than 575 closed and open ended structured questionnaires were prepared to generate the required information from 115 samples HH, which is more than what was calculated above in table 3.2. The structured questionnaires are available in Appendix B and H.

Focus Group Discussion (FGD): The primary data collected from HHS was enriched by additional information which gathered from FGD with the help of check lists unstructured questionnaires and discussions. Accordingly, two from woreda water experts and two from NGO water experts were randomly selected for first round of FGD Appendix D. Five community water committee and five water users were also randomly selected for second round of FGD. Check lists unstructured questionnaires and discussions are available in Appendix F.

Key informant's interview: A key informant interview was particularly important in getting information related to the technical and non technical aspect of water supply sector. Therefore, views of water supply agencies (head and experts) were very important as they had better knowledge and experience on problem and community participation of rural water supply issues. To obtain the views of key informant interviews, checklists were prepared and information was collected. Accordingly, three woreda water experts and three NGO water experts were randomly selected for first round interview. Six scheme technical monitories were randomly selected for second round and five community water committee chair persons and five water point users were randomly selected for third round interview. Check lists for key informant interview are available in Appendix C and E.

Personal Observation: Personal observational was also a handful instrument to directly observe the problems of all existing non-functional RWSSs in the study area. To obtain the views of observed data, checklists were prepared and information was collected. Accordingly, seven woreda water experts randomly selected and the researcher were observed all non-functional schemes within two rounds. The checklists for observational data are available in Appendix G.

3.2.4. Data Analysis

Once the relevant data were collected, the next step was analyzing it using different methods.
The quantitative data collected from the sample households were organized, and processed using Composite programming model.MS Excel were used to analyze the qualitative data. Descriptive statistics (frequencies, percentages and means) were produced for the quantitative data depending on the nature of data collected about the water points and beneficiary households.
Accordingly, report produced on the results of the study. The qualitative data collected through the key informant interviews, focus group discussions, and observations made were used to triangulate the findings of the quantitative survey of water points and beneficiary households. Some of the study findings are presented using pictures, diagrams, tables, and charts.

4. Data Analysis Results and Discussions

4.1. Introduction

Data analysis results and discussions of this research were assessed non-functionality of RWSSs in the woreda to meet the main objective of the research.

4.2. Functionality and Non- Functionality Rate from Secondary Data

The first data collection of this research was collecting secondary data of the woreda that is inventory data from different water sectors. A total of 407 RWSSs were exist during non-functionality rate data inventery of Lailay Miachew Woreda include hand dug well, shallow well, spring development at spot and deep well. From those 22.98% for HDW, 19.37% for SHW, 43.75% for SPR and 0% for DPW were secondary data input score percentage of non-functional scheme type fig 4.1. Secondary data collected from Lailay Maichew Woreda were analyzed using frequency analysis method as shown table 4.1.

Table 4.1 Non-functionality rate of RWSSs from secondary data

Scheme Type	Functional Schemes	Non-Functional Schemes	Total	Percentage of Non-Functional Schemes
HDW	201	60	261	22.98
SHW	104	25	129	19.37
SPR	9	7	16	43.75
DPW	1	0	1	0
Total	315	92	407	22.60

As shown below fig4.1 from secondary data total non-functionality rate of RWSSs of the research area were score 22.60%.

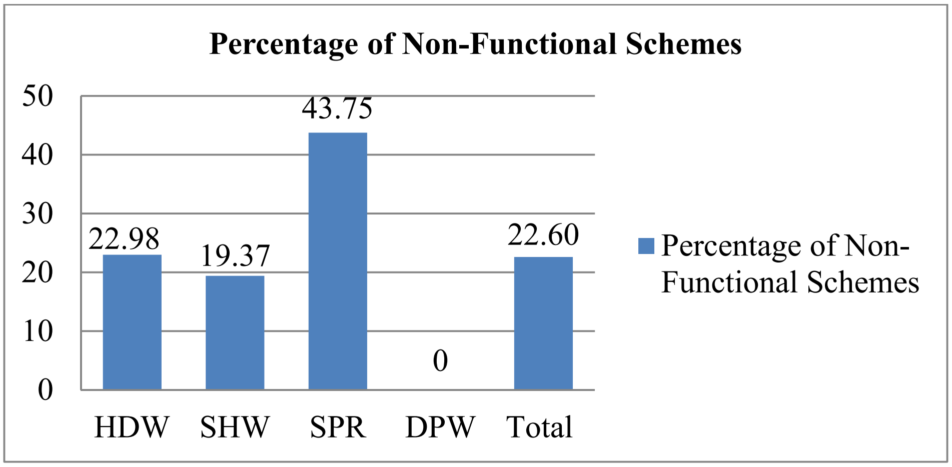


Figure 4.1 Non-functionality rate of RWSSs from secondary data

4.3. Functionality and Non- Functionality Rate from Primary Data

There were a total of 407 RWSSs in the Woreda, from those 305 are functional and 102 are non-functional which accounts 28.35% for HDW, 13.95% for SHW, 56.26 for SPR and 50% for DPW. Thus implies that 74.94% are functional and the remaining 25.06% are non-functional table 4.2.

Table 4.2 Functional and non-functional rate of RWSSs from primary data

Scheme type	Non-Functional	Functional	Total	Percentage of Non-Functional
Spring	9	7	16	56.25
Hand dug	74	186	261	28.35249
Shallow	18	111	129	13.953488
Deep	1	1	2	50
Total	102	305	407	25.06

As shown below fig 4.2 from primary data collected of total non-functionality rate of RWSSs were 26.05% which is 2.46% higher than the rate of non-functionality from secondary data which was 22.60% and this was because of continuous non-functionality rate in the woreda and improper non-functionality data collection.

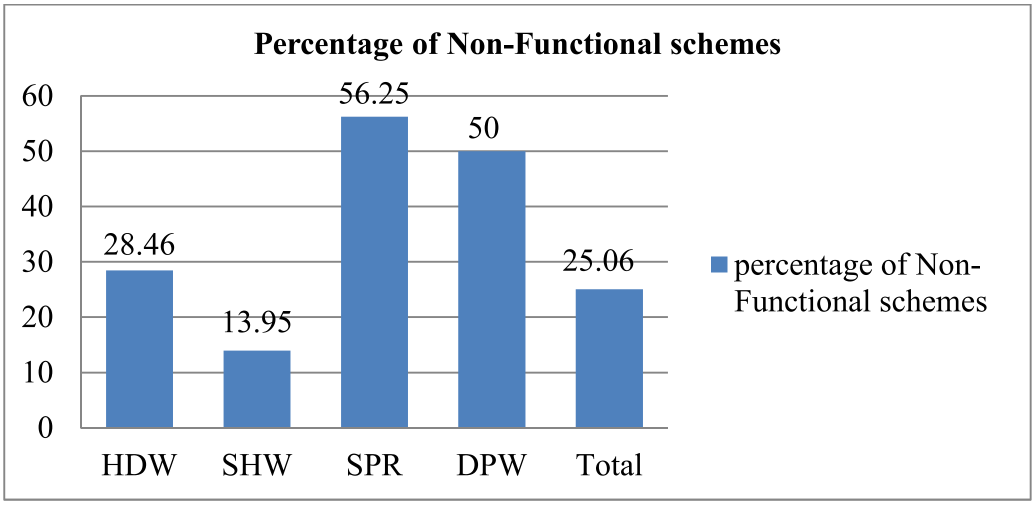


Figure 4.2 Non-functionality rate of RWSSs from primary data

4.4.1. Over View of Respondents for Primary Data Collection

From the respondent's socio-economical characteristic the minimum age is 18 and the maximum one is 80 years old. Head or water committees of sampled households in each water point were used to answer the questions that assess different aspects of their water point.

As female are more responsible and aware of water collection and usage of a family female household heads are preferred as possible and they account for about 60% of sample households and 40% were for Male. 45% of the sample populations are illiterate who cannot read and write**,** 30% were account for 1st to 8th grade, 20% for 9th to 10th and only 5% of the sample populations were diploma fig4.3.

Size of the family of households is one of the factors that determine the amount of water offered and number of water points to be constructed. Based on the household survey, more than the average (57%) of the sample households has between 5 to 9 family members per household and 40% less than 5 family members. Only 3% of the households had 10 and above family members. The average family size per household was found almost 5 individuals per household.

Table 4.3 Respondents community educational statues

Education status	Number of Respondents	%age	Female	Male
Not Educated	207	45	276	184
Grade 1-8	138	30	60(%)	40(%)
Grade 9-10	92	20		
Diploma	23	5		
Total	460	100		

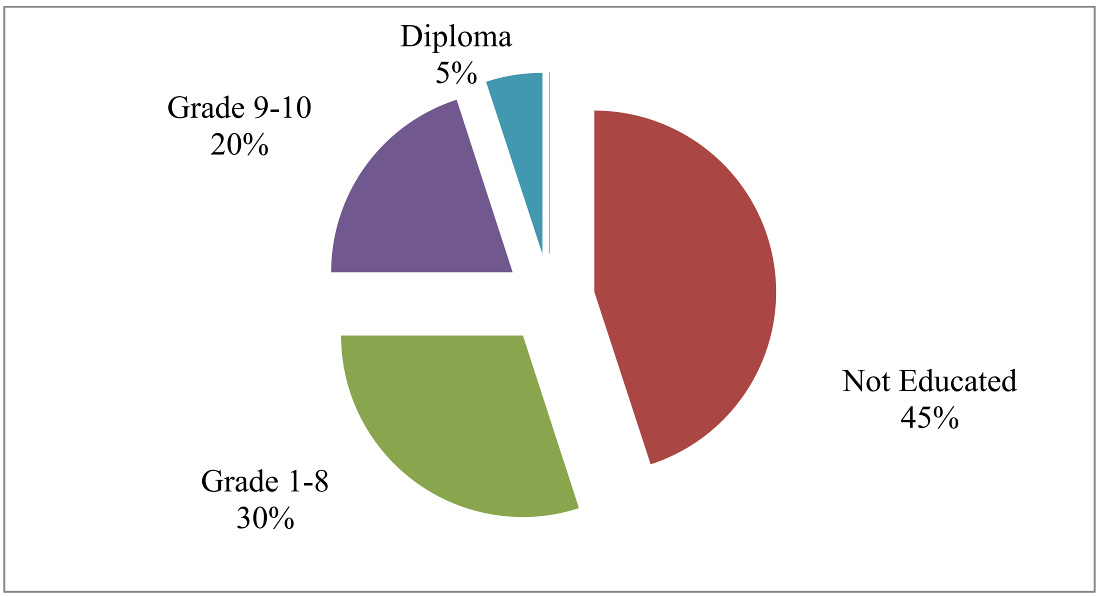


Figure 4.3 Respondents community educational statues

4.4.2. Community Participation for RWSSs Development

The community of Lailay Maichew Woreda had participated during different stage of water point development. The researcher finalized community participation within five level of development to measure their participation towards their water point on community management, design, construction, technical training and non technical training fig4.4.

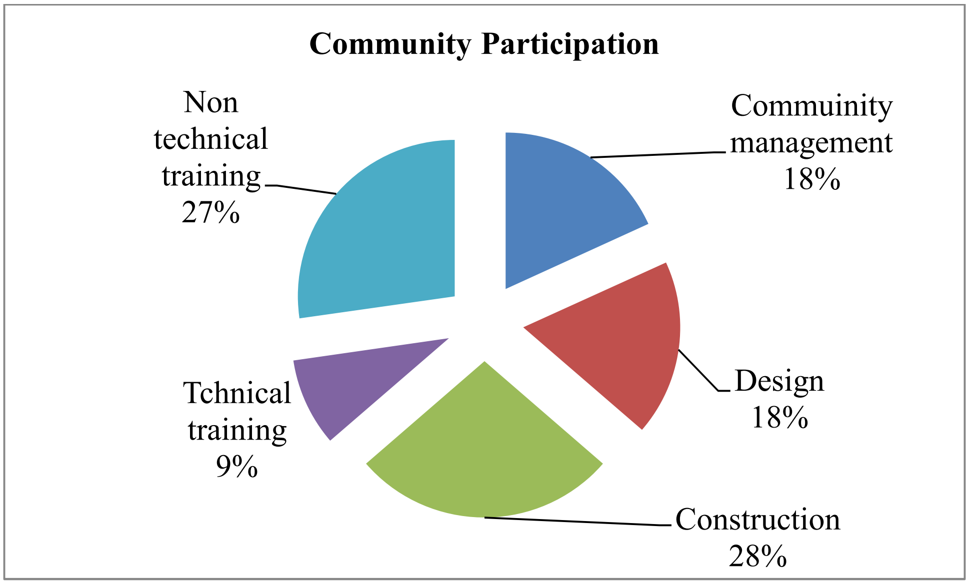


Figure 4.4 Community participation to their water point

Figure4.4 shows community participation during construction score high (28%), non technical training (economic and health aspect training) is the second most participation of the community (27%), the third one is during design phase and community management (18%) and the last one community participation on technical training (technical aspects) is very low (9%).

4.5. Design period and Duration of RWSS Non-Functionality

The questionnaire surveys conducted in 102 water point site in the past 16years, since 1991. Within 16years from 36 collapsed water schemes highest frequency of non functionality rate was recorded at the age of seven years after scheme constructed. It means the life age of eight water schemes is seven years. From those collapsed water schemes nine water schemes could only pass ten years on functioning after construction. The average non-functionality period of schemes in Lailay Maichew woreda is seven years as presented below fig.4.5.

Figure 4.5 Duration of non- functionality of RWSSs

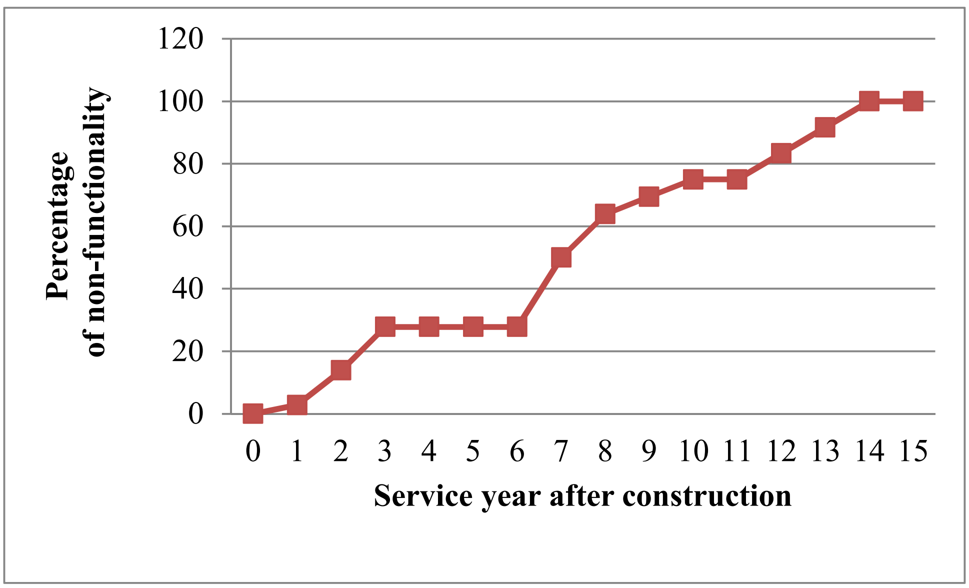


Figure 4.6 Service year of RWSSs after construction

The above fig.4.6 shows that about 28% of schemes failed within the first three to six years after construction. Non functionality increases thereafter. For example, by year 12 total of 30 water schemes collapsed. This is around 83.3 % of non functionality occurred 12 years after construction. Generally, most non functionality occurs much lesser than expected design periods. More than two third of water schemes fail lower than a minimum design period, which is 10 years.

4.6. Water Schemes Cost and Non-Functionality

Non-functionality is one of the main causes for losing of capital cost of the project. During the study time more than 65% construction costs of schemes were known. The rest 35% cost was estimated by act of examining resemblances with known scheme cost within the same period of construction. Based on the above measures total estimated project cost for 407 water supply schemes is 44,548,718 birr. From the total, non functional water schemes costs 11,164,544 birr fig 4.7. Capital cost lost due to non functionality is directly and indirectly affect local and national economy of the country.

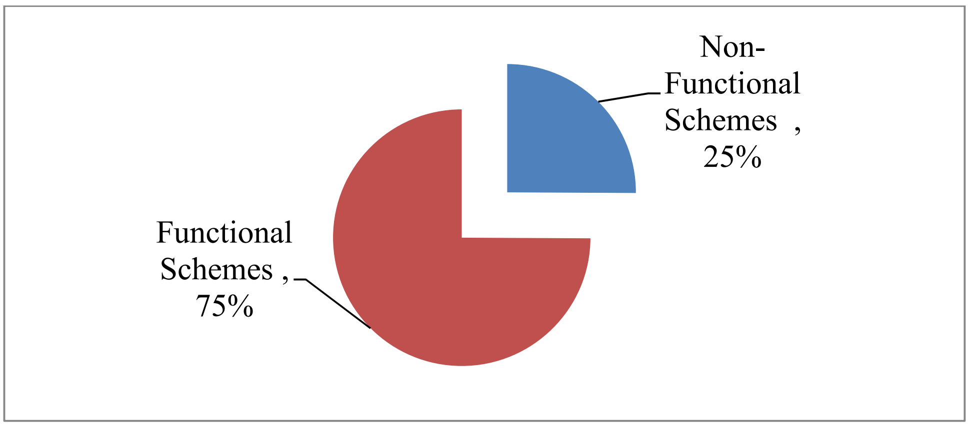
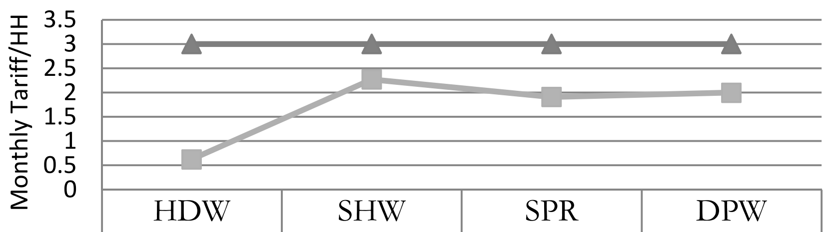


Figure4.7 Cost of functional and non-functional RWSSs

Furthermore, there is no project cost recovery trend in rural water supply projects. Generally there is 9.5% community and 7% local administration cost contribution activity in the woreda. There are some separate institutions which are costing for rehabilitation of water, Most of them are local and international nongovernmental organizations which are supply basic equipments; assign budget for water sector, assist major maintenance and giving training for water committees and artesian after scheme development which was not continues to sustainable water points.

4.7. Monthly Tariff Fee and Non-Functionality

Communities are the main actors on sustainable their water point regarding to minor issues of maintaining water point. But community was not able to collect monthly tariff fee according to specified fee by water committee and woreda water resource office as presented in fig.4.8.



	HDW	SHW	SPR	DPW
Actual Monthly Tariff / HH (Birr/month)(Non-functional)	0.625	2.27	1.91	2
Monthly Tariff /HH Set by Woreda(Birr/month) (Functional)	3	3	3	3

Figure 4.8 Monthly tariff fee of scheme type

The average monthly tariff per household was 1.704 Birr/month and this indicates 43.17% of the tariff set by woreda was not collected.

4.8. Training and Non-Functionality

Household and scheme water committee members training play a great role in ensuring the sustainability of RWSS. Even if the community members have high demand for water they may lack the ability to operate and maintain the system by their own. Training provides knowledge about how to operate and maintain the system and also increase the awareness of the communities' willingness to sustain the system. Training for Functional schemes and Non Functional schemes was assessed by interview the water point committee members and community elders those who were participate during scheme development. Functional schemes score high 62% compared to Non Functional schemes 38% and this indicates as training play great role to sustain RWSS as shown below in figure 4.9.

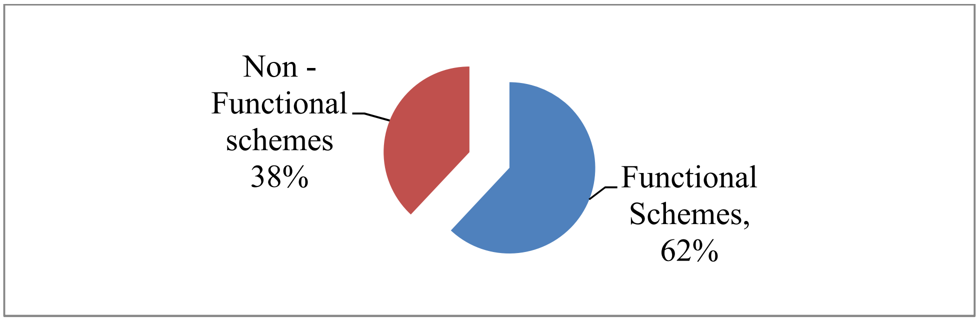


Figure 4.9 Training comparison of functional and non-functional schemes

4.9. Non-Functionality and Skilled Staff, Tools of RWSS

The number of skilled human power within the woreda play great role to sustain RWSS as the number of scheme increase skilled number should also increase. But, in case of Lailay Maichew Woreda skilled human power were not proportional with the number of schemes developed it was one skilled person to fifty RWSS which is difficult to see after all during maintenance.

The average distance of skilled person residence relative to RWSS is 18.5Km and there are two Motorcycle for rural water supply development staff and those are not enough for sustain RWSS in Lailay Maichew Woreda.

For example if two water points are suddenly become temporary non functional within each kebele totally becomes 32 schemes and it will be difficult to maintain all of them once within two Motorcycles. Skilled persons may maintain two to four schemes per day and the rest 28 to 30 schemes may extend their non functional. In addition to this, the main reason of time extend of non functionality was because of necessary tools and spare parts were not available on time.

4.10. Non-Functionality of Rural Water Supply Schemes

Non-functionality of RWSSs are schemes which does not give service to community at time of spot (water point) check due to different reason that can be technical, management, financial, mechanical, institutional, social, gender, health and education problems of different rural development sectors.

4.10.1. Non-Functionality Reason of RWSSs

1. **Technical Reason of Non-Functionality**

Construction: Non-Functionality reason of RWSS can be during, before or after construction. During construction problem accounts for absence of construction firm to perform the construction, not fence water point with firm gate, absence of collapse preventing during construction stage, absence of standard construction manuals and absence of consulting firm locally which able to take care of the design of the scheme.

Generally reason of Non-Functionality due to construction problems were account 26% for HDW, 5% for SHW, 42% for SPR and 27% for DPW fig4.10. Spring development score high (42%) of construction problems due to using poor construction material, missing of spring eye capping, and poor fence construction of water point.

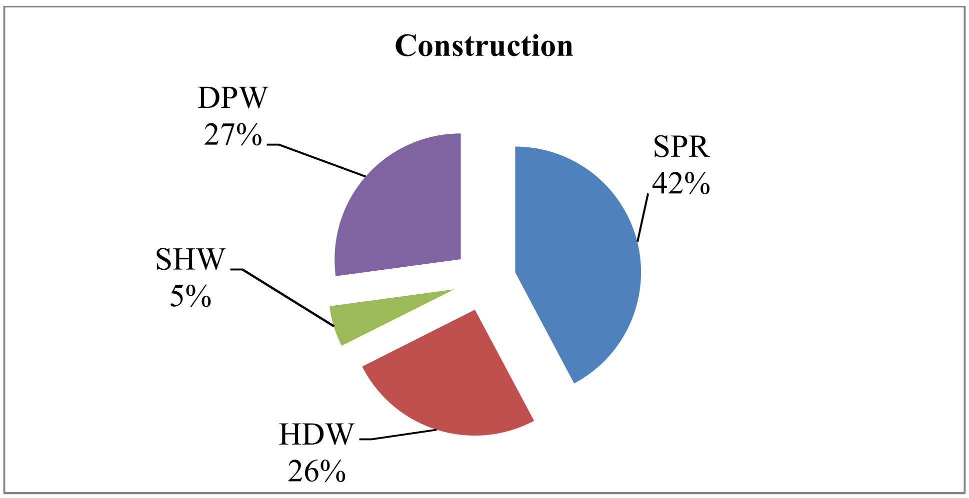


Figure 4.10: Non-functionality due to construction problems of scheme type

Quantity (Yield):,Quantity of water were assessed using the functional schemes and the consumption per day per capita were 20 l/c/d for functional schemes, but non-functional water point users were forced to have consumption of 10 l/c/d because they were displaced from their water point due to yield problems. Yield problems were defined were extraction period and duration during well development and yield assessment for spring during dry season and wet season. Schemes which does not give service throughout year, fetching time more than

30minute, distance of water point from their home more than 1.5km, community water consumption less than 20l /c/d, public health centre water consumption less than 50 l/ bed and school water consumption less than 15 l/person,

Generally yield problems were account 57% for HDW, 26% for SHW, 17% for SPR and 0% for DPW fig4.11. HDW yield problem accounts for 57% because of extraction of water during wet season, distance of water point from their home more than 1.5km, community water consumption less than 20l /c/d, public health center water consumption less than 50 l/ bed and school water consumption less than 15 l/person compare to other schemes.

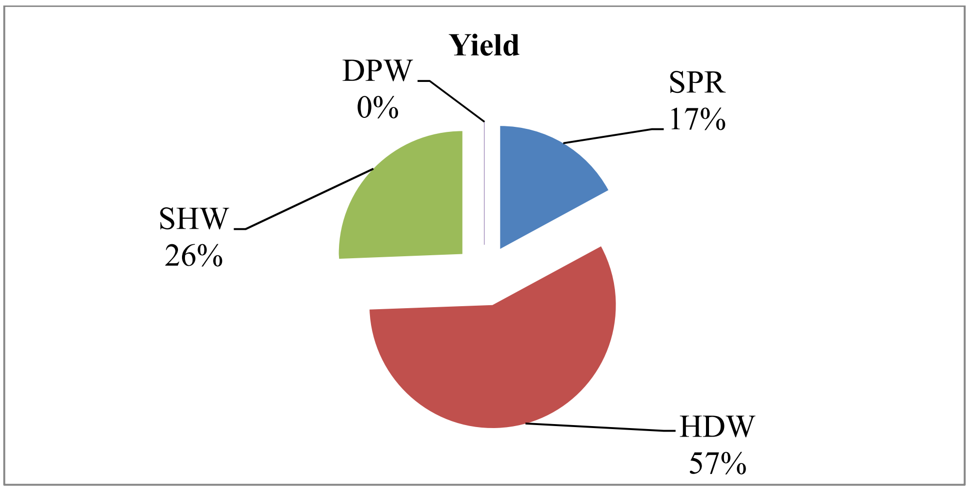


Figure 4.11: Non-functionality due to yield problems of scheme type

Quality: Quality problems were defined more by the physical parameters like test, odor, color and turbidity of water sample from the water point, chlorination process and distance of water point from pit latrine, communal dumping of the community

Generally quality problems were account 32% for HDW, 30% for SHW, 34% for SPR and 4% for DPW fig4.12. quality problem of each schemes were similar but Spring development score high (34%) as most of spring box manhole were open , chlorination delay, easily contaminate and have test, odor, color and turbidity of water sample problem from the water point.

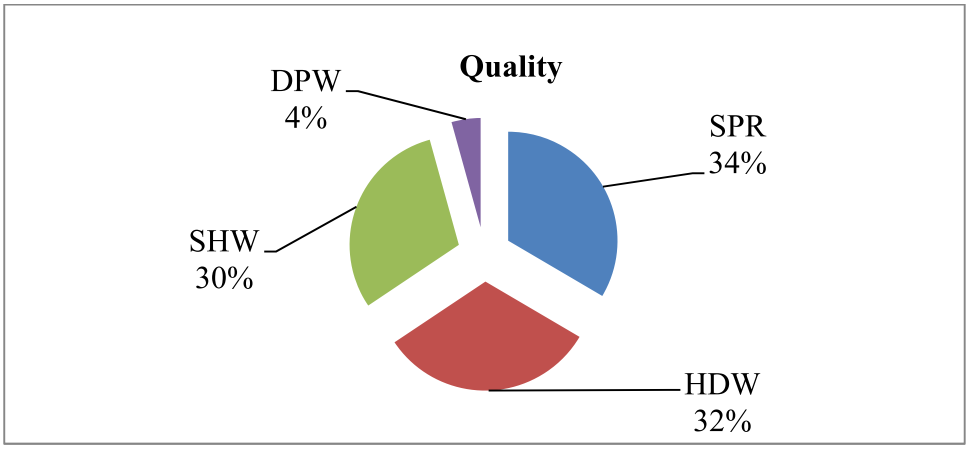


Figure 4.12: Non-functionality due to quality problems of scheme type

Site Selection: Appropriate Site selection of rural water supply scheme is important phase of planning and physical development of any water supply scheme. Site selection problems were defined by missing of spring eye, not considering upstream and downstream water shade of water point, less community participation in water point location, placing of water point near to river with no consideration of high flood level.

Generally site selection problems were account 13% for HDW, 5% for SHW, 54% for SPR and 28% for DPW fig4.13. spring development scores high (54%) of site selection problems of RWSS because of missing spring eye, constructing spring component near to river course and not participation community elders during selection location of water point compare to other RWSS.

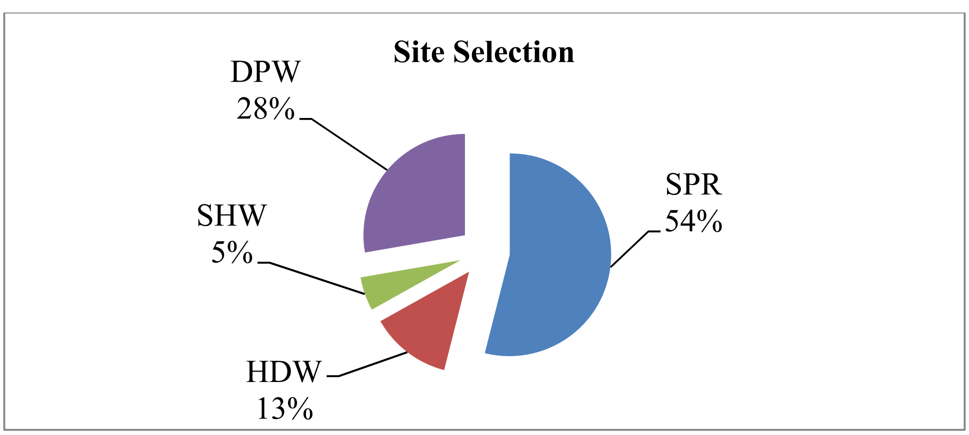


Figure 4.13: Non-functionality due to site selection problems of scheme type

2. **Finance Reason of Non-Functionality**

Financial sustainability for any rural water supply schemes is more important than the other indicators of functional sustainability as water points are easily need maintenance when ever if breaking of pumps or its spare parts occur while operations.

Financial problem were indicated by the willingness of the community to pay tariff on time for operational and maintenance, cost recovery of the scheme and community contribution during construction.

Generally financial problems were account 29% for HDW, 22% for SHW, 28% for SPR and 21% for DPW fig 4.14. HDW score high (29%) financial problem as most HDW schemes have small mechanical problems but the community cannot collected money according to structured tariff for maintenance and those schemes were non functional for more than a year.

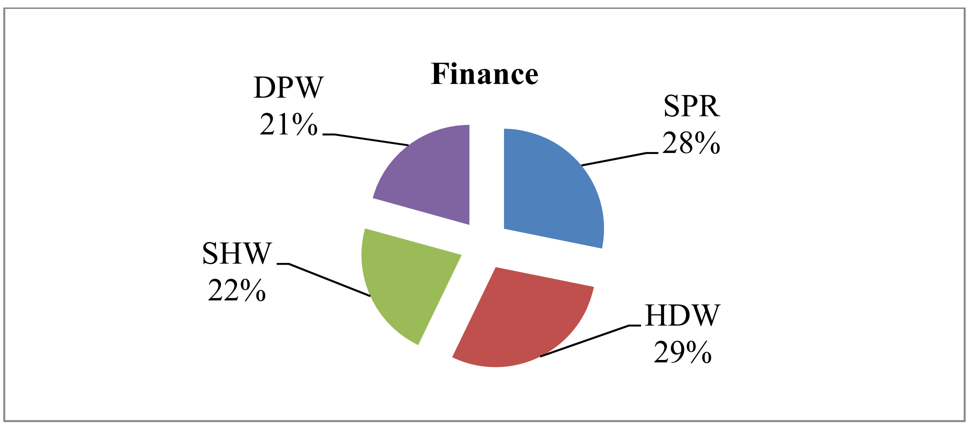


Figure 4.14: Non-functionality due to financial problems of scheme type

3. **Management of Operational and Maintenance Reason of Non-Functionality**

Non-functionality reason due to management of operational and maintenance were assessed by mechanical and management problems.

Mechanical (hand pump and pipe system components) : Mechanical problems which are sensitive for non functional reason include broken of hand pump, U-seal, bush bearing, pedestal cracked, plunger body damaged, cracking of PVC, spare parts problem and pipe fitting problems.

Those were account 22% for HDW, 20% for SHW, 32% for SPR and 26% for DPW fig.4.15. Mechanical problems for SPR score high (32%) as most of those schemes were non functional for more than three months averagely because of less mechanical spare parts available on time and technical follow up from Lailay Maichew woreda water experts.

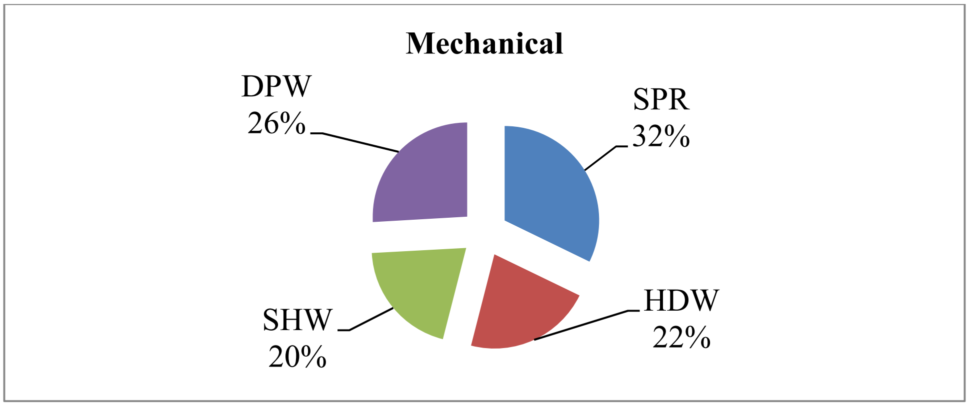


Figure 4.15: Non-functionality due to mechanical problems of scheme type

Management: Management problems rise due to poor community management include less ownership fleeing, less work rate of water committee, conflict among water users, poor woreda expert's management and those were account 21% for HDW, 27% for SHW, 28% for SPR and 24% for DPW .as shown in fig.4.16.

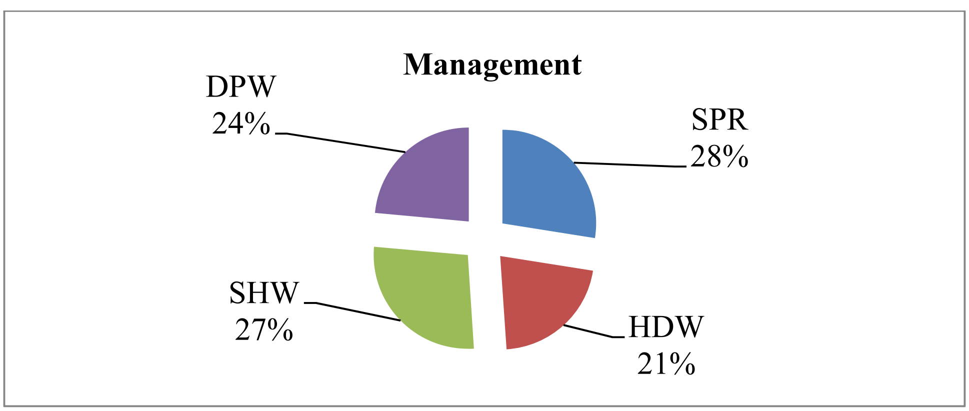


Figure 4.16: Non-functionality due to management problems of scheme type

4. **Institutional Reason of Non-Functionality**

Active integration between different institution has positive impact for sustainable operational and management of rural water supply schemes as they are interdependent of each other. In Lailay Maichew Woreda there are different institutions those can be governmental, NGO's and civil societies.

Institutional problems were because of poor integration between different rural development sectors and those were account 21% for HDW, 4% for SHW, 42% for SPR and 33% for DPW fig.4.17. Institutional problems of scheme type, SPR score high (42%) because NGS's were not participating to community on construction of their water point, handed over of scheme were not include woreda water experts, woreda administration and Lailay maichew woreda water resource office were not coordinate with the community to fence their water point and take technical training to spring development users.

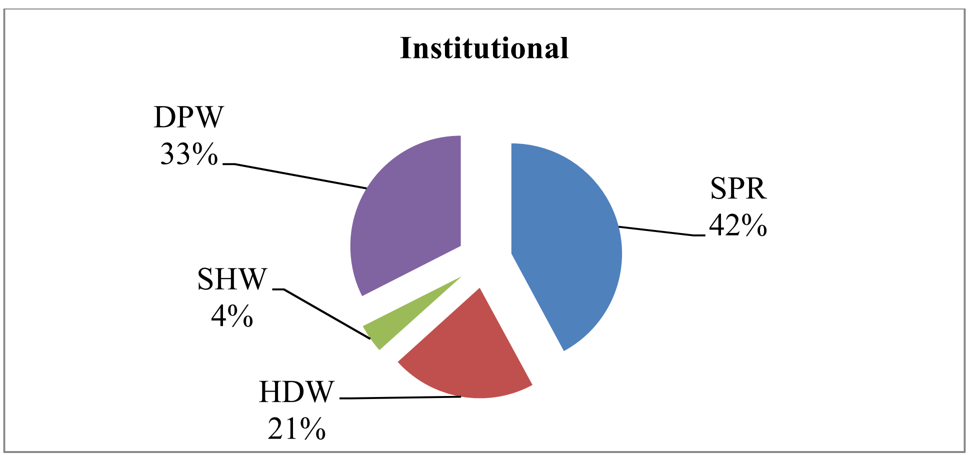


Figure 4.17: Non-functionality due to institutional problems of scheme type

5. **Other Reasons of Non-Functionality**

Other non functionality reason of RWSS include social and cultural, gender, health and education of rural water supply schemes problems are explain below. Those problems were account 20% for HDW, 27% for SHW, 29% for SPR and 24% DPW fig.4.18.

Social and Cultural Reason of Non-Functionality: Social and cultural problems were assessed the acceptance of new technology and bad cultural problems by the community

Gender Reason of Non-Functionality: Gender problems were assessed the activity of women to participation of water committee of their water point, man and boys activity towards helping women to fetching water and women participation activity towards community issue.

Health and Education Reason of Non-Functionality: Health and educational problems were assessed by the available of functional health facility, community health workers, formal education facility and informal education opportunities. Prevalent of water borne diseases, wither hygiene and sanitation education included in curriculum, and Sanitation and Hygiene education provided in the community.

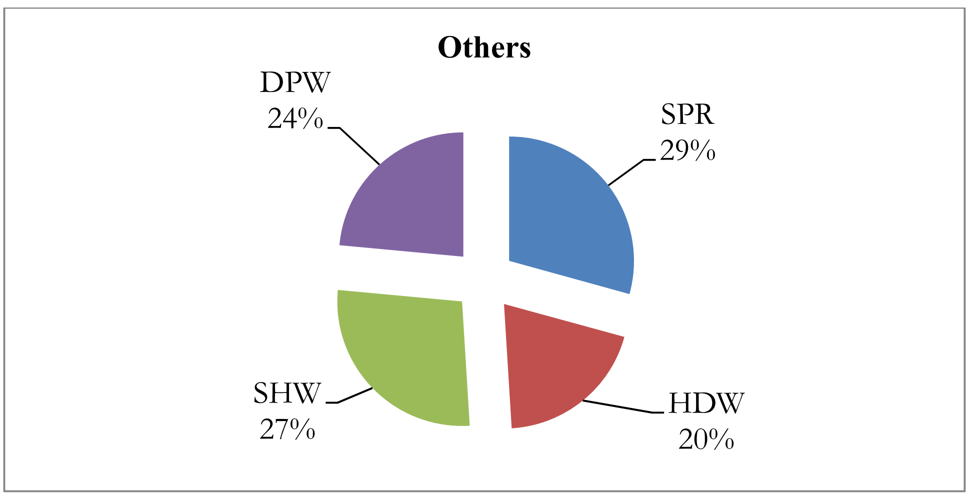


Figure 4.18: Non-functionality due to other problems of scheme type

4.10.2. Scheme Type and Non-Functionality Reason

Non-functionality reason of RWSS has been analysed wide within different factors which related to planning, development and sustainability of rural water supply schemes include: Technical problems (construction, yield, quality, and site selection), Financial, Mechanical, Institutional, Management and Others (social and cultural, gender, health and education etc...).

Non-functionality rate of the study area of scheme type for HDW was 28.35%, SHW 13.95%, SPR 56.25% and for DPW 50% averagely 25.06% as reported graphically in this chapter fig.4.1, The main causes of non-functionality of the study area are explain below for each scheme type.

Hand Dag Well (HDW): The rate of non functionality of HDW of the study area was 28.35% and the main causes of non-functionality account 7% for Construction, 10% for Yield (Quantity), 4% for Site selection, 17% for Mechanical, 15% for Quality and Management, 23% for Financial, 8% for Institutional and 1% for other problems include social and cultural, gender, health and education etc. As presented below fig.4.19. Non-functionality cause due to financial reason scores high (23%) as most HDW water points were not functional for more than five months without repair, Those water points were not functioning because; the community were not able to collect money according to structured tariff for maintenance or less willingness to pay tariff on time was the main cause of non-functionality of HDW in the study area.

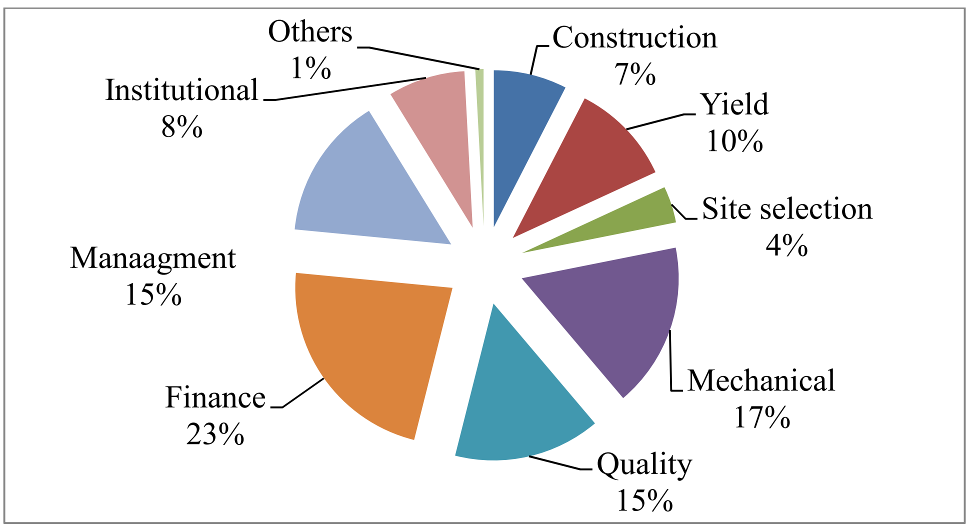


Figure 4.19: Non-functionality rate due to non-functionality indicators of HDW

Shallow well (SHW): The rate of non-functionality of SHW of the study area is 13.95% and the main causes of non-functionality of this account 2% for Construction, 6% for Yield (Quantity), 2% for Site selection, 20% for Mechanical, 18% for Quality, 25% for Management, 23% for Financial, 2% for Institutional and 2% for other problems include social and cultural, gender, health and education etc. As presented below fig.4.20. Managements reason of non-functionality scores high (25%) as most SHW water points were not functional because of three level management problems:

The first one is poor community management towards their water point include less ownership fleeing, poor activity of water committee to water point users on informed necessary information's and information gap between water committee and woreda water monitoring experts.

Second, less management of woreda water resource office towards water point monitoring of each water point. The third one is poor financial management of water committee and woreda water resource office on monitoring the collected money of water users.

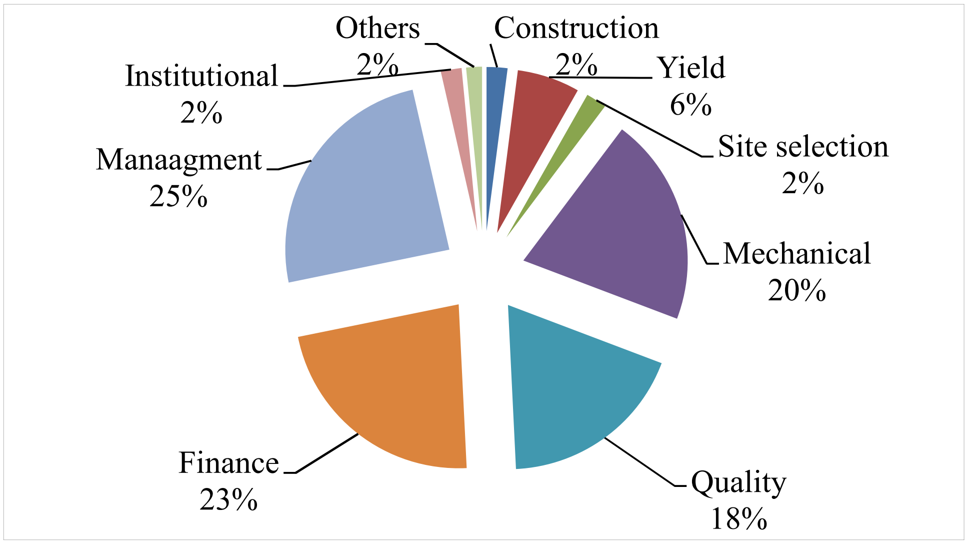


Figure 4.20: Non-functionality rate due to non-functionality indicators of SHW

Spring Development (SPR): The rate of non-functionality of SPR of the study area were 50.26% and the main causes of non-functionality of this account 10% for Construction, 2% for Yield (Quantity), 12% for Site selection, 19% for Mechanical, 12% for Quality, 15% for Management, 17% for Financial, 12% for Institutional and 1% for other problems include social and cultural, gender, health and education etc. As presented below fig.4.21.

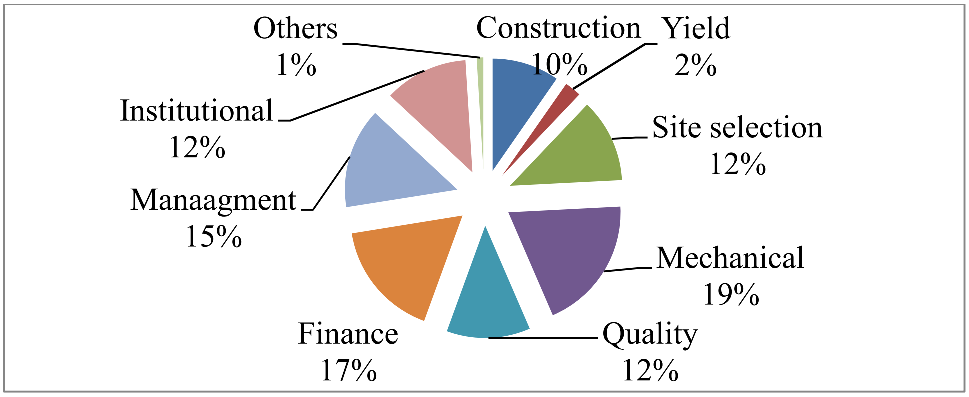


Figure 4.21: Non-functionality rate due to non-functionality indicators of SPR

Deep Well (DPW): The rate of non-functionality of DPW of the study area is 50% and the main causes of non-functionality of this account 10% for Construction and Site selection, 24% for Mechanical, 2% for Quality, 19% for Management and Financial, 15% for Institutional and 1% for other problems include social and cultural, gender, health and education etc.

As presented below fig.4.22 Mechanical reason of non-functionality scores high (24%) In the study area there are two DPW schemes and from those two schemes one is non-functional and the other is semi-functional.

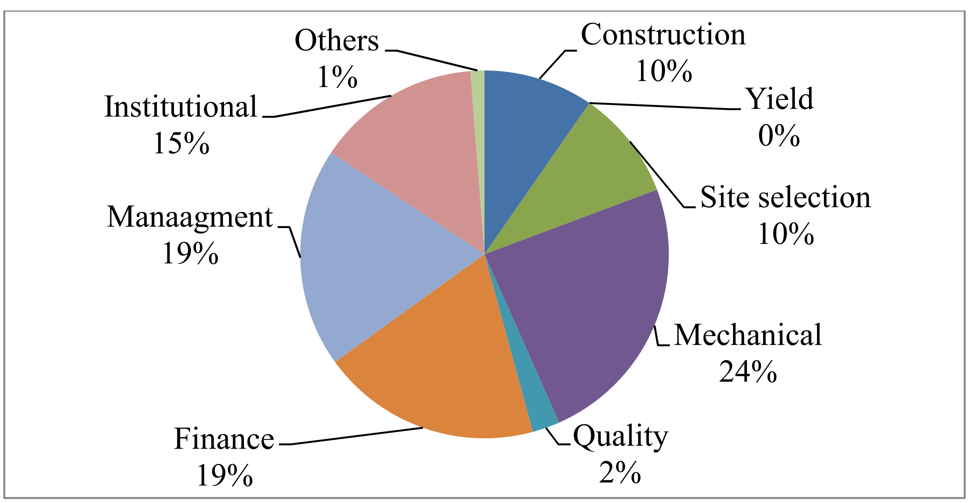


Figure 4.22: Non-functionality rate due to non-functional indicators of DPW

4.10.3. Key Informant Interviews Data Analysis Results and Discussions

Woreda Water Resources Experts: Important points were gathered through interview of three woreda water resource experts. Accordingly, RWSSs developed were based on study engineering aspects of the project area, rough estimation, prepared bill of quantity and other design criteria. Baseline survey was according to water supply coverage of community before and after project only decides for water point development. The amount of water supply to community was estimated sometimes using pump test for HDW and water flow measurement for spring development. Water point digging for HDW was from December to June (REST) and in dry season (woreda), Woreda water experts was not enough in number and not capable for RWSSs development.

For water point constructed by NGOs construction supervision was by the organization but woreda water resource experts were enforce during handed over scheme to participate with no design documents. For water point constructed by woreda construction supervision was by woreda water resource experts.

Community participation was not in every project phase, they were not willing to contribute money, technology selection were not enough as community does not have knowledge on technology selection and women participation was not enough toward their water point.

Some training and guide lines which guide to prepared community water committee was given by woreda management department, Water committee was train to manage the water users, how to collect money, employ caretaker and most important technical train is given how to operate and fence their water point. From a single water point three women and men were selected.

Community water users was given training how to operate and maintenance after development of the project by Woreda water resource experts. But this was not enough as the community educational background less and need continuous training. There was no guide line left with the community except temporary training.

There was no coordination through regular meeting, joint planning and monitoring between water, health and education sector at local level, there was no a coordination through regular meeting, joint planning and monitoring between government, privet sector and NGO and there was no any support from institution at higher level.

During implementation no budget for water supply, no monitoring, planning of water supply was left higher priority to NGO's at higher level to local level rather than to woreda , financial management of water committee, less environmental protection and poor ownership feeling of the community was main observed problems of RWSSs. Therefore, for government it should give focus to water supply projects similar to irrigation projects and for the communities continuous training should be given.

Nongovernmental Organizations (NGOs): The interview with NGOs was also similar but NGOs were used explosive materials to dig HDW well based on the design depth which was not practiced by woreda.

Community were participating on clear temporary access road, prepared construction materials like stone, sand, soil and loading ,unloading of materials and machinery during scheme construction.

Generally the causes of non-functionality results of frequency analysis of key informant interview with three woreda water experts and three NGOs water experts were analyzed as shown fig4.23. Mechanical, Management, Financial, Construction and Yield causes of non-functionality scores top five 17% ,15%,15%,12% and11% respectively compare to other causes of non-functionality of RWSSs.

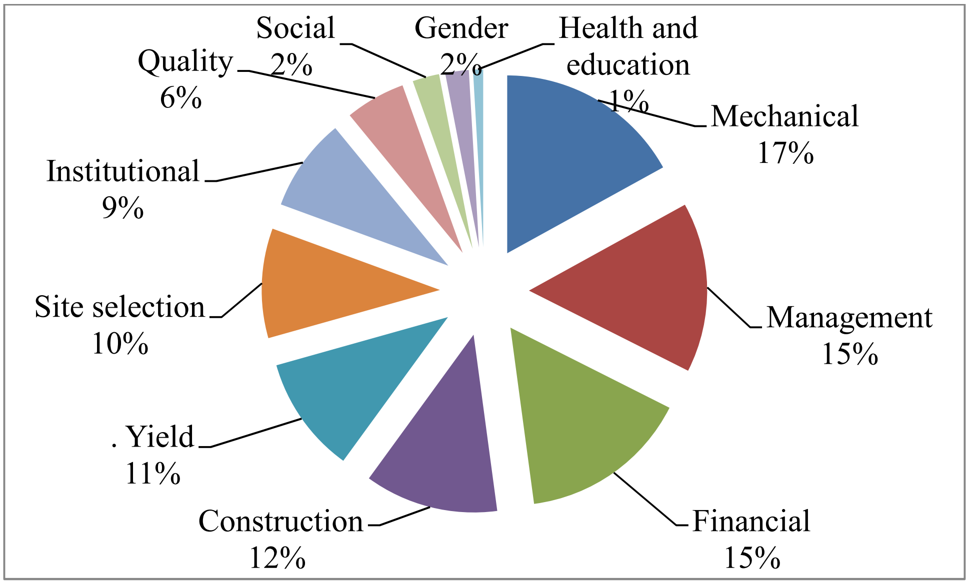


Figure 4.23: Non-functionality rate due to non-functional indicators of key informal interview

Scheme technical monitors of woreda water experts: In this case six water experts were interviewed**.** The number of skilled human power within the woreda play great role to sustain RWSS as the number of scheme increase skilled number should also increase. But, in case of Lailay Maichew Woreda skilled human power were not proportional with the number of schemes developed it was one skilled person to fifty RWSS which is difficult to see after all during maintenance.

Participation of scheme technical monitories woreda water experts on technical training were very low as one out of six were actively participated which is 16.67% the rest of those were monitor water points technically with no training after graduations of their respective field. If breakdown of any component of a scheme occurred it takes averagely three days to maintain. Most of breakdowns were mechanical components include U-seal, Bush bearing, PVC and Rod. U-seal were sensitive to break compared to other mechanical components.

The average distance of skilled person residence relative to RWSS is 18.5Km and there were two Motorcycle for rural water supply development staff and those were not enough for sustain RWSS in Lailay Maichew Woreda. Whenever breakdowns occurred contacts were by phone and face to face in woreda water office through caretakers or community water committee. The main reason of time extend of non functionality was absence of necessary tools and spare parts on time

Community financial management and financial persons: five community water committee chair persons were selected randomly for interview. Accordingly, scheme was financially managed aim money collection to cover operational and maintenance cost by the community.

All selected community water committee chair persons were not have aware of criteria's for tariff setting structures. Cut off service for those does not pay tariff fee were the main source of conflict among water users with suggested financial person.

4.10.4. Focus Group Discussion Data Analysis Results and Discussions

Woreda water experts and NGOs: Focus group discussion was conducted by randomly selected two woreda water experts and two NGOs water experts. Accordingly, community participation to their water point was not enough with in all stage of scheme development and the capacity of local contractors of RWSS were less.

At woreda level and NGOs have not standard design and construction manuals. RWSS development were design and construct according to past experience of water experts methods and there was no scheme monitoring practice.

Community Water Committee and Water Users: five community water committee and five from water users was randomly selected to gathered data through community water committee and water users of FGD. Accordingly, community participation was explained as it was actively participation during construction phase and low participation during technical training.

Selection of community water committee was informal as community water point users were pointed member of water committee simply peoples who has good social interaction with the community.

Community water committee was having no management structure to manage water point users and water point. Most water committee members were not knew as they are the managers of their water point. In most water points caretakers were as financial person, gourd, manager and owner of water point.

There was no any support from higher institutions and whenever breakdowns occurred contacts were made by phones and face to face at woreda water office. Community water committee was having no any plan of operation and maintenance. The absence of spare parts on time was the main being non-functional time extends of water pints. The community water committee and water users were able to finalized FGD by ranking main problems of non-functional of RWSSs as shown fig4.24.

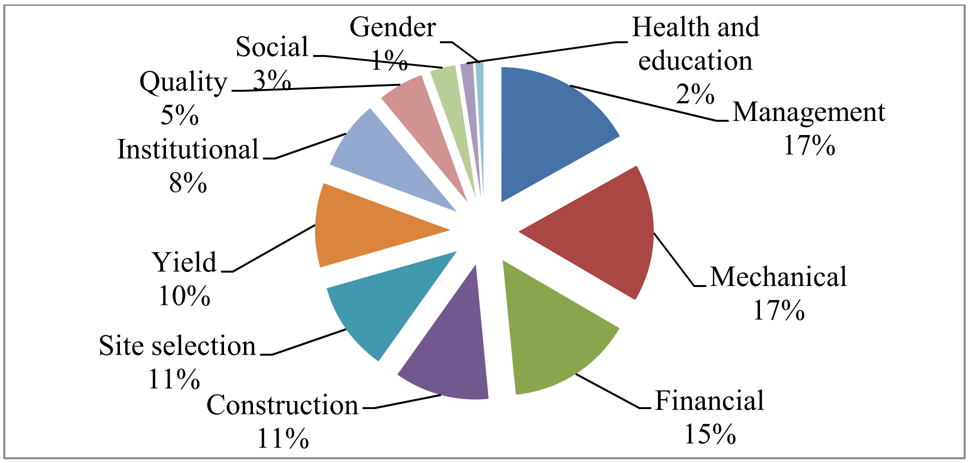


Figure 4.24: Non-functionality rate due non-functional indicators of FGD

4.10.5. Observational Data Analysis Results and Discussions

1. **Technical**

Construction: In site name **Serha** the researcher observed that the water scheme was HDW and during data collection the scheme where dry and the reason of dryness of the scheme was during digging of the scheme the contractor were not able to dig required depth they dig 3m. But this was not acceptable by the community and instead of keep digging enough depth they were punished to construct fence with no fee. During data collection the scheme was almost with no fence and dries fig 4.25.

Figure 4.25 Dry HDW with damaged fence

Quantity (Yield): In site name **May Keshi** community women's were enforce to fetch water 2Km away of their house which takes one hour. They were demand water point within their nearest place because it was difficult to fetch water within 2Km distance especially during harvesting time fig4.26.

Figure 4.26 Women fetching water 2Km away of water point

In site name **Golo-1, 2** the researcher observed that the scheme type were HDW which is dry. According to the community elders at the beginning of the extraction of the scheme it was a wet season so, while digging takes place water were at 5m but it was reported as 9m from the ground and the daily workers were happy to have water at this depth then they stop digging and this time problem occurs while dry season comes the scheme becomes partially functional and sometimes get dry. This indicates main reason for dryness of the scheme is extraction of water during wet season fig4.27.

Figure 4.27 Dry HDW

Quality: In Site name **May Hutsa** the scheme was SHW. During data collection it was functional but while users fetching water there was much quality problems it was fenced properly but the drainage canal (gutter) inside and outside of the fence was full of dirty things which have bad smell that can bring water born diseases fig4.28.

In site name **My Keshi** the scheme was HDW and it was non-functional because of its bad odor and high turbidity of water.

Figure 4.28 Poor drainage quality of SHW

Site Selection: In site name **May Keshi.** The water scheme was spring development the spring eye were missed fig4.30 and the spring cape where constructed downstream of the main spring source. But during data collection the spring box was completely empty of water (fig4.29). The scheme was only functional for one week and communities were enforcing to fetched water from the missed spring source up to the spring eye become dry.

Figure 4.29 Spring box structure with no water

Figure 4.30 Missed spring eye

In site name **May Ayni,** The scheme type is spring development and it was constructed across river which is difficult to protect by community members. During data collection the scheme was almost cover by sediment the water point and collection box plus pipe system component of the scheme were completely lost fig4.31. But the collected water was used for showering and cattle by breaking the Man hole as shown below.

Figure 4.31: Failed spring component due to poor site selection

In site name **Arekiyti** the scheme type was spring development even in this scheme the site selection for box and distribution point is on a river coarse with poor construction materials, method and all the distribution point of the scheme were destroyed by flood during rainy season, and there was also Deep Well constructed near to the scheme which is 300m depth that is why it was dry during dry season but the university (Aksum university) was provided water for the community from the main pipe away to the university by constructing new spring component (distribution water point and cattle trough) for the community. But the scheme was not properly managed, every component of the scheme was not functional and the valve from the main pipe was closed fig4.32.

Figure 4.32 Failed spring because of miss high flood level consideration

In site name **May Lelet,** The scheme was HDW and it was constructed near to river which is easy to be damage by flood during rainy season there was open borehole with depth 15m and at a distance of 10m from the HDW with approximately more than 3.5m hydraulic gradient and this scheme was dry during dry season. The communities where use open bore hole which is digging for traditional irrigation purpose as alternative during dry season with 20birr/month/hh fee to owner of bore hole. Even though, this was not enough for communities because sometimes the alternative bore hole becomes empty during night. This indicates communities may pay tariff for water greater than 36birr/year/hh which is practiced in most water point.

2. **Finance**

The researcher was tried to observe willingness of the community to pay tariff according to the structured tariff by community water committee during water fetching. Operation time of almost all water point has two shifts those of functional schemes were morning and afternoon

The community water users were have less willingness to pay tariff fee for their water consumption and in some water point's tariff were the source of conflicts with financial person.

Generally Finance problems rise to be reasons for non-functionality of RWSS because the community were not willing to pay the allowed fee per month money for maintenance and protection of the scheme (guard) or in some water points there were not ownership fleeing of the community they think that the water point should protect by the government only even after construction. And there was also confusion among water committee members of collected money, which they did not deposit within the bank book on time. Financial problem were indicated by the willingness of the community to pay tariff on time for operational and maintenance, cost recovery of the scheme and community contribution during construction.

3. **Management of Operational and Maintenance**

Non-functionality reason due to management of operational and maintenance were assessed by mechanical and management observational problems.

Mechanical: In site name **May Feso,** the water point was HDW and the water point has multi problems it was not fence. Because of this hand pump handle was break by students and the scheme become non-functional for two years up to data collection because the communities were not able to collect money for maintenance. This time an open borehole for irrigation is their best alternative which is not protected and these bearings different water born diseases fig.4.33.

Figure 4.33 Pedestrian breakdown of hand pump

Mechanical problems which are sensitive for non-functional reason include broken of hand pump, U-seal, bush bearing, pedestal cracked, plunger body damaged, cracking of PVC, spare parts problem and pipe fitting problems.

Management: In site name **Ruba Dengur,** the scheme type was SHW and it was sensitive to break PVC and the location of the scheme was at river course which is easy to destroy by flood during rainy season.

community water committee were not actively manage their water point, while asked for their poor management of the scheme they were not interested to inform to woreda water experts while break dawn occurs because of continuous problems of the scheme rather they were prefer service near to their scheme that was other SHW fig.4.34.

Figure 4.34 Cracked PVC and discussion with water point users

Management problems were rise due to poor community management include less ownership fleeing, less work rate of water committee, conflict among water users and poor woreda expert's management on provide spare parts on time.

4. **Institutional**

Active integration between different institution has positive impact for sustainable operational and management of rural water supply schemes as they are interdependent of each other. In Lailay Maichew Woreda there are different institutions those can be governmental, non-governmental and civil societies..

In site name **Golo-1 and, 2,** The scheme is HDW and at the beginning of the extraction of the scheme was a wet season so, while digging takes place water were at 5m but it was reported as 9m from the ground and the daily workers were happy to have water at this depth then they stop digging and this time problem occurs while dry season comes the scheme becomes partially functional and sometimes get dry. This indicates 4m depth of the HDW cost were exposed to

Generally in study area NGO's had less integration with water resource office and woreda administrators during all phase of water supply scheme development and sustainability. Simply during design phase came to community with one woreda water supply expert and woreda administrators may or may not present. During this phase NGO's collect data ignoring the idea of community members and woreda experts.

At the end mean during handed over of the scheme to community they may or may not give training to community and need one woreda experts to check their work with no supervision and with no any drawing and work plan ,specification etc.

Water resource and energy office was one of the institutions within the study area and this institution had different contribution during design, construction and after construction of water supply scheme for development and sustainable of water point.

During design phase this institution contributed on demand assessment and understanding the need of the community towards water problems and coordinate with NGO’s and local political administrators to facilitate of developing water point.

But, during assessment they do not assess according to manuals or they have no manuals for rural water supply schemes development, then they used to assess according to previous work for similar schemes.

During construction they had not coordination with NGO’s for follow up and supervision of any water point construction as they check while handed over takes place between NGO’s and woreda water experts.

After construction or during operation, try to monitor every water point within the study area but woreda water expert member were very less compare to water schemes of the study area.

Tow water supply and environmental engineering (Degree), three water supply and sanitary (Diploma) and mechanical technicians (Diploma) woreda experts were responsible to monitor 407 water supply schemes which is more than 50 schemes per one expert. During data collection some water point committee members were surprised while the researcher visits their water point or woreda expert because it was once after construction.

Generally there was a problem for monitoring every water point because of less in number woreda water experts and no cars or motorcycles for transport, there were two motorcycles for woreda rural water supply and irrigation team within the study area and this account more for extending duration of non-functional water point.

Rural Health center had no their own water point they were used water from the community with no fee charged even they do not give training to community on contamination of water born diseases, simply they had no contribution for rural water supply sustainable.

Deep well water supply schemes were suffering of energy source that is electricity form Electric Corporation of the study area. Deep well in **Kebele seglamen** were not functioning for consecutive two months because of less energy source.

Social and Cultural: Social and cultural problems have been developing for reason of scheme non-functionality during festive periods when scheme gourd is not informed to open for service of 24hours per day and this become a reason to break the lock and make it free for every one even for a person came from other water point member and exposed for any purpose. Community participation during development of the scheme is almost 100% active unless NGO's or woreda experts altered their participation. But after development there is frustration to sustainable the scheme because of less ownership feeling and not willingness to pay tariff fig4.35.

Figure 4.35: HDW with no fence exposed to animals and children's

Gender: Gender empowerment and equity are major issues of developing countries to establish a system based on the same rights of both genders in social management tasks. In case of rural water supply scheme water committee members' more than 50% women participant is important as women are familiar to fetching water unless it raises reason for non-functionality of water point. But more than an average of non-functional schemes were with less than 50% women participants during water development and no active participant women committee member. Generally women participation during and after development of scheme were dominant by men. But they were active in case of health workers of the community with no fee.

Health and Education: Poor health and education practice within the community rise for reason of non-functionality of RWSS. Awareness of how to use the fetching water at home was only given while the scheme completed. Then after no training was given from any health institutions and this were main problem for quality problems which bring to water born disease. Having less literate people of the community were decreases the ownership feeling of their water point and to protect the scheme

At the end of all data collected was takes place the researcher was asked to collect the main reason of non-functional by seven woreda water experts including the researcher through all non-functional schemes of the woreda. Accordingly, all non-functional schemes were assessed based on the following list of non-functional reason of RWSSs and was made frequency analysis as shown fig4.36.

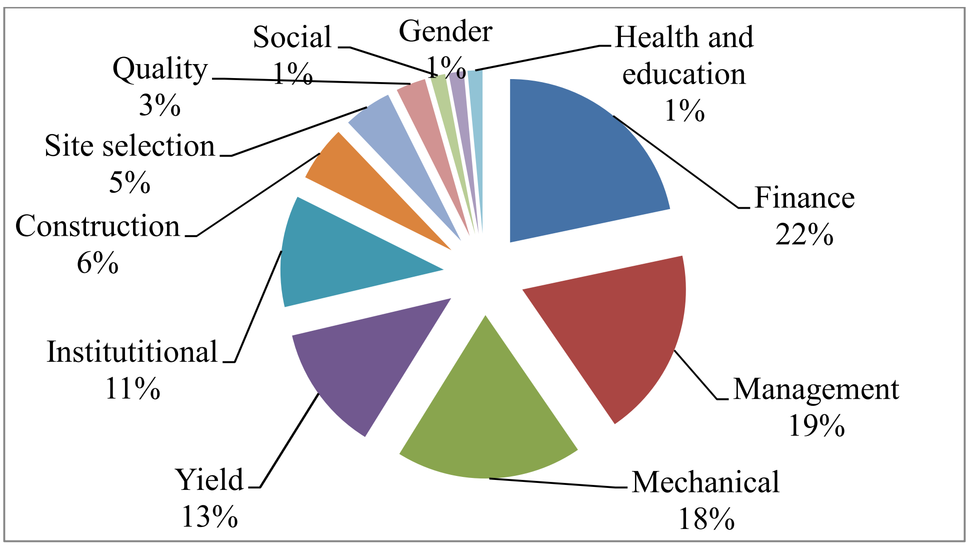


Figure 4.36: Non-functionality rate due to non-functional indicators of observation

4.10.6. General Causes of Non-Functionality Rate of scheme type

General main causes of non-functionality of RWSSs were assessed using the listed indicators include technical (construction, site selection, yield, quantity), management of operational and maintenance (management and mechanical), financial, institutional and others (social and cultural, gender, health and education etc...) as presented below fig4.37.

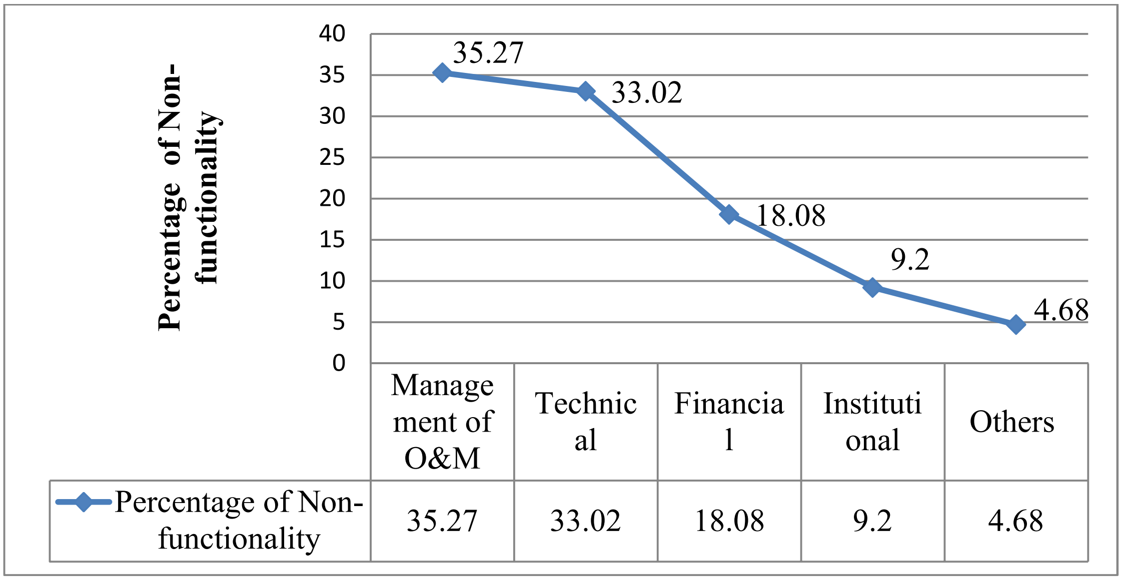


Figure 4.37: Main causes of non-functionality reason of RWSS in Lailay Michew Woreda

Management of operational and maintenance reason of non-functionality were the first among the main cause of non functionality of rural water supply schemes in the study area which accounts for 35.27% compared to other main cause of non functionality of scheme type fig 4.37..

4.10.7. Composite Programming Model Data Analysis Results and Discussions

In any rural water supply development there are two major activities that are to be successfully accomplished: planning and physical development of the scheme and after completion of construction its sustainable operation and management. These tasks require careful analysis of the various indicators that affect both, technical and sustainability aspects of any alternative scheme be it for a new development or evaluation of an already existing one (Gebre G, 2012).

Once the values of indicators and maximum and minimum boundary values are entered the model generates outputs at every level. Finally the total evaluation score is carried out for the two objectives planning and physical Development and Sustainable operation and Management by Scheme Type as presented in table 4.4. The scores are graphically represented in figure 4.38.

Table 4.4 Total evaluation scores of composite programming

Scheme Type	Planning and Physical Development of Scheme	Sustainable Operation and Management of Scheme	Total Evaluation
HDW	0.19	0.24	0.21
SHW	0.14	0.27	0.20
SPR	0.32	0.16	0.24
DPW	0.17	0.17	0.17

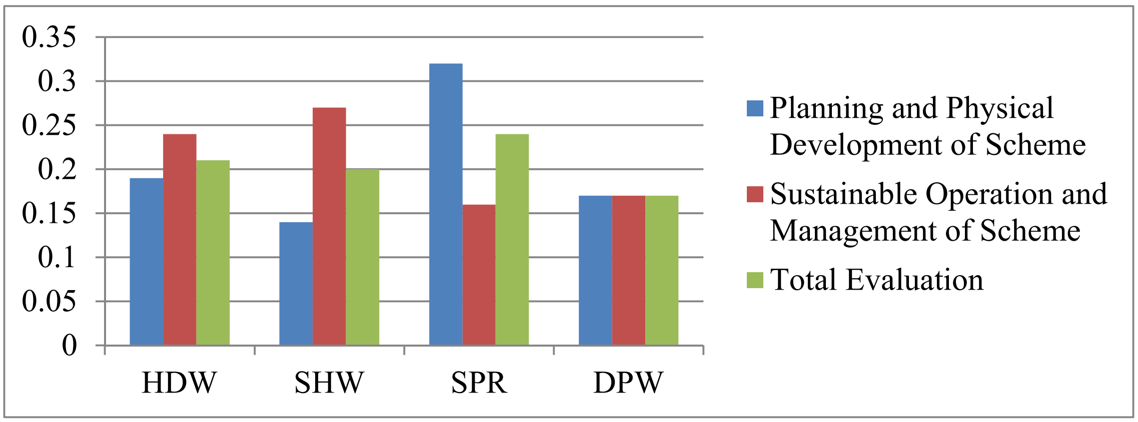


Figure 4.38 Total evaluation of composite programming of four alternative schemes

As we observe from the table and graph shallow well and spring development score the lowest and the highest for planning and physical development of schemes respectively. As shallow well takes high cost during planning and physical development and serve small number of beneficiary compared to its cost. But spring development takes less cost for planning and physical development with high beneficiaries.

For sustainable operation and management of schemes spring development and shallow well scores the lowest and highest respectively. As spring development has poor operational, maintenance and management because of their location compared to other schemes and more than 50% of spring developments are non-functional in the study area, poor scheme protection like fencing and no guard plus poor finance leadership like collecting tariff on specified time. But, scheme of shallow well has good financial leadership because of their yield is satisfactory, more than 50% of shallow well schemes has fence and guard for protection and they had good practice towards functional sustainability.

Generally spring development and deep well with motor distribution scores the highest and lowest of the total evaluation of four alternative RWSS of Laelay Maiciew Woreda using composite programming model.

Spring development scores highest because of its low cost for planning and physical development and gives service for large number of beneficiary and has cattle trough away from water point distribution.

Deep well with motor distribution scores the lowest because as observed during data collection from two deep well in the study area one of them was non-functional and the other was semi – functional. The non functional scheme had different problems after construction like transmission cables, poles and distributer pipe networks were not work properly, installed motor to lift water were with low power from the required power and every water point distributor were not working that is why 1500 users were traveled kilometers for searching water. If all schemes at spot are compared spring development score high and the lowest is shallow well.

The composite programming model that has been developed is based on average values of secondary data of nearly 407 schemes and a primary data of 55 schemes from the study area. The result of the two objectives and the final total evaluation scores are in line with the scheme based summarized result of the inventory of over 400 schemes in the same area. Spring development scores high at planning and physical development of scheme and shallow well scores high at Sustainable Operation and Management of Scheme and total evaluation level indicates that the model reflects the situation on the ground.

5. Conclusion and Recommendation

5.1. Conclusion

This study, under the topic "Assessment of Non Functionality of Rural Water Supply Schemes in Lailay Maichew Woreda", the researcher tries to assess the main cause of non functionality of RWSS within different non functionality indicators.

Assessment of non functionality of RWSS was assessed considering almost all sector of rural development to develop indicators of non functionality include technical (construction, site selection, yield, and quantity), management of operational and maintenance (management and mechanical), financial, institutional and others (social and cultural, gender, health and education etc...).

Findings showed that total of 407 water supply schemes in the Woreda, from which 260 hands dug wells, 129 shallow wells, 16 springs development and 2 deep boreholes. From the total water supply schemes, 305 are functional and 102 are non-functional which accounts 28.35% of hand dug wells, 13.95% of shallow wells, 56.26 of spring development and 50% for deep wells. Non functional rate of the study area were 25.06%.

Community participation during construction score high (28%) because communities participate on prepared construction row materials (stone, wood, water, sand etc...), loading, unloading of machineries and construction materials, clear temporary access road to water point. Community participation on technical training on repairing of small scale problems, changing spare parts; maintain head aprons cracks, drainage problems and this account for 11% which is very low.

The average non-functionality period of schemes in the study area is between six and seven years. Most non-functionality occurs much lesser than expected design periods. One third of water schemes failed lower than a minimum design period, which is 10 years

The main causes of non-functionality of HDW were financial problems as water points were not functioning for more than five months without repairs. Because of the community were not able to collect money according to structured tariff for maintenance or less willingness to pay tariff.

Management problems were the main reason for non functionality of SHW as water points were not functional because of three level management problems:

- poor community management towards their water point include less ownership fleeing, poor activity of water committee to water point users on informed necessary information's and information gap between water committee and woreda water monitoring experts.
- Less management of woreda water resource office towards water point monitoring of each water point.
- Poor financial management of water committee and woreda water resource office on monitoring the collected money of water users.

Mechanical reason was the main cause of non functionality of spring development (SPR). As water points were not functional because of mechanical system components of most spring were not properly functioning like pipes which install for water flow from spring eye to spring box, from spring box to water point and cattle trough were break. Pipe fittings on L and Y turning were not properly placed and most pipe fittings were failed to prevent water loss through pipe fittings.

Similar to spring development the main cause of non functionality of DPW was Mechanical problems. The main cause of non functionality were less capacity of water lifted pump but out of six water points four were not functioning because of malfunction of pipe valves, pipe from main well to high elevated reservoir were exposed to atmosphere and cross farming land of the community which was difficult for farmers while cultivation of their farm land.

Management of operational and maintenance reason of non functionality which include management and mechanical problems were the first among the main causes of non-functionality of rural water supply schemes in the study area which accounts for 35.27% compared to other main cause of non functionality of scheme type.

The average monthly tariff per household was 1.704 Birr/month and this indicates 43.17% of the tariff set by woreda was not collected. Training has impact on scheme sustainable as functional schemes (62%) were score high compared to non functional schemes (38%). Distance of skilled person to scheme location, access to spare parts and necessary tools were the main reasons of time extend of being non functionality of schemes.

Total evaluation of composite programming model indicates spring development scores highest because of its low cost for planning and physical development and gives service for large number of beneficiary and has cattle trough away from water point distribution compared to HDW and SHW. Therefore, the best technology option for the study area was spring development (SPR).

5.2. Recommendation

The objective of rural water supply schemes is to collect, on a continuing basis, a sufficient quantity of pure water to satisfy the daily physical needs of all community consumers in a district and their animals and deliver it to them in the most convenient way possible at the most convenient location.

Based on the findings the research forwards the following recommendation to control non-functionality of RWSSs:

- During design the following points should consider :
  - Peak flow of spring catchment should be measured using appropriate methods during wit and dry season.
  - Appropriate Location of water point should be selected 20m away from large trees and away from river courses considering high flood level of the river.
  - Appropriate population forecasting should include human and animal consumption.
  - The consultant team should prepare detail drawings for contractors and woreda water resource office.
  - The idea of community elders should include while gathering information on technology option and location of water point.
  - During design phase especially when information is collected from the site the following group of people should participate:

1. Designer from NGO’s
2. Water expert from woreda water resources office
3. Woreda political administration leader
4. Water committee
5. Community elders from water users

- During construction
  - _ Execution period of wells should in dry season in order to get water from the deepest level.
  - _ During spring development contractors should dig out in to the far to determine the origin of the spring eye flow.
  - _ Depth of HDW should dig according the design depth.
  - _ Drainage gutters should be constructing properly.
  - _ Fence should construct using available local materials for all schemes especially spring development as all spring have no fence.
  - _ Appropriate power required to lift water from DPW to higher elevation collection champers should be installed.
  - _ Appropriate formwork and construction materials should be used.
  - _ Community should participate not only on prepared local material but also on follow-up of construction process.
  - _ The contractors should have detail drawings on site similar to drawings given to woreda water resource office.
  - _ During construction phase the following group of people should participate:
    1. Consultant team from NGO’s
    2. Water expert from woreda water resources office
    3. Community water users
  - _ During handed over the following group of people should participate:
    1. Consultant team
    2. Water expert from woreda water resources office
    3. Water committee
    4. Water point Guard
    5. Woreda political administration leader

- During management of operational and maintenance:
  - _ Spare parts and necessary tools should be available for each scheme on woreda level.
  - _ The gab of communication between water committee and water resource office should be drop to zero.
  - _ Monitoring to every water point by the respective sectors should be in high performance as some water points was not visited after their construction date.
  - _ Financial management of water committee should be given follow up by woreda financial experts.
  - _ Training should be given to water point users how to operate pumps while fetching water.
  - _ Another way to achieve effective operation and maintenance is through private or small public enterprises from the community. Such enterprises should work with local authorities and government bodies responsible for control of quality, consistency, and equity of services.
- Financial :
  - _ Water committee should collect money according to the structured tariff on time unless cutoff service for those who does not pay.
  - _ Guards of water points should collect money at time of water fetching from water users for proper tariff collection.
  - _ The collected money by water committee should save in micro finance of the woreda based on specified scheduled.
  - _ The government should set budget for RWSS development as it gives attention to irrigation structures development.
- Institutional:
  - _ There should be strong bond between different government and NGO's institutions mean between water resources, electric, environmental protection, health and sanitation offices towards rural development.
  - _ Woreda water resource office should be strong enough on cooperating institutional relationship towards RWSS.

- _ Watershed protection practice should practice by cooperation of soil and water conversation department of woreda forestry office with water resources office to prevent erosion and dryness of water points.

- Gender:
  - _ Women participation in water committee should be higher than 50% towards their water point.
  - _ Exceptional training should be given to women on how to prevent water bore disease.
- Social and cultural:
  - _ Woreda Political administration leader and water resource office coordinator should play great role on changing the community on bad ideas related to social and cultural problems towards new technologies of RWSS.
  - _ The first step before design steps should be making users to accept new technologies of RWSS using different training.
- There should be design and construction standards manual at woreda level.
- Training to water committee should be continuing to increase capacity building of the community.
- There should be minimum two people per scheme well train to maintain small problems of schemes in community level to decrease being non functionality time extend.
- Privet spare part sellers near to schemes should be organized and motivated by woreda water resource office.
- Ethiopian small mechanical factors should motivate by government to manufacture standard hand pumps.
- Data base of all RWSS with their list of community water committee and caretakers name should develop for direct access to water point monitoring and easy with SMS or cell phone communication of stake holders.
- Community water point map of each scheme should develop for easy access during planning of new schemes development of specific area.

5.3. Limitation of the Research

Less willingness of community water point users to share information towards non-functionality reason of their water point with no fee, Lack of budget and, Lack of access to laboratory at woreda and regional water office to conduct water quality test. Lack of access to observe design documents of constructed RWSSs at all level of water resources offices.

5.4. Future study

The researcher recommended being conduct future study with in the study area under different research issues of RWSS is important. Individual assessments of the non-functionality indicators of this research will be much important to analyzed in depth especially management and financial non-functionality. Development of communication skill to non-functionality of schemes can be also need in depth study for future plus similar research with in different woreda will be also important to community for functional sustainability of RWSSs.

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APPENDIX

Appendix A: List of non-functional RWSS in Laielay Maichew Woreda

S.No.	Tabia	Kushet	Site Name	Scheme Type
1	Adi Tsehafi	A/Tsehafi	Enda Abate	HDW
2	Adi Tsehafi	Akeltgna	May beles	Sp
3	Awleo	Z/Awleo	May Zagra-1	HDW
4	Awleo	Zeban	May Matsa	HDW
5	Awleo	Zeban	May Korakur	HDW
6	Awleo	Zeban	May Zagra-2	HDW
7	Awleo	Denbesho	M/Tsekente	HDW
8	D/Brhan	Adi-kerni	Adi –Aki	SHW
9	D/Brhan	Adi-kerni	Koranu	SHW
10	D/Brhan	Adi-kerni	May Kremto	SHW
11	Dereka	ThetayDereka	Kiha	HDW
12	Dereka	ThetayDereka	May Geeh	HDW
13	Dereka	ThetayDereka	May Wuray	SHW
14	Dereka	ThetayDereka	May Tselim	HDW
15	Dereka	LaelayDereka	Serha	HDW
16	Dereka	LaelayDereka	Gasha harmaz	HDW
17	Dereka	LaelayDereka	Ksad aleka	HDW
18	Dereka	LaelayDereka	E/beray	HDW
19	Dereka	LaelayDereka	May Gundi	SHW
20	Dereka	LaelayDereka	May Qechabo	SHW
21	Dereka	Adi Kelekel	Adi kelekel	HDW
22	Dereka	Adi Seye	May Defae	HDW
23	Dereka	Adi Seye	May Giba	HDW
24	Dereka	A/kelkel	A/kelkel	HDW
25	Dereka	May Sye	E/kolankul	HDW
26	Dereka	A/kelkel	Shkudi	HDW
27	Dereka	Adi Seye	Kolali	HDW

28	Dereka	A/berah	Adibieray	HDW
29	Dereka	Laelay Dereka	Gunger	Sp
30	Dura	Dura	May Nugus	HDW
31	Dura	Dura	May Ayni	HDW
32	Dura	Dura	May Nugus-2	HDW
33	Dura	Flfli	Erget	SHW
34	Dura	Flfli	L/sewhi	SHW
35	Dura	Dura	Maykho	HDW
36	Edaga Arbi	Tahga	Ruba Tahga-2	HDW
37	Edaga Arbi	Adi Tsehello	May Leham	HDW
38	Edaga Arbi	Zeban Tahg	May Zeynay-1	HDW
39	Edaga Arbi	Melhaso	M/abuer	HDW
40	Edaga Arbi	Melhaso	Mehgi	HDW
41	Edaga Arbi	A/tsihelo	May Adi	HDW
42	Hatsebo	Semret	Semert-1	HDW
43	Hatsebo	Meshlam	May Keshi	HDW
44	Hatsebo	Meshlam	May Engeda	HDW
45	Hatsebo	May Shire	May Ayni	HDW
46	Hatsebo	May Shire	May Shire-1	HDW
47	Hatsebo	May Shire	E/K/Mehret	HDW
48	Hatsebo	May Shire	May Shire-2	SHW
49	Hatsebo	Gebgeb	May –Ayni	Sp
50	Hatsebo	Semeret	Semema	HDW
51	Hatsebo	Semeret	May Zerea	SHW
52	Lesaleso	Lesaleso	Lesaleso Felfe(Gibtsit)	Spring
53	Lesaleso	Adege	May Ella	HDW
54	Lesaleso	Adege	D/mendel	HDW
55	Lesaleso	Endaeyesus	May Qola	HDW
56	Lesaleso	Adege	My eigame(keshi)	Spring
57	Lesaleso	Adage	may keshi	Sp
58	Lesaleso	Mefalso	may semhal	HDW

59	M/selam	Hesta	May Gudae	HDW
60	M/selam	A/Harbo	May Golagul	HDW
61	M/selam	Adi Berkity	May Hakay	HDW
62	M/selam	A/kelkel	A/abay	SHW
63	Mai Weyni	Adi Asahatia	My Awuere	HDW
64	Mai Weyni	Adi Asahatia	Medri Agam	HDW
65	Mai Weyni	Adi Kere	My Agazen(1)	HDW
66	Mai Weyni	Adi Kere	My Agazen(2)	HDW
67	Mai Weyni	Adi Kere	My Cheba	HDW
68	Mai Weyni	Adi Kere	May weyni	SHW
69	Mai Weyni	Adi Kere	Great Agominy	SHW
70	Mai Weyni	Adi mesrut	My Euto	HDW
71	Mai Weyni	Adi mesrut	Grat raesi (1)	HDW
72	Mai Weyni	Adimasrot	Tselimbayta	HDW
73	Mai Weyni	Adimasrot	Daerosar	HDW
74	maiweyni	Adikere	mychenakit	HDW
75	Medego	L/ Medego	Doka	HDW
76	Medego	L/ Medego	May Shurura	SHW
77	Medego	L/ Medego	May Ansti -2	SHW
78	Medego	Sefeho	Golo-1	HDW
79	Medego	Sefeho	Arekity	Sp
80	Medego	Sefeho	May Lelt	HDW
81	Medego	Sefeho	Duka	HDW
82	Medego	Medego	Kelkelsesalu	SHW
83	Medego	Medego	May kebdi	HDW
84	Meha	Meha	Endamomona	HDW
85	miha	Bringa	Ketema	HDW
86	Natkabelae	Adiganso	May Abdiruba	HDW
87	Natkabelae	M/Dekena	May gundi	HDW
88	Natkabelae	M/Dekena	May hutsa	HDW
89	Natkabelae	M/Dekena	N/Belae	HDW

90	Natkabelae	N/Belae	May Gundi	SHW
91	Seglamen	A/serawit	Haselo	DPW
92	Welel	Welel	May Temti	Spring
93	Welel	Abreham	Maikodo	Spring
94	Welel	Abreham	M/dikula	HDW
95	Welel	Godagudi	Adi Fengel	HDW
96	Welel	Abreham	May bareta	HDW
97	Welel	Aditselimo	May atcaro	HDW
98	Welel	Welel	May Welel	HDW
99	Welel	Abreham		HDW
100	Welel	Aditselimo		HDW
101	Welel	Abreham		HDW
102	Welel	Welel	May Azeba	SHW

Appendix B: Questionnaire for primary data collection of non-functionality of RWSSs

Item	**Descriptions**	**Unit**	**Data**
1	Scheme Name	Type	
2	x coordinate	GPS	
3	y coordinate	GPS	
	Design		
4	Number of Beneficiaries	Ind	
5	Average Family Size	ind/hh	
6	Design period	Years	
7	Year of Construction	Year	
8	Scheme yield	l/s	
9	Daily Scheme Production	m3/day	
10	Demand per capita per day	l/c/d	

11	Consumption per capita per day	l/c/d	
12	Distance from Community	Km	
	Functionality		
13	Is the scheme functional?	Yes/No	
14	If not functional for how long?	Days	
15	If there is a problem how long does it take to be maintained?	Days	
	Construction indicator of non-functionality		
16	Is there a construction firm to perform the construction work fully?	Yes/No	
17	Is it able to carry out small projects such as HDW and Spring at Spot	Yes/No	
18	Is it able to carry out drilling and fixing of pump?	Yes/No	
19	Does it have machinery and equipments?	Yes/No	
20	Does it have financial capacity?	Yes/No	
21	Are communities participating during construction stage?	Yes/No	
22	Is water point fence with firm gate?	Yes/No	
23	Were collapsed preventive equipments used?	Yes/No	
24	Is there standard construction manuals?	Yes/No	
25	Is there a consulting firm in the locality which is able to take care of the design of the scheme?	Yes/No	
	Yield indicators of non-functionality		
26	Does the system function throughout the year/ all seasons	Yes/No	
27	If not when does it not function (not due to technical non-functionality)	Months	
28	What is the alternative source during this time?	Type	
29	What is the distance to this alternative source?	Km	
	Quantity indicators of non-functionality		
30	Is the water potable?	Yes/No	
31	Has there been treatment of water?	Yes/No	
32	If yes when? Frequency of Treatment	No.	
33	Who carried out the treatment?		
34	Has there been quality problem?	Yes/No	
35	Is there contamination problem near to scheme?	Yes/No	

	Site selection indicators of non-functionality		
36	Was community participating during scheme site selection?	Yes/No	
37	Is there flooding problems during rainy season near to water point?	Yes/No	
38	is the scheme in appropriate site to community	Yes/No	
	Financial indicators of non-functionality		
39	Do users pay for water?	Yes/No	
40	Is there structure tariff?	Yes/No	
41	Is it monthly lump sum or based on consumption?	monthly/consumption	
42	Was there any revision of tariff structure?	Yes/No	
43	Monthly Tariff/household	Birr	
44	Is there a cut-off service for non-payment from any user?	Yes/No	
45	Does the tariff cost recovery of capital cost	Yes/No	
46	Does the tariff cover operation and maintenance cost	Yes/No	
	Management indicators of non-functionality	Yes/No	
47	Are water users willing to pay tariff?	Yes/No	
48	Are water users satisfied from water service?	Yes/No	
49	Did community water committee manage water users	Yes/No	
50	Did water committee actively participate at every management level of water point?	Yes/No	
51	Did community protect their water point?	Yes/No	
52	Is there conflict among water point users?	Yes/No	
53	Is there responsible person for absence of caretaker?	Yes/No	
	Mechanical indicators of non-functionality		
54	Are there capable plumbers in locality?	Yes/No	
55	Is there continuous breakdown of mechanical component of water point?	Yes/No	
56	Are spare parts available on time?	Yes/No	
57	Did community participate during pump installation?	Yes/No	
	Institutional indicators of non-functionality		
58	Is there a separate institution responsible for water supply?	Yes/No	
59	Has it allocated budget?	Yes/No	

60	Has it required water professionals?	Yes/No	
61	Has it basic equipment?	Yes/No	
62	Does it give training to community?	Yes/No	
63	Does it assist in maintenance of projects?	Yes/No	
64	Is there support from local political administration?	Yes/No	
65	Is there any support from institution at higher level?	Yes/No	
66	Is there coordination through regular meeting, joint planning and monitoring between water, health and education sector at local level?	Yes/No	
67	Is there coordination through regular meeting, joint planning and monitoring between water, health and education sector at higher level?	Yes/No	
68	Is there coordination through regular meeting, joint planning and monitoring between government, private sector and NGO?	Yes/No	
69	Is there a guideline or structure for coordination mentioning the responsibility of each stakeholder?	Yes/No	
	Social and cultural indicators		
70	Did community accepted new technology of water point?	Yes/No	
71	Do cultural problems decrease after scheme development?	Yes/No	
72	As a habit do users filter or boil water before use believing water should be clean?	Yes/No	
	Gender indicators of non-functionality		
73	Are boys and men helping women and girls/children in fetching water?	Yes/No	
74	Are women allowed to participate in public activities?	Yes/No	
75	Are women actively participating in community water committee?	Yes/No	
	Health and Education indicators of non-functionality		
76	Is there a functional health facility available?	Yes/No	
77	Are there community health workers?	Yes/No	
78	Are water borne diseases prevalent	Yes/No	
79	Is there a formal education facility available?	Yes/No	
80	Are there informal education opportunities?	Yes/No	
81	Is hygiene and sanitation education included in curriculum?	Yes/No	
82	Is Sanitation and Hygiene education provided in the community?	Yes/No	
83	From the following lists which one you think that have direct impact to main		

	causes of non functionality in the worda ?		
		1. Construction	
		2. Yield	
		3. Quality	
		4. Site selection	
		5. Management	
		6. Financial	
		7. Institutional	
		8. Social	
		9. Gender	
		10. Health and education	

Appendix C: Key Informant Interviews for Woreda Water Resources Experts & NGO's

S.No	Descriptions	Data
1	How do you prepare water projects?(RWSS)	
2	Do you make baseline survey before the project and what situation do you examine?	
3	Did the communities participate in the project?	
4	Did communities participate in choosing place of construction for hand dug wells and spring development?	
5	Did women participate in the processes involved?	
6	Did your organization give chance to community in choosing the type of technology of the water point constructed?	
7	How do you know the yield of well or spring that your organization constructing is enough for community consumption?	
8	What contribution did your organization to organize water committee for water point users?	
9	How do you train water committee members?	
10	Did you make contractors supervision?	
11	Do you think that your staff water experts are enough and capable for your woreda rural water supply schemes?	
12	What support did you give to water point users or community members after construction of project?	
13	At what season does water point (Hand dug well) digging?	

14	Is there a guide line or structure for coordination mentioning the responsibility of each stakeholder?	
15	Is there coordination through regular meeting, joint planning and monitoring between water, health and education sector at local level?	
16	Is there coordination through regular meeting, joint planning and monitoring between government, privet sector and NGO?	
17	Are there guidelines and standards for water sectors at local level?	
18	Is there any support from institution at higher level?	
19	What problem did you observe during implementing of rural water supply schemes?	
21	From the following lists which one you think that have direct impact to main cause of non -functionality in the worda? Please rank those from higher to lower cause of non functionality. 1. Construction 2. Yield 3. Quality 4. Site selection 5. Mechanical 6. Management 7. Financial 8. Institutional 9. Social 10. Gender 11. Health and education	
22	What mitigation should apply to control non-functionality of rural water supply scheme in Lailay Maichew Woreda?	

Appendix D: FGD with Woreda Water Experts and NGO's

S,No	Descriptions	Data
1	How do you explain the participation of community water point users during different stage of water point development?	
2	What are the main steps you adopt for design, construction and monitoring of RWSS?	
3	Do you have standard design and construction manuals?	
4	How do you explain the capacity of local RWSS contractors?	
5	What mitigation should apply to control non functionality of RWSS in Lailay Maichew Woreda?	

Appendix E: Key Informant Interviews for Woreda Technical Staff & Community Water Committee

Item	Descriptions	Unit	Data
	Technical staff name		
1	Are spare parts available on time?	Yes/No	
2	At what level are spare parts available?	Regional/Wereda/Community/Other	
3	Are you employing Full-time/Part-time to operate the water system?	Full-time/Part-time	
4	if yes who is paying your monthly salary?	wereda/NGO/Other	
5	Did you undergo any technical training for the operation of the water system?	Yes/No	
6	Do you have your own transport?	Yes/No	
7	Where are you based relative to the village?	Km	
8	if there is a brake down who do you contact?	Woreda/Water committee /caretaker	
9	How do you make contacts?	Phone/SMS/letter	
10	How are you informed about break downs?	Phone/SMS/letter	
11	How many times do you get break downs?	#/year	
12	What can you repair?	Hand pumps /water structure	
13	Do you have the necessary tools?	Yes/No	
14	If yes do you have storage for your tools and other relevant materials?	Yes/No	
15	Are there any other operators?	Yes/No	
16	If yes how many?	#	
17	How many days take to repair a scheme?	# of days	
18	Is a quantity decrease after repaired?	Yes/No	
19	Is there a quantity sufficient after repaired?	Yes/No	
	Community Financial management		
20	How well is the scheme being managed financially?		
21	What are the criteria for tariff setting?		
22	Is there a differential tariff stricture?	Yes/No	
23	Do you have tariff adjacent to meet costs?	Yes/No	
24	What costs cover by tariff?		
25	Do you cut-off service for non-payment from any user?	Yes/No	
26	Is there connection fee charged?	Yes/No	
27	Did you assign financial person?	Yes/No	
	Financial person		
28	Do you have community bank account?	Yes/No	

29	What % current in payment?	%	
30	Do you think that tariff covers scheme Cost?	Yes/No	
31	From the following lists mechanical component of hand pump which one is sensitive to breakdown?	**a.** U-seal **b.** Bush bearing **c.** PVC **d.** Rod **e.** Other	

Appendix F: FGD with Community Water Committee and Water Users

S.No	Description	data
1	How do you explain community participation towards their water point?	
2	At what stage community actively participated?	
	a, Design	
	b, Construction	
	c, Technical training	
	d, Non technical training	
	e, community management	
3	How do you become community water committee?	
4	As you are members of community water committee what challenges have you face?	
5	How do you manage community water users?	
6	Do you have management structure?	
7	How do you collect money from water point users?	
8	In your own experience, are there caretakers of water point in the communities? If yes, how often are they present at the water source?	
9	Do community water management committees have an Operation and maintenance Plan ?	
10	Is there any kind of support to communities and their committees to ensure sustainability of water schemes?	
11	What kind of support was provided and by which institution?	
12	How do you manage problems related to spare parts?	
13	How do you announce for service break dawn of water point?	
14	From the following lists which one you think that have direct impact to main cause of non -functionality in the worda? Please rank those from higher to lower cause of non functionality. 1. Construction	

	2. Yield 3. Quality 4. Site selection 5. Mechanical 6. Management 7. Financial 8. Institutional 9. Social 10. Gender 11. Health and education	

Appendix G: Scheme type observational check list of RWSSs

Item	**Descriptions**	**Scheme Type**				
1	**Technical**	**HDW**	**SHW**	**SPR**	**DPW**	Remark
1.1	**Construction**					
	Water point fence and gate					
	Quality of construction materials					
	Hand pump location					
	Drainage gutters quality and size					
	Apron construction quality					
1.2	**Yield / quantity**					
	Dryness of borehole					
	Dryness of spring eye					
	Less with draw of water point					
1.3	**Quality**					
	Location of water point towards:					
	a. Pit latrine s(30m)					
	b. Cemetery(50m)					
	c. Communal dumping site (100m)					
	Physical characteristics of water sample:					
	a. Taste					
	b. Oder					
	c. Color					
	d. Turbidity					
	Disinfection methods:					

	a. Chlorination process					
1.4	**Site Selection**					
	Water point site location towards:					
	a. Road way(20m)					
	b. Large trees(20m)					
	c. Pit latrine(30m)					
	d. Cemetery(50m)					
	e. Communal dumping site (100m)					
	f. Dwelling House (10m)					
	g. River high flood level consideration					
5	**Management of operational and maintenance**					
5.1	**Management**					
	a. management structure of community water committee					
	b. role and activity of community water committee					
	c. women's role and activity of community water committee					
	d. community administration activity of water point management					
	e. skilled of water point care takers management and problem identification chain					
	f. water point kit tools management					
	g. spare part chain					
5.2	**Mechanical**					
	a. hand pump selection					
	b. breakdowns of hand pump component					
	c. is the hand humps handle at the correct height for users both adults and children					
6	**Financial**					
	a. tariff collection methods					
	b. willingness of water users to pay tariff					
7	**others**					
	a. impact of social and cultural to water point					
	b. impacts of health and education to water point					
	c. impact of gender to water point					

Appendix H: Primary and Secondary Data Collection Questionnaire or Format for RWSS of composite programming model input

Item	Descriptions	Unit	Data	Remark
1	Scheme Name			
2	Location (Kebele/Wereda/Zone)			
3	GPS			
4	Number of Beneficiaries	ind		
5	Average Family Size	ind/hh		
6	Design period	years		
7	Year of Construction	year		
8	Scheme yield	l/s		
9	Daily Scheme Production	m3/day		
10	Demand per capita per day	l/c/d		
11	Consumption per capita per day	l/c/d		
12	Distance from Community	km		
13	Is the scheme functional?	Yes/No		
14	If not functional for how long?	days		
15	If there is a problem how long does it take to be maintained?	days		
16	Does the system function throughout the year/ all seasons	Yes/No		
17	If not when does it not function (not due to technical non-functionality)	Months		
18	What is the alternative source during this time?	type		
19	What is the distance to this alternative source?	km		
20	Is the source of the system easily expandable?	Yes/No		
21	Is the distribution component of the system easily expandable?	Yes/No		
22	Can the amount of supply be increased?	Yes/No		
23	Is the water potable?	Yes/No		
24	Has there been treatment of water?	Yes/No		
25	If yes when? Frequency of Treatment			
26	Who carried out the treatment?			

27	What type of treatment?			
28	What is the treatment cost per month or year?	Birr/month(year)		
29	Area of Settlement	ha		
30	Distance of distribution from source	km		
31	Total Scheme Cost	Birr		
32	Design Cost	Birr		
33	Extraction Cost	Birr		
34	Transmission Cost	Birr		
35	Treatment Cost	Birr		
36	Distribution Cost	Birr		
37	Average Daily Consumption/household	Liter		
38	Average Monthly Income/House hold	Birr/hh		
39	Do users pay for water	Yes/No		
40	Is it monthly lump sum or based on consumption? Was there any revision?			
41	Monthly Tariff/household	Birr/hh		
42	Tariff/m3	Birr/m3		
43	Does the tariff cover Operation and Maintenance and Cost Recovery of Capital Cost	Yes/No		
44	If yes what is the share of			
44.1	Operation and Maintenance?	%age or Birr		
44.2	Capital Cost Recovery?	%age or Birr		
45	Manpower Cost/month	Birr/Month		
46	Energy Cost/month	Birr/Month		
47	Maintenance Cost/month	Birr/Month		
48	Environmental Protection Cost	Birr		
49	Training Cost	Birr		
50	Community Contribution	Birr		
51	Local Budget Contribution	Birr		
52	Is there water and sanitation committee?	Yes/No		
53	Are committee members paid? If so how much/month	Yes/No		
54	Do they have regularily scheduled meeting?	Yes/No		
55	Do they control the income from tariff?	Yes/No		

56	Do they manage most of the maintenance?	Yes/No		
57	Are there capable plumberes in locality?	Yes/No		
58	Are there capable artesians in locality?	Yes/No		
59	Is there a separate institution responsible for water supply?	Yes/No		
60	Has it allocated budget?	Yes/No		
61	Has it required water professionals?	Yes/No		
62	Has it basic equipment?	Yes/No		
63	Does it give training to community?	Yes/No		
64	Does it assist in maintenance of projects?	Yes/No		
65	Is there support from local political administration?	Yes/No		
66	Does it assign budget for water sector?	Yes/No		
67	Does it monitor the activities in the sector through regular meeting?	Yes/No		
68	Is there any support from institution at higher level?	Yes/No		
69	Do they assign budget for water?	Yes/No		
70	Do they support with professional input?	Yes/No		
71	Do they give training for local authorities/personnels…?	Yes/No		
72	Do they assist major maintenance?	Yes/No		
73	Is there a consulting firm in the locality which is able to take care of the design of the scheme?	Yes/No		
74	Does it have necessary staff?	Yes/No		
75	Does it have necessary equipment?	Yes/No		
76	Is it available at higher level?	Yes/No		
77	Is there a construction firm to perform the construction work fully?	Yes/No		
78	Is it able to carry out small projects such as HDW and Spring at Spot	Yes/No		
79	Is it able to carry out drilling and fixing of pump?	Yes/No		
80	Does it have machinery and equipments?	Yes/No		
81	Does it have financial capacity?	Yes/No		

82	Is there a local NGO/Civil Society?	Yes/No		
83	Does it focus on water?	Yes/No		
84	Does it give financial support?	Yes/No		
85	Does it provide technical support?	Yes/No		
86	Does it give capacity building support?	Yes/No		
87	Is there External (Sub-Regional /Regional/National /International) NGO working in the area?	Yes/No		
88	Does it focus on water?	Yes/No		
89	Does it give financial support?	Yes/No		
90	Does it provide technical support?	Yes/No		
91	Does it give capacity building support?	Yes/No		
92	Are there guidelines and standards for water sectors at local level?	Yes/No		
93	Do the guidelines include technical aspect?	Yes/No		
94	Do the guidelines include operational and maintenance aspect?	Yes/No		
95	Are the guidelines understood at local level?	Yes/No		
96	%age of Scheme operating via gravity only	%		
97	Is the pump manually operated?	Yes/No		
98	Is a standard manual pump used (Afridep/Mark I/II..)?	Yes/No		
99	Is a low technology manual pump used (like/rope/foot pump…)	Yes/No		
100	Is power driven submersible/surface pump used?	Yes/No		
101	Is the source of energy fuel?	Yes/No		
102	Is the source of energy wind or solar?	Yes/No		
103	Is the source of energy hydropower?	Yes/No		
104	Average distance of traditional source before the scheme construction	km		
105	Average distance of distribution point of current scheme from community?	km		
106	Is there any yard connection?	Yes/No		
107	If so how many household?	No.		
108	Is there in-house connection?	Yes/No		

109	If so how many household?	No.		
110	Distance of			
	Water Source from Community			
	Water Source from Last Reservoir			
	Last Reservoir from Distribution Point			
	Size, Material and cost of Reservoir			
	m3			
	Material			
111	Distance of Accessible Road			
	Source			
	Community			
112	Distance to town where all service (manpower/material) can be obtained	km		
113	Distance where partial service can be obtained	km		
114	Who is fetching water?	Men/Women/Girls/Boys		
115	How many persons per household?	No.		
116	How many times per day?	No.		
117	What is the average container size?	Liter		
118	%age of Literate Women in community	%		
119	%age of girls attending school	%		
120	%age of Women Water Committee members	%		
121	Is there Women Association or Civil Society?	Yes/No		
122	Does it give awareness and training to women?	Yes/No		
123	Does it deal with health, water and sanitation issues	Yes/No		
124	Does it have regular meeting with the community?	Yes/No		
125	Are boys and men helping women and girls/children in fetching water?	Yes/No		
126	Are girls allowed to go to school?	Yes/No		
127	Is the marriage age for girls normally greater than 18?	Yes/No		

128	Are women allowed to participate in public activities?	Yes/No		
129	Are women allowed to use different types of family planning techniques?	Yes/No		
130	Traditionally, do people believe water should not be free?	Yes/No		
131	As a habit do they filter or boil water before use believing water should be clean?	Yes/No		
132	Do they regularly wash their body and cloth?	Yes/No		
133	Is there a functional health facility available?	Yes/No		
134	Are there community health workers?	Yes/No		
135	Are they paid if so how much?	Yes/No		
136	Are water borne diseases prevalent	Yes/No		
137	What was the prevalence of diharea in the area before the project	%		
138	What is it after the project?	%		
139	Is there a formal education facility available?	Yes/No		
140	Are there informal education opportunities?	Yes/No		
141	Is hygiene and sanitation education included in curriculum?	Yes/No		
142	Is Sanitation and Hygiene education provided in the community?	Yes/No		
143	Was it part of the project or given by other entities?			
144	If by others by whom?			
145	What was its cost?	Birr		
146	%age of people using improved sanitation	%		
147	Is there coordination through regular meeting, joint planning and monitoring between water, health and education sector at local level?	Yes/No		
148	Is there coordination through regular meeting, joint planning and monitoring	Yes/No		

	between water, health and education sector at higher level?			
149	Is there coordination through regular meeting, joint planning and monitoring between government, private sector and NGO?	Yes/No		
150	Is there a guideline or structure for coordination mentioning the responsibility of each stakeholder?	Yes/No		

Thank you for your valuable participation in evaluated questionnaire of my research!!!

Appendix I: Community Rural roads network by type of surface and year of construction

S.NO.	Road Name(Tabiea)	Length (Km)	Distance from near town(Axum)	Area(ha)	Road density per $1000Km^2$	Year of commenced	Year of completed	Road standard
1	Aditsehafi	9.2	9.2	4079	2.2554548	2000	2001	Ds 8(RR10)
2	Awlou	13.84	27.34	4261	3.2480638	2002	2002	Ds 8(RR10)
3	D/brhan	2.9	8.4	1311	2.2120519	1987	1989	Ds 1(RR30)
4	Dereka	7.9	7.9	4964	1.5914585	2004	2004	Ds 8(RR10)
5	Dura	7	7	2563	2.7311744	1987	1989	Ds 1(RR50)
6	Edaga-arbi	4.33	11.83	4539	0.9539546	2004	2004	Ds 8(RR10)
7	Hatsebo	9.1	9.1	4323	2.1050197	1997	2000	Ds 1(RR30)
8	Lesalso	5.8	5.8	3978	1.4580191	1997	1998	Ds 1(RR30)
9	M/selam	13.5	13.5	6228	2.1676301	1997	2001	Ds 1(RR30)
10	Mayweyni	4	7.5	2718	1.4716703	2004	2004	Ds 8(RR10)
11	Medego	4	4	4014	0.9965122	1987	1988	Ds 8(RR10)
12	Miha	3.63	9.43	2767	1.3118901	2004	2004	Ds 8(RR10)
13	Natkabilae	16.1	16.1	1369	11.760409	1996	1996	Ds 8(RR10)
14	Seglamen	3.7	12.1	1128	3.2801418	1987	1989	Ds 1(RR30)
15	Welel	7	16.2	5591	1.2520122	2000	2001	Ds 8(RR10)
	Total	112	165.4		38.795463			
	Average	7.4667	11.02666667		2.5863642			

Appendix J: List of health institutions of Lailay Maichew Woreda

s.No.	Tabiea	Name	E	N	Elev	year of establish
1	Aditsehafi	H.P	468178	1567651	2018	
2	Awleo	H.P	483618	1545719	2044	
3	D/brhan	H.P	463278	1557156	2045	
4	Dereka	H.C	469913	1554586	2050	2002
5	Dereka	H.P	469792	1555110	2053	1996
6	Dura	H.P	463316	1559451	2070	
7	Edagaarbi	H.P	482631	1555009	2118	
8	Hatsebo	H.P	475961	1559184	2090	
9	Leslaso	H.P	476152	1564928	2112	2005
10	M/selam	H.C	475744	1550696	2104	
11	M/selam	H.P	476423	1551223	2098	
12	Mayweyni	H.P	479573	1557590	2130	
13	Medego	H.P	466932	1557231	2054	
14	Miha	H.C	475739	1567063	2042	
15	N/bilae	H.P	469004	1548360	1965	
16	Seglamen	H.P	462946	1553701	2053	2003
17	Seglamen	H.P	463172	1557176	2052	2006
18	Welel	H.C	467914	1569311	2012	
19	Welel	H.P	470654	1571663	1886	

Appendix K: List of Schools in Lailay Maichew Woreda

S/No.	Tabiea	School Name	E	N	Elev
1	Seglamen	Seglamen	462960	1553953	2053
2	Dereka	Maisiye	471945	1555810	2050
3	Dereka	Firetsibah	469826	1551099	2045
4	Dereka	Dereka	469543	1553590	2052
5	Medego	Sefeho	467464	1556736	2060
6	Medego	Fireselam	465410	1555373	2043
7	Dura	Dura	463386	1559916	2048
8	Dura	Ketete-Ekili	464874	1565081	
9	Dura	Ergat	463702	1563030	
10	Aditsehafi	Aditsehafi	468878	1565393	

11	Aditsehafi	Kelembet	465851	1567788	2084
12	Miha	Miha	473674	1570845	1809
13	Miha	Lesalso	475551	1567435	2042
14	Welel	M/welel	467676	1569138	
15	Welel	H/t/haimanot	471340	1573516	1948
16	Welel	Daernegad	470508	1571669	1876
17	Welel	Abrham	467586	1571656	1795
18	Welel	G/godagudi	472438	1575516	1627
19	Lesalso	Gure	478303	156192	2051
20	Lesalso	Yohans-VI	476074	1564492	2108
21	Mayweyni	Mayweyni	479579	1557932	2139
22	Mayweyni	Adikirae	478503	1556222	2083
23	Mayweyni	Adimaeserot	481335	1556867	
24	Edagagarbi	Edagagarbi	482566	1555045	2116
25	Edagagarbi	Aditreekbe	485671	1551291	2020
26	Edagagarbi	Aditsehelo	480602	1554623	2104
27	Natkablae	Natkabilae	468665	1548079	1942
28	Natkablae	Adigaunso	470684	1548827	1936
29	D/brhan	Debrebrhan	462998	1557441	2051
30	Hatsebo	Semeret	474911	1557305	
31	Hatsebo	Maishire	476094	1559277	2091
32	Hatsebo	Mairuba	474625	1564477	2093
33	Hatsebo	Zorat	474044	1562464	
34	Awleo	Tselalgebrezgi	483640	1545922	2044
35	Awleo	Mai-elel	486918	1547876	1710
36	Awleo	Denbesho	486290	1542710	1687
37	M/selam	Sehul michael	476489	1550203	2113
38	M/selam	Mahberedego	476354	1550588	2110
39	M/selam	Kisad geba	476458	1550621	1943
40	M/selam	Adiberekti	476947	1554245	2108
41	M/selam	Kiindergartner	476547	1550716	2111
42	M/selam	Kuiha	481692	1551155	