ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

Ensuring Functional Sustainability of Water and Sanitation Developments in Rural Areas

(Southern Ethiopia)

By

Fiseha Israel Goda

ADDIS ABABA INSTITUTE OF TECHNOLOGY APRIL 2014

Ensuring Functional Sustainability of Water and Sanitation Developments in Rural Areas

Case Study from Southern Nations, Nationalities and People's Regional State of Ethiopia, Chencha Woreda

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 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

Ensuring functional sustainability of water and sanitation developments throughout the design period is vitally necessary. It helps to identify the main causes of non functionality and indicate the troubleshooting for non functionality per scheme system components at the stage of design, construction and service period.

To identify the major causes of non functionality the research has employed both primary and secondary data sources. Secondary data was collected from respective governmental and non-governmental organization at federal, state and woreda level. Primary data, on the other hand, was obtained using questionnaire, Focus group Discussion (FGD) and observation.

Data from the secondary and primary sources enabled the researcher to scan and investigate more than 95 % of water and sanitation schemes in Chencha woreda rural areas. The common rural water and sanitation technologies include hand dug well, shallow well, spring with gravity distribution, spring at spot and simple pit latrine. All have been studied and evaluated for their cause of non functionality.

The research found that 87 % of non functionality occurred before its estimated design period, which is within ten years. But the average non functionality occurrence of the schemes is between six years up to seven years. The most common non functionality causes are poor design, below the standard construction and poor institutional set ups of water and sanitation infrastructures. It includes: spring capping failure, management and financial problems, construction materials problems, source yield decreasing, poor quality of water, pumping system failure, poor quantity of water and pipe line failures.

Water and sanitary schemes are functionally sustainable, only when social, financial, technical, institutional and environmental factors are integrated with every project life stages. The stages are needs assessment, conceptual design, design and action planning, implementation, and operation and maintenance. To get rid of non functionality every system component design and construction activity should be in accordance with the applicable design and construction methods.

All respective governmental, nongovernmental and community stakeholders should carry out responsibility for functionality and sustainability of water and sanitation schemes. It is impossible to meet the functionality of water and sanitation schemes developments, without the integration of all respective bodies in all project life stages through feasibility study, designing, construction and service periods

ACKNOWLEDGEMENTS

Above all, all times and forever my heartfelt esteem goes to the Almighty God, who is always with me and imparting knowledge and skills freely on right time and , keeping me on the right track. Without His blessing I would never have succeeded.

First, I wish to express my genuine perceptiveness to my supervisor, Dr.Ing. Geremew Sahilu for, his great valued advice and guidance throughout this research project

In the second place, I am also gratitude all academic and administrative staff in School of Civil and Environmental Engineering for their valuable support not only for the research paper but also at my whole study period in Addis Ababa Institute of technology.

Further I acknowledge Ministry of Water and Energy, Care Ethiopia, UNICEF, Water aid, SNNPRS Regional Bureau of water and Energy, Gamo Gofa Zone water and Energy office, Chencha woreda Water and Energy office and Chencha woreda Health office for continuous sharing of valuable data to my study.

I would like to thank my family for their lifetime support and encouragement. Thank you for supporting and guiding me throughout my life. Especially thanks to my dear wife Amelework Daniel for her support and encouragement in all the way through my study programme.

I would also like to thanks all my friends and colleagues for their moral supports and encouragement for the success of this paper. My special thanks go to Abebaw Kebede for continuous encouragements, boost and support to complete my thesis.

Last but not least, my heartfelt thanks goes to my brother Ephrem for inspiring me in taking a right direction in life choice among which is continuing my master studies. Furthermore, I thank him for meticulously editing the entire document. God bless you bro!

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ACRONYMS AND ABBREVIATIONS

CGI	Corrugated Galvanized Iron
ESRD	Ethiopian Social Rehabilitation and Development
GDPW	Gravity distribution public water
GRP	Glass reinforced plastic
GTP	Growth and Transformation Plan
HDW	Hand dug well
HDWr	Hand dug with rope pump
HDPE	High density Polyethylene pipes
DFID	Department of International Development (of the United Kingdom)
DBD	Deep bore well with distribution
JMP	Joint Monitoring Report
MDGs	Millennium Development Goals
MoWE	Ministry Of Water and Energy
NF	Non Functional
NFC	Non Functional Causes
NFP	Non Functionality percentage
NGO	Non-Governmental Organization
NRDWP	National Rural Drinking Water programme
NWI	National WaSH Inventory
PSU	Pennsylvania State University
RWSHP	Rural Water, Sanitation & Hygiene Program
SHW	Shallow well
SNNPR	Southern Nations Nationalities and. People's Region
SPL	Simple Pit Latrine
SPRgd	Spring with gravity distribution
SPRspt	spring at spot
UNICEF	united nation children fund
UPVC	Unplasticised polyvinyl chloride
WASH	Water Sanitation and Hygiene
WATSAN	Water and Sanitation
WCED	World Commission on Environment and Development
WHO	World Health Organization

CHAPTER ONE

1. INTRODUCTION

1.2 BACKGROUND

In the world billions of people lack access to affordable and functional potable water and improved sanitation. The problem can be categorized as follows. First, billions of the world's poor people still lack access to basic water and sanitation services (UNICEF and WHO 2012). Second, in regions where water and sanitation services are being extended, many projects have a high failure rate, but the extent is unknown due to lack of transparency by implementing organizations (Bliss and Bowe 2012). Third, even where formal water supply and sanitation services exist, the service is often unreliable and of poor quality for the most vulnerable populations (WaterAid, 2011; Rheingans et al, 2012).

The most common causes for non functionality of water and sanitation projects are poor construction, inappropriate technologies, insufficient operation and maintenance, Poor quality of water, lack of financial resources and little interest or even opposition from stakeholders (McPherson & McGarry, 1987).

In Africa and other developing countries, sustainability of rural water supply is quite low with 30 to 60% of the schemes becoming non-functional at some point after construction (Brikké and Bredero, 2003). Ethiopia has a lot of assignments to increase accessibility for water and sanitation. In 2012 national water and sanitation access both in rural and urban was 58.28 %, national rural is 55.21% and national urban is 78.71% only. National WaSH inventory result in 2013 shows 74.5% rural schemes are functional and 25.5% rural schemes are non functional (MOWE, 2013).

Southern Nations Nationalities and People's Region water schemes inventory 2011 shows that 73% of water schemes are functional and 27% water schemes are non functional. Water and sanitation access both urban and rural is 50.72 % only, in rural 49.12% and in urban 75.53 %.

In Gamo Gofa Zone 73% of water schemes are functional and 27% are non functional. Non functionality rate is very high at remote woreda in Gamo Gofa Zone, most of the people using unsafe water for their daily consumption (SNNPR, 2011).

1.2 PROBLEM STATEMENT

In Chencha woreda access to improved water sources has increased and thereby sanitation as a result of provision of new rural water infrastructure both by government and nongovernmental organization. Despite this positive trend, there has to a large extent been a failure to find durable solutions to meet the needs of the rural poor for safe, reliable domestic water. Rural people face continuing and unacceptable problems with systems that fail prematurely, leading to wasted resources and false expectations.

Study on the Woreda shows that 76% water schemes are functional and 24% water schemes are non functional and potable water coverage is only 19.5 % (SNNPR, 2011). Non functionality of water and sanitation schemes is most common problems in the woreda as most rural people depends on unprotected water source and less reliable on developed water sources. It resulted in loss of significant project cost, their scarce land has become unproductive and their precious time has vanished without alleviating communities request for potable water.

The main thing which has been challenging and hindering the effort in water supply and sanitation sector is the lack of functional sustainability and increase of non functioning schemes in significant number among any number of implemented schemes.

In rural Chencha variety of developed water sources are available. Most of them failed permanently. In fact some developed water source may recover after mini maintenance. About half of them are functioning with dozens of problems. In some place the communities have not enough knowledge and skill to operate and maintain advanced water scheme technologies.

The present available water schemes quality and quantity is deteriorating from time to time. If no right measure is taken to encounter causes for non functionality, it is improbable to raise pure water coverage in Chencha woreda. As a result the already dire health status of the rural people will deteriorate further as the communities continue suffering from water borne and water related diseases.

Ensuring functional sustainability in rural water and sanitation is a major challenge in the study area, because it is not easy to establish institutional arrangements that will ensure that water and sanitation facilities are provided, maintained, managed, functional, efficient, equitable, and sustainable way.

1.3. RESEARCH QUESTIONS

1. What are the general causes of non functionality?
2. What are the specific causes of non functionality?
3. What is the average non functionality period of the scheme compared with design period?
4. What remedial measures should be taken to ensure functionality of water and sanitary infrastructures?

1.4. RESEARCH OBJECTIVE

1.4.1. General objective

Determining causes of non functionality of water and sanitation schemes and recommend remedial measures to secure functional sustainability of water and sanitation infrastructures throughout design period.

1.4.2. Specific objectives:

- To compare scheme design period respect to non functionality
- Identify the general and specific causes of non functionality.
- Assess the current water supply and sanitation systems
- To recommend proactive measures to prevent or minimize rate of non functionality.

1.5. RESEARCH METHODOLOGY

An extensive elaboration on the methodology and data collection system is given in chapter four. Here, a brief on the methodology is presented. That is, the study addresses and emphasizes rural water supply schemes sustainability issues in Ethiopia using case study. Parameters like beneficiaries, population growth, scheme yield, consumption rate, tariff and household income have been included and analyzed. Rural water supply Sustainability issues are directly or indirectly interconnected with the above parameters.

Four rural water schemes have been studied on this research based on most part of Ethiopian context. These are hand dug well, shallow well, spring at spot and spring with gravity distribution.

CHAPTER TWO

2. DESCRIPTION OF THE STUDY AREA

2.1. GENERAL

Chencha city is one of the oldest cities in Ethiopia with its age estimated only 15 to 20 years less than main capital of Ethiopia, Addis Ababa. It is around 105 up to 110 year. Chencha woreda is the home of Chencha city. It is one of 133 woredas in the Southern Nations, Nationalities and Peoples' Region of Ethiopia. It is subscribed in Gamo Gofa Zone. It had been the capital of Gamo-Gofa province until 1962 when a decision was made to transfer the province capital to the more accessible city of Arba Minch.

Chencha woreda is divided in to 50 kebeles. From 50 kebeles, 45 kebeles are rural and the rest 5 kebeles are urban. According to a 2004 report, Chencha had 36 kilometers of all-weather roads and 1 kilometer of dry-weather roads, for an average road density of 101 kilometers per 1000 square kilometers.

2.2. LOCATION

Chencha Woreda is situated between 1200 m and 3250m above sea level. It forms the upper rectangular landmass of the highland. Geographically the woreda is located between 37° 29' 57" East to 37°39' 36" West and between 6°8' 55" North and 6° 25'30" South(figure 2.1)

Part of the Gamo Gofa Zone, the woreda is bordered on the south by Arba Minch Zuria, on the west by Dita, on the north by Kucha and Boreda, and on the east by Mirab Abaya. Chencha woreda is located at about 320km North of Hawassa, 517 km from Addis Ababa and 32 Km from ArbaMinch

2.3. DEMOGRAPHICS

Based on figures published by the Central Statistical Agency in July 2013, Population Size by Sex, Area and Density by Region, Zone and Wereda; Chencha woreda has an estimated total population of 134,371, of whom 61,846 are men and 72,525 are women; 14,230 or 11.19% of its population are urban dwellers, which is greater than the Zone average of 8.5%. With an estimated area of 373.52 square kilometers, Chencha has an estimated population density of 359.7 people per square kilometer, which is greater than the Zone average of 173.3.

2.4. HYDROLOGY, WEATHER AND CLIMATE

The mean temperature of Chencha Woreda is 22.5°c.According to the meteorological report, the mean annual rainfall is 1201-1600 mm in the past two decades. Rain usually starts in mid March, but the effective rainy season is from May to mid September.

Many small rivers and streams originate from Chencha highland. However, the main rivers of the highland are Kullufo, Zute, Hare, Gina, Shaye, Basso and kulano. These rivers are not providing any economic value in the highlands, except eroding away the vulnerable highland soils. But in their lower courses some of the rivers like Kullufo, Hare and Basso provide the life line for irrigation purposes in low land areas in ArbaMinch, Mirab Abaya and Kucha woreda.

2.5. EDUCATION AND HEALTH

Formal educational institutes recorded at the end of May 2013, Chencha woreda has 4 high schools, sixty-seven junior secondary schools and three kindergarten schools. Concerning health institutes, it has one hospital, six health centers, forty seven local health centers and two rural pharmacies. Most health center is located in towns and their accessibility is low for the rural community. Consequently, the rural people have to travel longer distances to get such health services which sometimes ends on tragic loss of their beloved ones before they reach it. Nevertheless, woreda has introduced ambulance service but it only give services in some road accessible rural kebeles on dry seasons.

2.6. WATER SOURCES

There are different water sources in Chencha woreda. From the total 24% water schemes are non functional. Hand dug well fitted with rope pump is not secured potable sources due to its purpose and operating system. Table 2.1 shows types and functionality water sources in Chencha woreda.

Table 2 . 1 Chencha woreda water supply schemes (SNNPR, 2011)

	Scheme Type	Functional	Non functional	Sum	Non functionality Rate
1	Hand dug wells fitted with Rope pump	13.0	6.0	19.0	32
2	Hand dug wells fitted with hand pump	0.0	1.0	1.0	100
3	Shallow wells fitted with hand pump	8.0	4.0	12.0	33
4	Deep wells with distribution	1.0	1.0	2.0	50
5	Springs with distribution	14.0	11.0	25.0	44
6	Spot springs	46.0	12.0	58.0	21
7	Gravity distribution public water	44.0	5.0	49.0	10
	Total	**126.0**	**40.0**	**166.0**	**24**
	Percentage (%)	**76**	**24**	**100**	

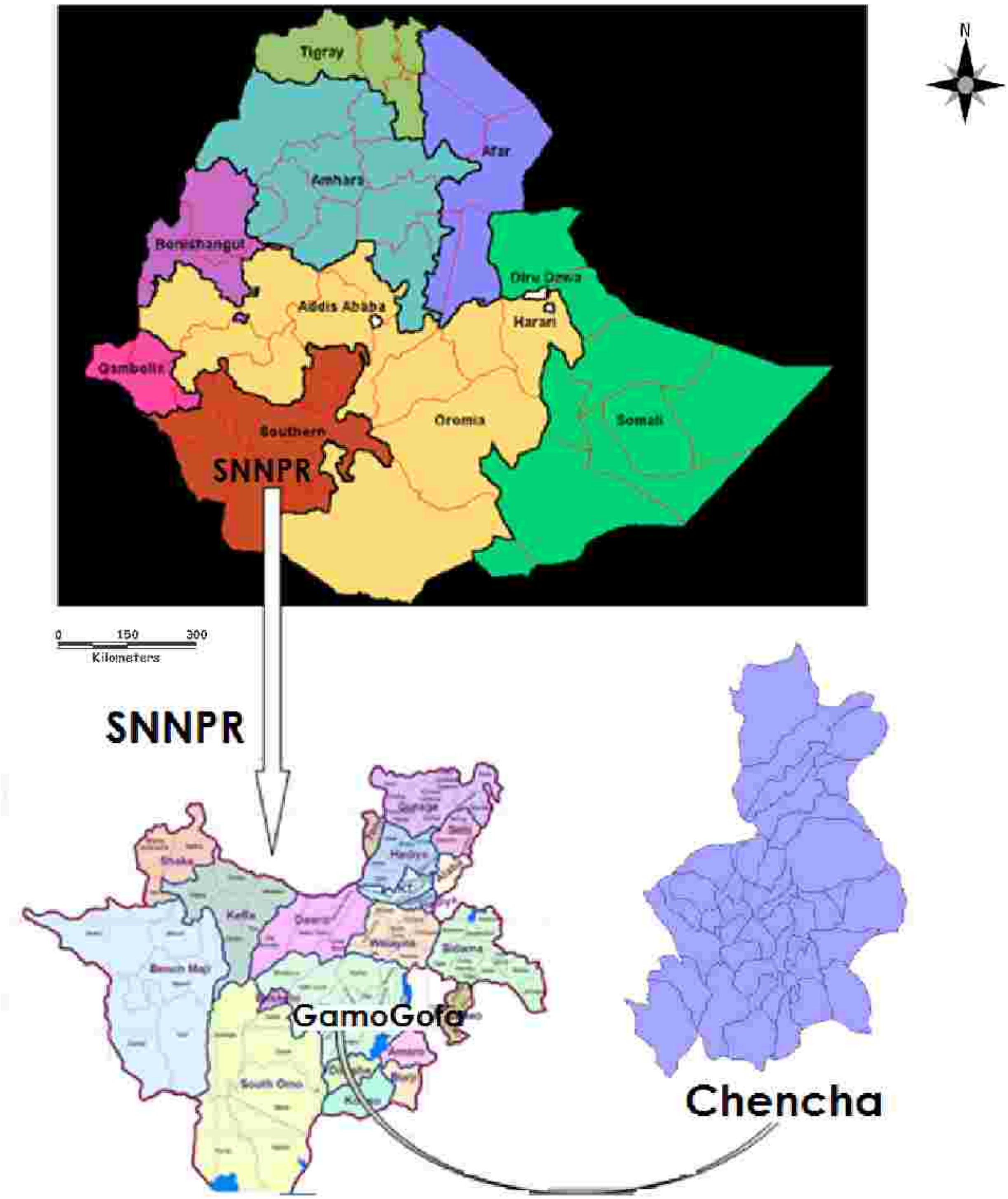


Figure 2 . 1 Location of Chencha Woreda

(Source: SNNPR Regional Administrative Map)

CHAPTER THREE

3. LITERATURE REVIEW

3.1. GENERAL LITERATURE REVIEW

The author has gone through relevant scientific articles, books, theses, dissertations, new published documents and internet, to scan what international organizations dealing with functionality of water and sanitation infrastructures. Further, documents from Ministry of Water and Energy, UNICEF, Water aid, and Region to woreda level were reviewed.

This chapter, therefore, reviews the existing theories and practices, different techniques of water and sanitation scheme developments based on the present water and sanitation technologies standards. That is, it reviews water and sanitation infrastructures sustainability frameworks in detail and guiding to relevant direction towards sustainability. Going further, those theories and findings are analyzed against the actual practices in the woreda.

3.2. WATER SCHEMES DESIGN PERIOD

The number of years for which the designs of the water works have been done is known as design period-number of years the scheme s supposed to serve. Mostly water works are designed for design period of 22-30 years (Rao, 2005).

Design period of water schemes are vary among types of schemes. "Water supply projects are designed for a design period of 20 to 40 years, after their completion" (Punmia, 2001). The time lag between the design and completion should not be more than two years. In some specific components of the project, the design period may be modified. Different segments of water treatment and distribution systems may be approximately designed for differing periods of time using differing capacity criteria (Punmia, 2001). The following table 3.1 gives the design periods for various components of a water supply projects.

Water supply projects are designed to serve over a specified period of time. This time after completion of the project is called "design period". It is expressed in years. During design period, the structures, equipment and components of the water supply scheme are supposed to be adequate to serve the requirements. As per normal procedure water works is designed for a period of 30 years (Arvind K, 2012).

Project components may be designed to meet the requirements of the users in specific design period. In table 3.1A ground water sources like spring and water wells designed for 20 to 30 years. Table 3.1A and B below shows varies water supply schemes design period in Indian National Rural Drinking Water programme (NRDWP, 2013) and (punmia, 2001).

Table 3. 1 A. Design periods for projects components (NRDWP, 2013)

No	Items	Design period in years
1	Source	
	a) Surface sources	30
	b) Ground sources	20
2	Intake works	30
3	Pumping	
	a) Pump house (civil works)	20
	b) Electrical meters and pumps	10
4	Water treatment units	20
5	Pipe connection to several treatment units and other small appurtenances	20
6	Raw water and clear water conveying mains	20
7	Clear water reservoir at the head works, balancing tank and service reservoirs(overhead of ground level)	20
8	Distribution system	20

B. Design periods for projects components (punmia, 2001)

No	Components	Design period(years)
1	Storage by dams	50
2	Infiltration works	30
3	Pump sets	
	I. All prime movers except electrical motors	30
	II. Electric motors and pumps	15
4	Water treatments units	15
5	Pipe connections to the several treatment units and other small appurtenances	30
6	Raw water and clear water conveying mains	30
7	Clear water reservoir at the head works, balancing tanks and service reservoirs(over head and ground level)	15
8	Distribution systems	30

3.3 FUNCTIONALITY AND NON-FUNCTIONALITY OF SCHEMES

Functionality refers to a discipline through which the water and sanitation scheme provides water and sanitation services to the users. Therefore, the scheme is said to be fully functional when the quantity and quality of the water schemes sanitation provision is sufficient that the people can get full services. Functionality is having or serving a utilitarian purpose; capable of serving the purpose for which it was designed: functional architecture; a chair that is functional as well as decorative (Mohan et al, 2005).

“In 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 place”(Mohan et al, 2005).

Though it is controversial, less or non quantity and quality of water and poor or less sanitation services from water and sanitation schemes respectively and can't fully satisfy the standards of a functional is called non-functional scheme. Non functional schemes are schemes which are not giving service at all due to various reasons or repeatedly breaking down and do not give service as required most of the time. Non functionality is the major challenge of sustainability of rural water and sanitation schemes.

In Africa and other developing countries, sustainability of rural water supply is quite low with 30 to 60% of the schemes becoming non-functional at some point after implementation (Brikké and Bredero, 2003).

In Ethiopia National WaSH Inventory Result in 2013 shows 74.5% rural schemes are functional and 25.5% rural schemes are non functional. Table 3.1 below shows the National rural scheme functionality (MoWE, 2013). National WaSH inventory was not conducted in urban areas.

Table 3. 2 Rural Schemes Functionality (MoWE, 2013)

No	Region	Functionality (100%)
A	National	74.48
B	Regions	
1	Tigray	67.12
2	Afar	65.9
3	Amhara	79.56
4	Oromia	74.9
5	Benishangul	67.86
6	SNNPR	72.95
7	Gambela	73.64
8	Harar	77.67
10	Diredawa	75.49

In SNNPRs water schemes inventory 2011 shows that **73%** of water schemes are functional and 27**%** water schemes in are non functional. The same figure was recorded for Gamo Gofa Zone. **73%** of water schemes are functional and 27**%** are non functional and the inventory for Chencha Woreda shows**76%** on water schemes are functional and 24**%** water schemes are non functional. Potable water coverage is only 19.5 % (SNNPR, 2011).

3.4. CAUSES FOR NON FUNCTIONALITY

Water and Sanitation schemes fails and to become non functional. Many authors and research worker investigated causes for non functionality with integrating sustainability of water and sanitation schemes. Ethiopia National water supply, Sanitation and Hygiene Inventory had investigated causes of non functionality in four main broad groups (NWI, 2011).

1. Broken
2. Not enough water
3. Management and financial problem
4. Others

The inventory data collected by the Water Resources Development bureau of SNNPR has analyzed by Gebrie (2012) shows the degree of non functionality by the different types of schemes, causes for non functionality, and the extent of maintainability. In the study, non functionality varies among scheme types. Among investigated five types of water schemes, hand dug well recorded the highest non functionality rate, which is 34%, secondly shallow well with non functionality rate at 29% and the lowest non functionality rate recorded for spring at spot 25% (See figure 3.1).

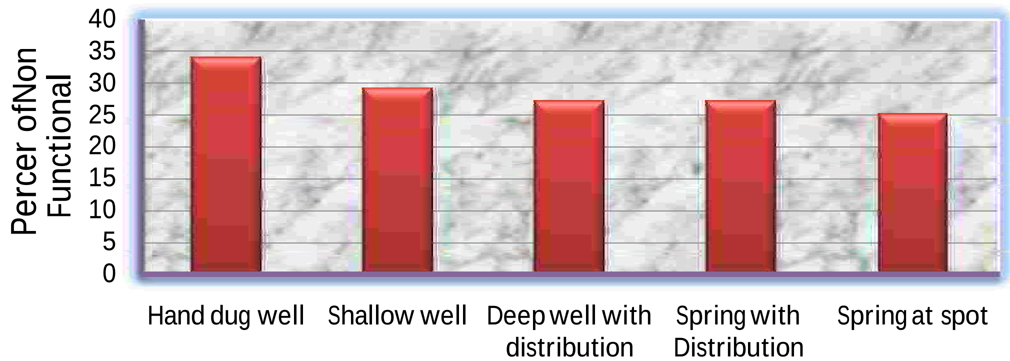


Figure 3 . 1 Percentage of non functionality of rural water scheme in SNNPR

Percentile causes on non functionality was analyzed in four causes for non functionality (*Gebrie, 2012)*, namely:

1. Mechanical,
2. Yield,
3. Quality
4. Construction

In SNNPR the most non functional causes are construction (44%), followed by mechanical (40%). The yield and quality assumes the third and fourth place respectively. The following figure 3.2 shows causes for non functionality in SNNPR.

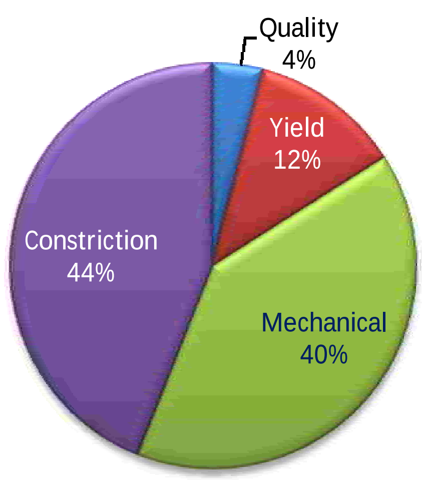


Figure 3 . 2 Percentages of Causes of Non Functionality in SNNPR (Gebrie, 2012)

3.5. SUSTAINABILITY OF WATER AND SANITATION DEVELOPMENTS

3.5.1. Defining Sustainability

World Commission on Environment and Development (WCED), 1987 defines sustainability as "meeting the needs of the present without compromising the ability of future generations to meet their own needs". Sustainability is defined as whether or not a water schemes continues functioning over time (Abrams, 1998). Abrams stated that if water continues to functioning then all the elements required for sustainability must be in place. Those elements were identified as:

- Money for recurring expenses and the occasional repair,
- Acceptance from consumers of the service,
- An adequate source supplying the service,
- The service must have been properly designed,
- Sound construction quality.

Abrams arranged these elements into social, financial, technical, institutional and environmental factors; and described each factor as being necessary for sustainability, but noted none would be sufficient in itself.

Sustainability of water and sanitation schemes have also been identified as factors required for sustainability to be achieved (Harvey and Reed, 2004). This is social, financial, technical, institutional and environmental factors to consider.

McConville (2007) propose planning for and evaluating sustainability by dividing water and sanitation projects into the following five sequential stages: (1) needs assessment, (2) conceptual design, (3) design and action planning, (4) implementation, and (5) operation and maintenance. Each stage is represented as an element in a sustainability matrix and scored according to specific guidelines.

Figure 3 . 3 Cyclical life-cycle stages (McConville, 2007)

McConville Five life cycle stages for development work is directly relates with functional sustainability of the project from prefeasibility state up to life stage of the project.

Stage one: Needs Assessment

McConville extracted factors that are subscribed in need assessment. This stage is fundamental for the whole implementation of the project phase. Fail to pass this stage means early failure or non sustainable of the project. It is the stage of gathering the necessary and sufficient information for development of the project. It is initiated by either from the community or outside the community.
The major activities to be held in this stage are

- Collecting background information on social, cultural, and political situation along with environmental and technical constraints
- Analyzing motivation and demand driven initiations in all aspect the community
- Assess the extent of need and potential for improvement
- Conducting assessment and gathering information by series of site visits, participatory evaluation tools, interviews, observations, and relevant literature reviews during which the opinions of a variety of stakeholders (community leaders, council members, men, women, youth, and development workers) are solicited.

The above collected information helps to the planner to decide implement or not implement the project.

Stage two: Conceptual Designs and Feasibility Study

The feasibility and approval of conceptual design phase is marked by iteration process in which alternative plans are developed and assessed. The main aim of conceptual design plan is

- Selecting appropriate technology that is technically sound, economically feasible, and acceptable to the community.
- Multiple conceptual designs will be considered, identify potential solutions and selecting preferably project developments and in general this life stage brainstorming session
- Analyzing each new technology based on social, economic, and environmental constraints, and advantages and disadvantage.
- Determining the parameters for operation, maintenance, and the eventual disposal of the system.
- The feasibility study will consider sustainability issues from later stages in the project life cycle.

The main target of this life stage is the decision point of design selection based on feasibility studies will serve or not.

Stage three: Design and Action Planning

This is a stage where selected design is finalized and an action plan prepared for project implementation.

- A detailed technical design is developed, including sketches, schematics, construction and operation budgets, and resource inventories to be held.
- Synchronizing action planning with final design and indentify project constraint in planning and designing phase, which should not affect the final design outcome.
- The action plan covers tasks to be completed during implementation, including financing arrangements, the procurement of land and resources, recruitment of laborers, site preparation, and actual construction.
- Identified tasks can be assigned to appropriate project participants.
- The action plan also provides a timeline for task completion.

Stage four: Implementation

Implementation stage is the process of transforming what is in the design and action plan into construction stage.
Project implementation includes both the pre-construction and construction processes.

- Pre-construction involves contractor selecting, procurement of supplies and financing, site preparation, and identifying quality construction materials and procedures.
- The construction process is the major physical activities implementing stage.
    - ü Construct projects in accordance with final design and the procedures in action plan.
    - ü Giving technical training for the community from the beginning up to completion stage of the construction.
    - ü Make essential correction to make scheme well function, in which not revealed at the stage of designing with concerned bodies.

Stage five: Operation and Maintenance

To maintain sustainability, fundamental activities to be implemented at the stage of operation and maintenance

- ü Operational, management and financial issues.
- ü Organization with the capacity for adaptive management and ability to make adjustments for unexpected problems will oversee operation and maintenance programs.
- ü Giving continued technical training and education to support use of the system.
- ü Giving solution for financial , environmental burdens and unexpected problems raised

3.5.2. The importance of functional sustainability

The importance of sustainability may appear obvious, but four aspects are worth highlighting (Carter and Rwamwanja, 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”.

3.6. INTEGRATED DECISION SUPPORT TOOLS FOR RURAL WATER SUPPLY

The integrated decision supporting tools for rural water supply schemes clearly shows the sustainability of water scheme throughout the design period and sustain rural potable water supply even after the design period (Gebrie, 2012). All factors and parameters for sustainability have been carefully weighed in the study.

The study addresses and emphasizes rural water supply schemes sustainability issues in Ethiopia using case study. Parameters like beneficiaries, population growth, scheme yield, consumption rate, tariff and household income have been included and analyzed. Rural water supply Sustainability issues are directly or indirectly interconnected with the above parameters.

Six rural water schemes have been studied on this research based on Ethiopian context. These are hand dug well, shallow well, deep well with motorized distribution, spring at spot, spring with gravity distribution and spring with motorized distribution have been studied.

The researcher analyzed comprehensive tool-chain of decision support tool in three step mode. These are a cost estimation regression model, a multi-criteria composite programming model and system dynamics model. Three step models show that performance of key parameters of rural water supply through time, are integrated to assist in the section of scheme type that for new evaluation of existing schemes.

The research emphasizes that an integrated approach is required to ensure sustainability. Applying composite programming tool, the integration of indexes shows that among the six types of schemes spring with gravity distribution scores the highest point when evaluated based on two objectives – planning and physical development and sustainable operation and management that aggregate both quantitative and qualitative parameters based on the total of fifty-three technical and non technical indicators. Depending on the available options and number of beneficiary per scheme type the analysis of the model gives results for decision makers. In smaller community, spot schemes get higher total evaluation scores than the scheme with distributions and vice versa.

In the third mode, the system dynamic shows that for a given number of beneficiaries, the performance of a scheme through time highly depends on the consumption pattern, population growth, scheme cost, scheme yield, tariff, income of beneficiaries and sustainability.

The ration between the expenditure of a household for water to its income, the presence of a funding reserve for operation and maintenance, major rehabilitation or scheme replacement and the value of sustainability are key parameters for sustainability provision of potable rural water supply. The researcher showed that these values are in general within acceptable range for spot sources and spring with gravity.

The integrated system dynamics model shows the effect of increasing consumption on various key parameters. The increase in the tariff to income ration and decrease in sustainability index are the major ones.

Finally ensuring sustainable provision of rural water supply requires an integrated scheme based approach beginning from the inception of the scheme throughout the design period. Effective of rural water supply intervention could only be guaranteed if it is integrated with an intervention in hygiene and sanitation. This requires sector wise integration of stakeholders addressing water, health and education (Gebrie, 2012).

Insufficient financial planning and lack of spare part suppliers are two major barriers to dynamic operation and maintenance. Managers of rural systems without sufficient know-how and training may grossly underestimate recurrent and future costs (Harvey and Reed, 2004).

Generally appropriate and continuous function of water and sanitation developments meets the objects by fulfilling safe sanitation, safe hygiene, accurate design and proper construction of water schemes. Furthermore the management to be well integrated in society and involves the community; the costs of operation, maintenance and administration is covered locally; and the environmental effects must not be harmful (Brikké & Bredero, 2003)

3.7. DESIGN AND CONSTRUCTION CONSIDERATION OF FUNCTIONAL WATER SCHEMES

Water and sanitation schemes should be functional throughout specified design period. Properly designed and constructed schemes could function throughout their design period with proper management and on time maintenance. Each category of water and sanitation schemes has their own way of design and construction process.

3.7.1. Spring Capping and Spring Box Structure Design and Construction

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. The following should be considered when developing or improving a spring.

A. Location

It is easy for springs to become contaminated if they are located downhill from the source. For this reason, all sewage systems, barnyards, livestock pastures, and other sources of pollution must be located at least **30 m** away from springs. Depending on the soils, geology, and slope of the land, an even greater distance may be needed. Also avoid extremely wet areas when locating a new spring, because saturated soil can't filter out bacteria which is in Rural Water, Sanitation & Hygiene Program (RWSHP 2007).

B. Types of springs

There are three main types of springs that occur in nature (RWSHP 2007).

I. **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.

II. **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.

III. **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.

C. Construction methods

The objective of spring construction is to obtain maximum yield from the spring while protecting it from external pollution, especially of faecal origin. Every spring catchment has a special method of construction. But there are two common types capping structures (PSU 2007).

I. **Spring box capping structure**: it is used to cap Artesian and Gravity type of springs. 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 (Figure 3.4), and the second design has a pervious bottom for collecting water flowing from a single opening on level ground (Figure 3.2)

II. **Infiltration gallery capping structure**: mostly applicable in seepage springs types.

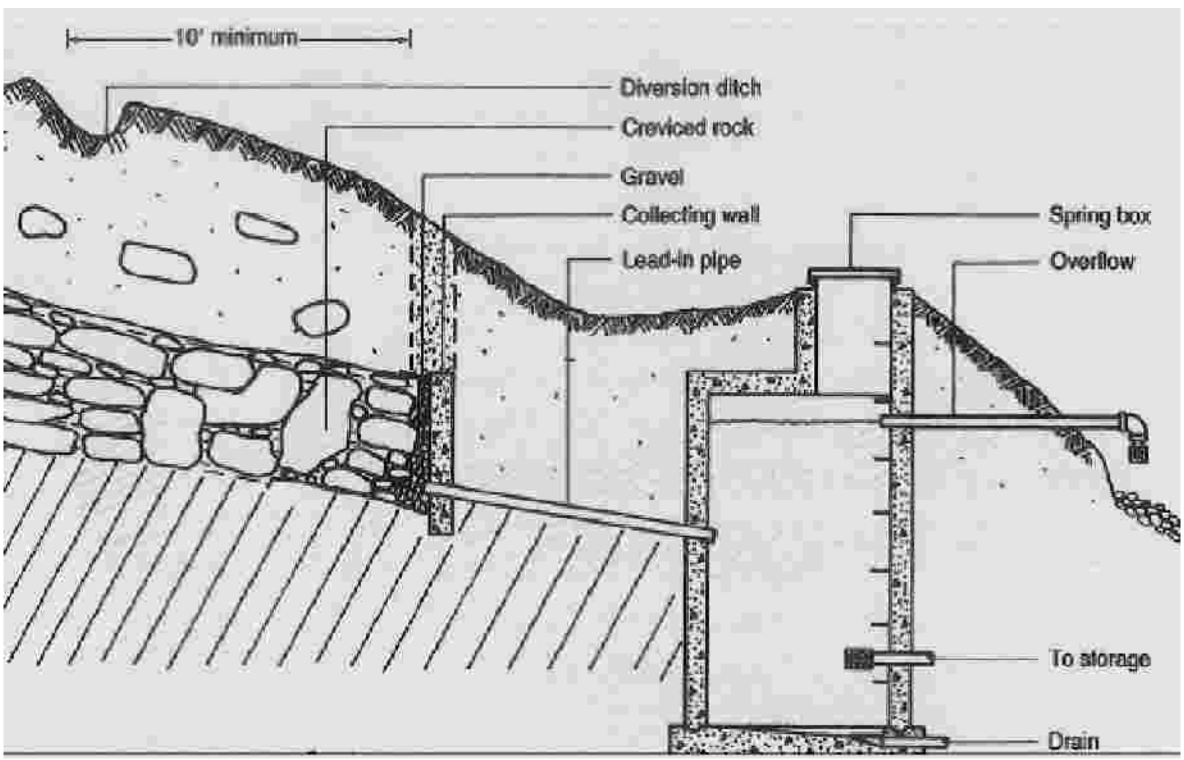


Figure 3 . 4 Development of a concentrated Gravity spring (PSU 2007)

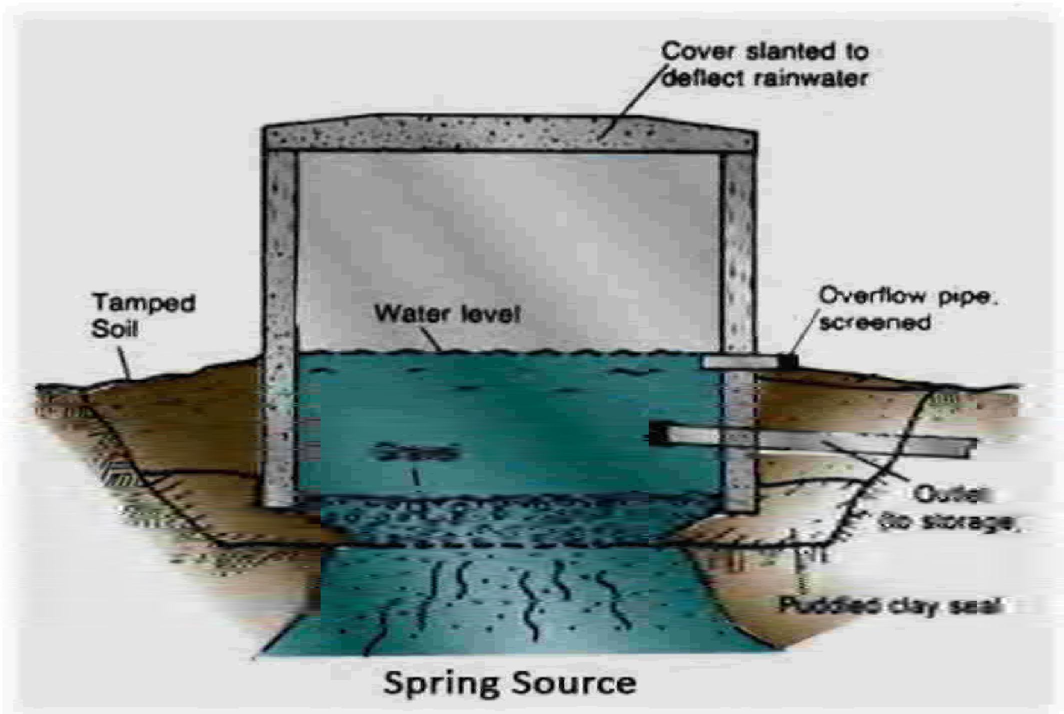
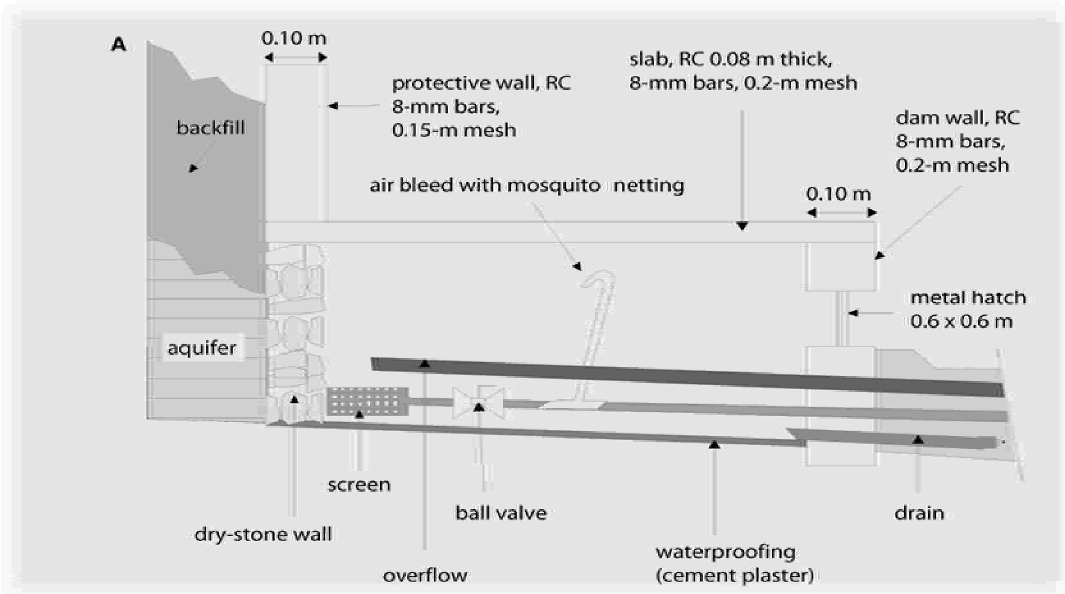


Figure 3 . 5   Artesian Spring Box Design with Permeable Bottom (USAID 1982)

The choice of catchment technique is determined during the site visit, but is mainly decided during the progress of excavation. The procedure is as follows:

- clear the discharge zone to locate the water outlets precisely;
- excavate towards the source of the water, taking care not to obstruct the flow;
- stop excavation when the impermeable level is reached:
- if the discharge is clearly localized and not very deep (less than 2 m), construct a spring box retaining wall to protect the structure;
- if the discharge is diffuse and/or deep, construct a dam wall with a drain behind it;
- Position outlets and overflows correctly below the discharge level;
- Erect a protective fence.

Figures 3.6 and 3.7 shows the principles of spring catchments using tanks and drains Structures, notably the drain dam wall or the spring box can be made of masonry or reinforced concrete. Infiltration galleries consist of 5-10 cm round pebbles, set behind the wall or in a gabion.



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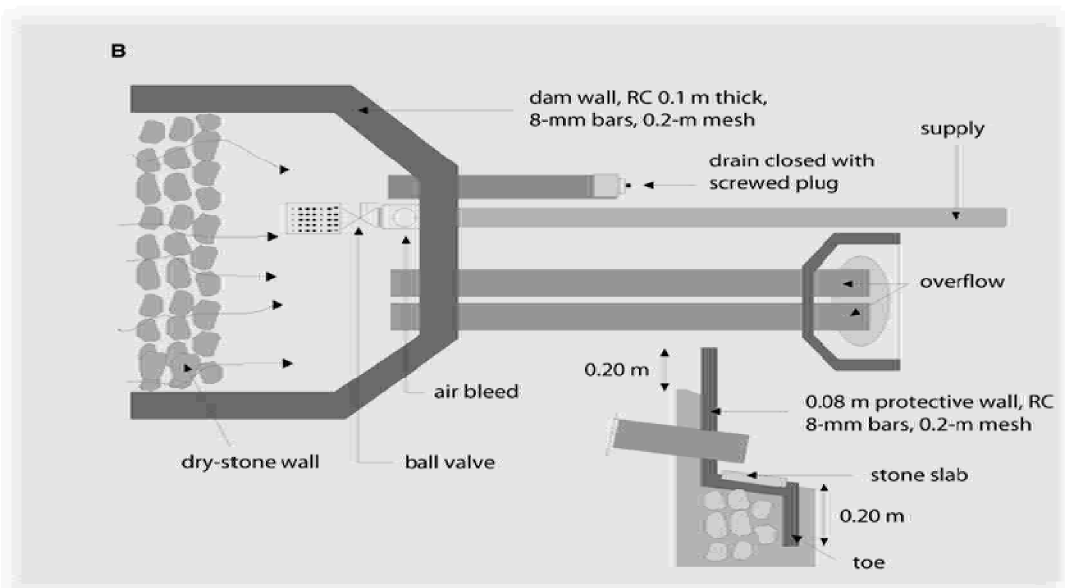
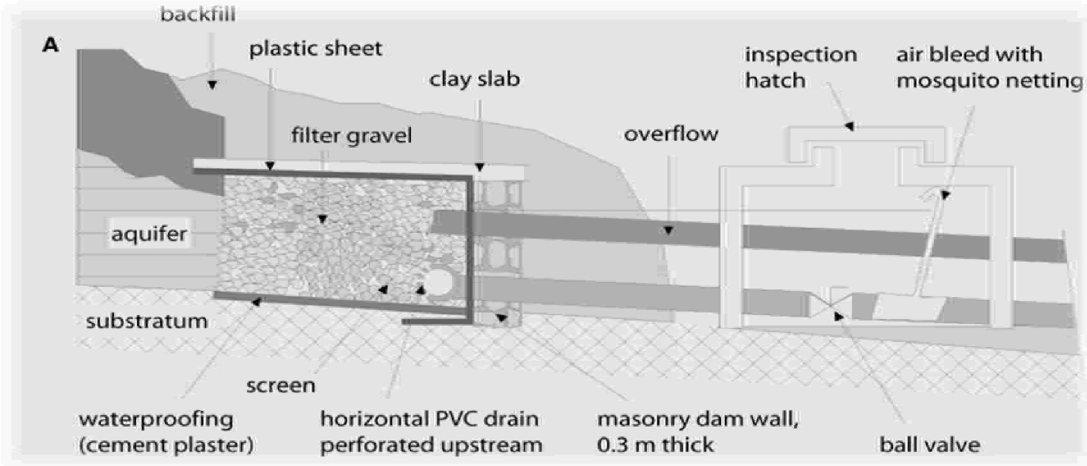


B: Plan

Figure 3 . 6 Gravity spring box in reinforced concrete (ACF, 2005)



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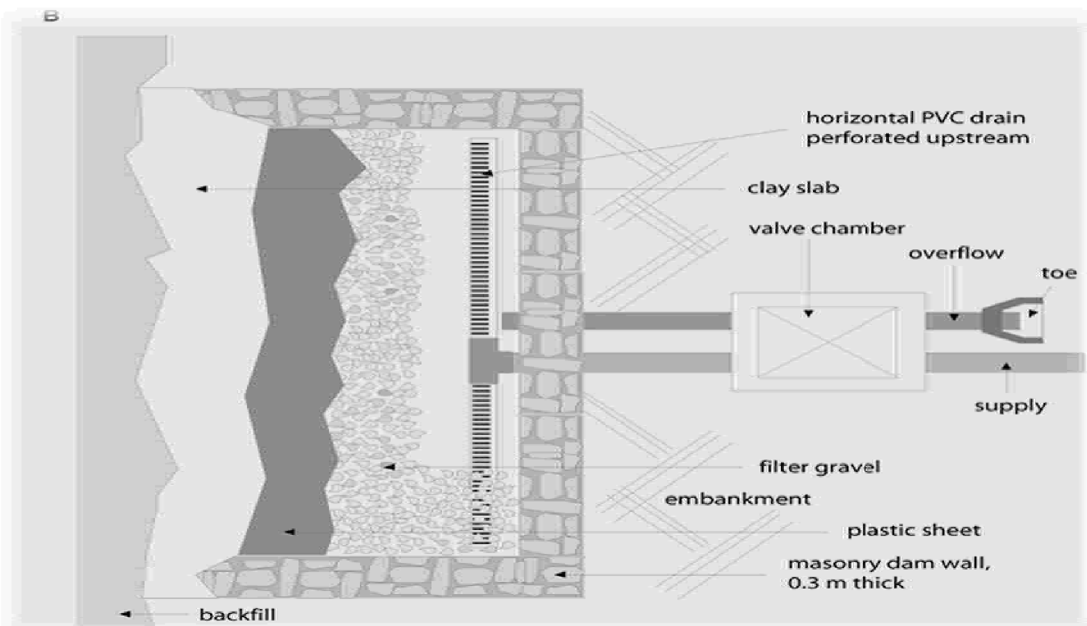


B: Plan

Figure 3 . 7 seepage springs infiltration gallery (ACF, 2005)

Three rules strictly applied in order to construct a reliable spring catchment (ACF, 2005)

A. **The catchment must never be subject to back-pressure**: the water level in the spring box or infiltration gallery must always be below the initial discharge level. The catchment must drain the aquifer while allowing extraction from the piezometric level, but must not increase pressure, or the spring could be lost. A reference peg can be used (set far enough away not to interfere with the excavation) to mark the initial discharge level. These acts as a reference mark at the time of the construction: the outlet and overflow are set below this level. However, to avoid accidental back-pressurization, it is essential to create an overflow; in the absence of information on the maximum flow, the overflow must be over-sized

B. **The dam must be located on impermeable terrain**: the excavation must reach down to the substratum. This sometimes requires substantial excavation, but is essential to ensure that water does not pass under the catchment after some weeks of use. The notion of substratum is sometimes difficult to define on site: it is therefore preferable to retain an idea of a less permeable layer over which water moves.

C. **The catchment must be protected**: the protective works are part of the catchment works. It is necessary to take care over sealing, especially the drain cover (clay, plastic sheeting etc.), and the construction of the tank.

3.7.2. Design and construction consideration of Pipe and Pipe Line Construction, Protection and Standards

Standardized design and construction of pipe and fittings in water supply system has a great value for functional sustainability of water schemes. The main problem in water supply pipe systems are trench excavation and backfill, valves and fittings, bending, joints, anchor blocks and break pressure. The following are some basic points on pipe line construction and protection (ILO, 2011 and ACF, 2005).

Trench excavation and back fill
Minimum and maximum trench widths and depth shall be done according to the contract specified. Trench excavation shall include the removal of all materials or obstructions and the control of water as necessary to construct the Work as shown or specified in the Contract. Surface water shall not be allowed to enter any pipe trench and shall not be permitted to enter the existing downstream pipe system. By any means no pipe to be exposed for damage. The trench backfill material may be native material excavated at the work site to be filled back. All backfill material shall be by mechanical pneumatic or vibratory compaction equipment.

Valves and fittings
Valves should be installed on appropriate place and location. Air release valve should be installed along the line for Release air from the pipeline during the filling process and to prevent the development of a vacuum. Washout Valves to be installed in any lower points of the pipe system. Pressure relief valves to be installed where higher pressure in the pipe system detected. Appropriate standardized fitting should be installed.

Anchor blocks
Coupled pipelines must be anchored at:

- All changes of direction greater than 10 degrees, at changes in pipe size, at slopes greater that 1 to 6 and at blank ends.
- The anchor blocks must be large enough to provide sufficient friction and bearing forces between the anchor block and soil to balance the thrust force in any direction; and Balance upward forces through the mass of the block.

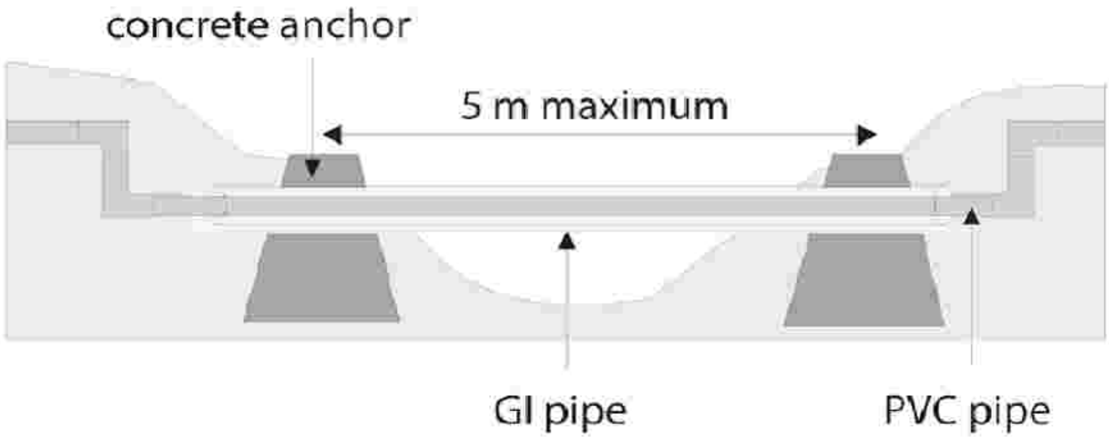


Figure 3 . 8 concrete anchor block over passing drops (ACF, 2005)

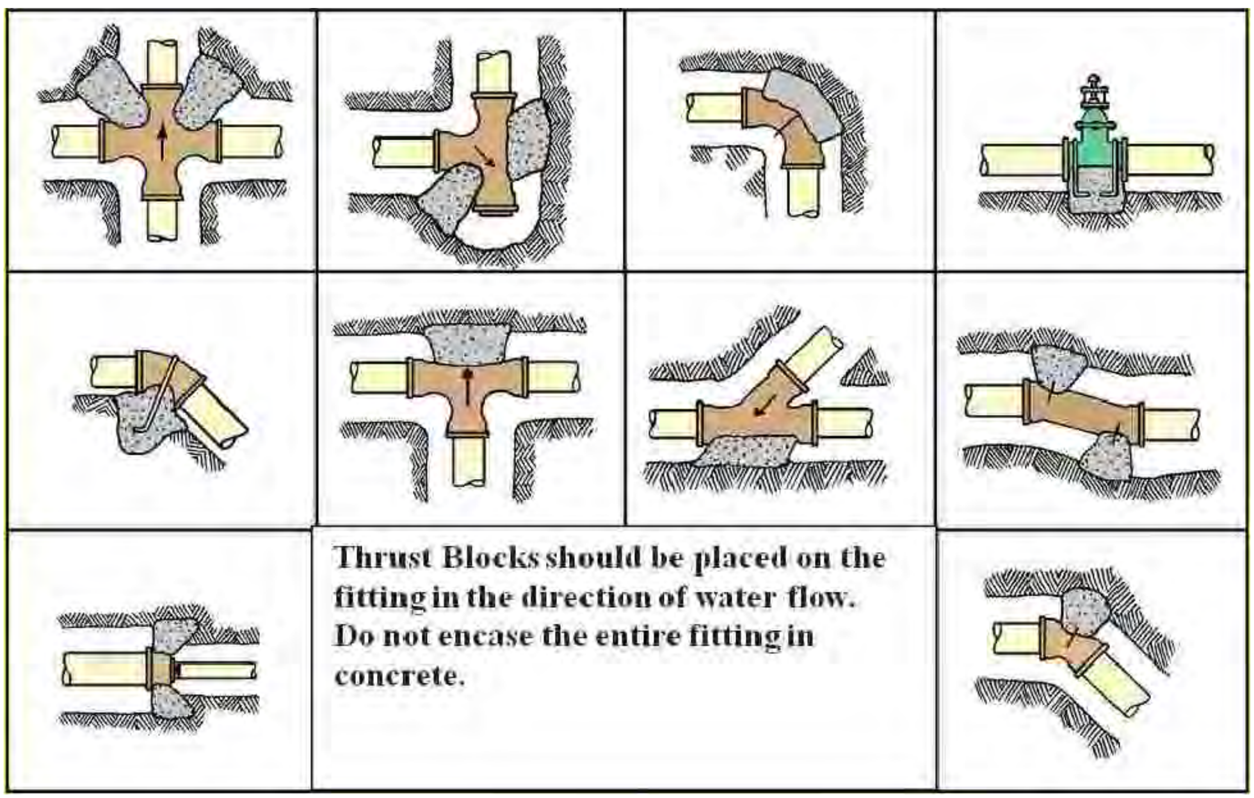


Figure 3 . 9 Typical trust block positioning detail (Ron Blies, 2012)

Structural design

- Pipelines should be designed for internal and external pressure including surge pressure.
- The structural load bearing capacity of the pipe is specified by the manufacturer and care should be taken not to expose the pipe to loading conditions other than that intended by the manufacturer.

Fittings

- Reducers / diffusers and inlets
- The range of angle of deflection for concentric or eccentric diffusers (enlarging diameter) should be between
- Where available NPSH is a problem, rounded inlets should provide better flow characteristics and less friction losses.

Bends

- Elbows should not have a bending radius smaller than the outside diameter of the pipe.
- Medium and long radius bends should not have a radius larger than seven times the outside diameter of the pipe. Long radius bends normally have a radius of approximately three times the outside diameter of the pipe.
- Standard angles of elbows are: 90, 45 and 22.5 degrees.

Dividers

- All flow dividers will cause change in flow direction and should therefore be properly anchored.
- Standard angles of deviation from the main pipe are: 90, 60, 45, 22.5 and 11 degrees.

Break pressure tank

Break pressure tank is installed where very high pressure is observed. These are structures where the hydrostatic pressure of water is allowed to drop to zero. This structure protects pipes and fittings from burst and break during high pressure.

3.8. WATER WELL CONSTRUCTION

3.8.1. Water Well Classifications

Water well is classified in to three main groups. These are hand dug well, shallow well and borehole. Each category of water well has its own method of construction and water lifting system from ground water (Ethiopian Social Rehabilitation and Development, *ESRD, 1997).* In the Table below some characteristics of different types of wells are stated.

Table 3. 3 Water well classification (ESRD 1997)

No	Type	Description	Depth
1	Hand dug well	It is usually excavated by hand. It can be fitted with hand pump or any type of water lifting mechanism.	Depth = < 20 meters
2	Shallow borehole well	A shallow borehole is a borehole drilled with drilling machine to an undefined depth. It is installed with 4-6" PVC casing/screens. It can either be drilled with the mud rotary methods or DTH. It is mostly fitted with hand pump.	Depth 20 - 60 meters
3	Borehole	A deep borehole is a machine drilled (mud drilling or down the hole hammer [DTH] well with a depth greater than the maximum depth defined for a shallow borehole. It is installed with 4-8"PVC casing/screens	Depth = > 60 meters

3.8.2. Siting of New Water Wells in Relation to Contamination Sources

In rural areas water sources are contaminated due to improper locations of water wells with respect to soil type and the proximity of contaminations sources. Many wells are polluted because they are located too close to a source of pollution, or are not properly constructed.

A well must be located so that it meets the minimum isolation distances known as "setback" or "separation" distances (Minnesota, 2010). As a general rule, a well should be located upslope from, and as far away as possible from, potential sources of pollution. The safe distance depends on the nature of the subsoil, the depth to the water table, the slope of the land, the rate of pumping, and the size of the pollution source. Suggested safe distances are shown in the table 3.4 (Ireland, 2009)

Table 3. 4 Recommended distance of a private well from likely pollution sources (Ireland, 2009)

Type of subsoil	Depth of subsoil above bedrock* (metres)	Minimum distance (metres) where groundwater flow direction is known or can be estimated				Minimum distance (metres) where groundwater flow direction is unknown	
		up-gradient from well		*down-gradient from well*			
		farmyard	*septic tank percolation area/polishing filter/ oil tank*	*farmyard*	*septic tank percolation area/polishing filter/ oil tank*	*farmyard*	*septic tank percolation area/polishing filter/ oil tank*
Clay or Silt/Clay (low permeability, poor drainage)	1 - 3	100	40	50	15	100	40
	>3	75	30			75	30
	> 8	60				60	
Sandy clay, silt (moderate permeability)	1 - 2	120	45	50	15	120	45
	2 - 8	90	30			90	30
	> 8	90	30			90	30
Sand and gravel (high permeability, free draining)	1 - 2	150	60	50	15	150	60
	2 - 8	150	40			150	40
	> 8	120	30			120	30

3.8.3. Water Well Construction Techniques

For functional sustainability the right water well constriction techniques and procedures should to be implemented (Arjen van der Wal, 2010).

I. ***Drilling Logs***: - It is very important to determine the exact location (depth) of permeable layers (aquifers), and the location of any impermeable layers in our well drilling process. Accurate drilling logs should be created. A drilling log is a written record of the geological formations (soil layers) drilled, according to depth. Soil samples should be taken at regular depths (e.g. every meter) and described during the drilling process. The soil description is then recorded in the form of a drilling log.

The drilling log will help us to determine

- The right aquifer for installation of the well-screen
- Depth and length of the well-screen
- Depth and thickness of the gravel pack
- Location of the sanitary seal

II. ***Soil Samples***: - drilling logs is to be take representative samples of the soil (geological formations) encountered in drilling. Samples should be taken every meter and/or every time the formation (soil) type changes.

III. ***Well-screen, position and length:-***The well-screen usually does not exceed a length of 6 meter, for manually drilled boreholes. Fine materials are often present in the extreme upper and lower parts of an aquifer. Also thin clay layers might exist in the aquifer. To prevent the fines (which may cause turbidity and pump damage) from entering the well-screen it is important not to install the well screen at the same level as these fines in the aquifer. In other words; one has to be sure that the whole screen length is installed in a permeable layer, consisting of sand or gravel. To achieve this in some cases the screen length might be less than 6 meters but should generally never be less than 3 meter. To avoid fines from entering, it is wise to install the well screen and backfill with a safety margin of at least 1 meter. In the drilling log above, the well-screen is to be placed in the middle of the aquifer, leaving a 1 meter margin of sand at each end.

IV. ***Materials: gravel pack:-***The gravel pack fills the space between the aquifer (sand particles) and the well screen (preventing the wall of the hole from collapsing on to the well-screen) and may serve to filter some of the fine sand particles from entering the well.

The gravel should consist of a grain size (generally 1.5 - 3mm) which is just larger than, and no more than twice to three times, the slot size of the well-screen. Good size gravel looks more like coarse sand, rather than gravel. The grains are best when round in shape. Such material can often be found on river beds or lake shores. The best way to prepare suitable gravel is using maximum and minimum sized sieves (grains which are too small or too big are sieved out). Strictly speaking, the screen slot size depends on the grain size of the aquifer

Table 3. 5 Choice of screen slot and gravel pack per aquifer grain size (ACF, 2005)

Aquifer grain size	Gravel pack grain size	Screen slot size
0.1 to 0.6 mm	0.7 to 1.2 mm	0.50 mm
0.2 to 0.8 mm	0.1 to 0.5 mm	0.75 mm
0.3 to 1.2 mm	1.5 to 2.0 mm	1.00 mm
0.4 to 2.0 mm	1.7 to 2.5 mm	1.50 mm
0.5 to 3.0 mm	3.0 to 4.0 mm	2.00 mm

V. ***Thickness of the gravel pack:-***Once the well-screen position is recorded (hatched) on the drilling log, the position and thickness of the gravel pack can be determined. The annulus (open space) around the well-screen is filled with coarse sand or fine gravel of specific size (gravel pack), up to about 1-2 meter above the top of the well-screen. The extra meters are necessary because during the development of the well, the gravel pack will settle (and shrink). It is therefore good practice to include at least 1-2 meter safety margin above the well-screen during installation of the gravel pack.

VI. ***Sump:-***After the installation and during the use of a well, some soil particles may still enter the well-screen. The bigger particles (which can cause damage to the pump) settle down to the bottom of the well by gravity. To prevent loss of well-screen surface area, a sump of 1-2 meter in length, with a closed bottom end is attached to the well-screen

VII. ***Thickness of the sanitary seal:-***When an impermeable layer is drilled through, it is advised to seal (close) again that whole impermeable layer with clay (bentonite) or cement (par 3.3). To be sure the layer is sealed properly; the thickness of this seal should be at least 3-5 meter.

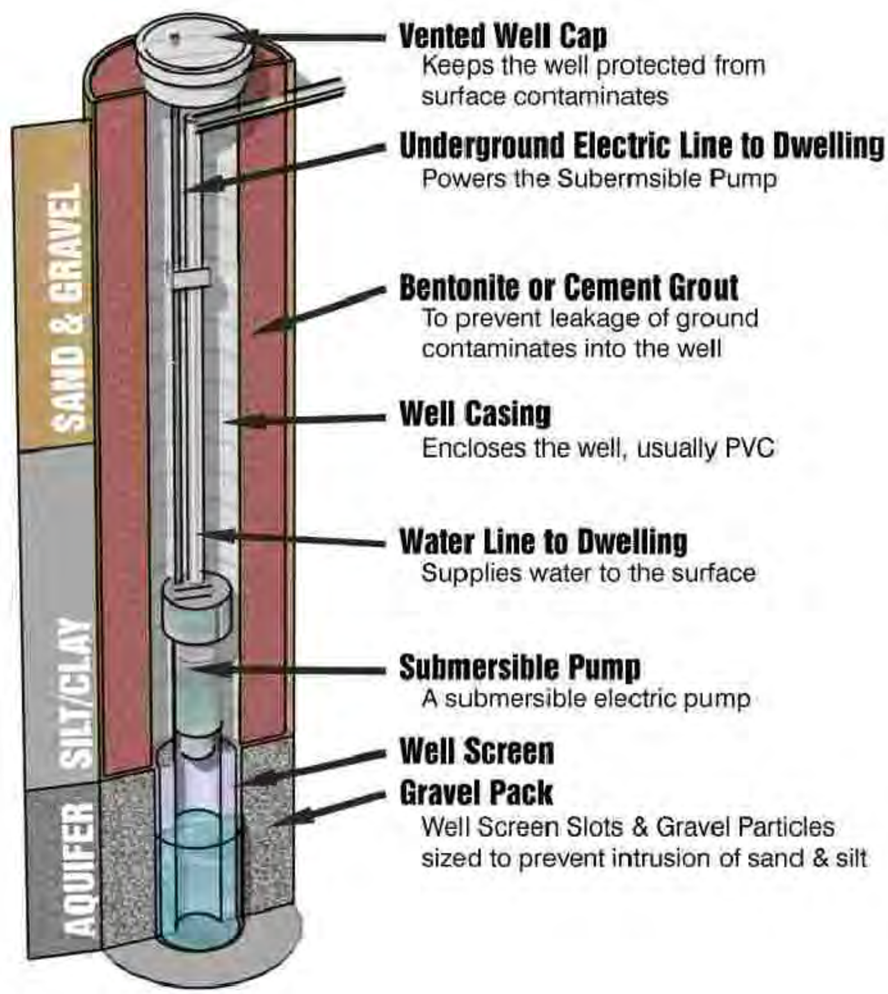


Figure 3 . 10 Water well diagram (Source: Epic Well Drilling)

3.8.4. Well Development

Well development is necessary to maximize the yield of the well and optimize the filter capacity of the gravel pack. This is achieved by removing the fines and drilling fluid additives, and settlement of the gravel pack (Arjen van der Wal, 2010)

After drilling some of the fines and drilling fluid additives remain behind in the borehole and are blocking the pores of the surrounding aquifer and the new installed gravel pack. After they have been removed by well development the water will be able to move freely from the aquifer to the well screen. During well development also the gravel pack will settle and become more compacted, ensuring that there are no large voids (holes) into which aquifer material (sand) could later collapse. The settled gravel pack will filter out some of the fines from the aquifer.
Several techniques are available for well development and sometimes a combination of these techniques is used to get the best development results. Useful techniques are:

- Surge block or plunger
- Discontinuous pumping (start-stop cycle pumping)
- Continuous pumping with large flows

3.8.5. Pumping test – well yield

Once a well has been developed and is free of any fines, the well should be test-pumped. Test pumping gives useful information about both the well and the aquifer. In particular it can indicate whether the well yield will be sufficient for its intended purpose (Arjen van der Wal, 2010)

Note: Reliable test pumping can only be done when the groundwater level has returned to normal after the well development. The well should rest for at least 24 hours after development before test pumping is started.

3.8.6. Pumping System

It is very important to inspect and maintain the pump regularly so it is possible to see problems and solve them before they become too big. Regular checking will help to keep the pump in good working order and avoid big expenses for repairs (RWSHP, 2007).

I. Inspect the Pump

Pumps should inspect the pump every week and every month.
Weekly Inspections

- Check that the nuts are tight.
- Make sure the locker pins have not fallen off.

Monthly Inspections

- Stroke test – how many strokes of the pump handle until water comes?
- Bucket test – how many strokes of the pump handle to fill a bucket?
- Check bearings – are the bearings worn or broken?

II. Routine Maintenance

It is more prudent to make routine maintenance to identify and solve problems before they become big and expensive. This means tightening loose nuts, welding locker pins back on (if they have fallen off) and replacing worn out parts.

Nuts: check that nuts are tight. However are not been over tighten t – if tighten too hard it may damage

Locker pins: if the locker pins have fallen off, weld them back on. It needs help form woreda or zone.

Bearings: remove the bearings and check their condition. If scratched, loose or uneven, replace them with new bearings. If they are okay, clean them with a rag before putting them back.

Stroke test: if it takes a lot of pump strokes before water comes, check the foot valve. Replace the bobbin or o-ring if they are worn. Make sure the foot valve is properly seated.

Bucket test: if it takes more strokes than usual to fill a bucket, remove the plunger and check the condition of the u-seal. Change the u-seal if it is damaged or worn.

Fast moving spare parts

Some parts, which need to be replaced regularly, are known as fast moving spare parts. These include:

- The u-seal
- The o-ring
- The bobbin
- The bearings

It is more advisable to buy and keep some of the above spare parts in the village so that when they wear out or break, it is easily you can replace them straight away without having to wait until someone can go and buy them

III. Solve Minor Problems

If there are problems in the pump, it should be solve quickly so that they don't become bigger problems. A delay may cause more damage the pump and costs more to repair and mean that the community cannot use the pump for a while.

Table 3. 6 Minor pump problems and solutions (RWSHP, 2007)

Water does not flow at all	
Cause	**Solution**
Foot valve is not in place	Check and re-seat foot valve
Bobbin is stuck or missing	Check and replace bobbin
Broken pump rods	Replace pump rods
Low water yield	Limit use of pump – deepen well.

- **There is delayed flow**

Cause	**Solution**
Foot valve is not in place	Check and re-seat foot valve
O-ring is worn	Check and replace O-ring
Broken and leaking pipe joint	Repair joint(contact Woreda or Zone)

There

Cause	Solution
U-seal is damaged or worn	Check and re-seat U-seal
Broken and leaking pipe joint	Repair joint(contact Woreda or Zone)
Low water yield	Limit use of pump-deepen well

- **The handle is loose**

Cause	Solution
Fulcrum nut is loose	Tighten nut. If necessary replace fulcrum pin
Locking pin missing	Weld new locking pin on fulcrum pin (contact Woreda or Zone)
Worn bearings	Replace bearings

IV. Get Help with Major Problems

After three or four years the pump will begin to have some major problems which needs help to solve and repair. These problems will be too difficult for community level maintenance. It is recommended to contact with respective organization to get assistance with them.

V. Keep tools, spare parts and record problems

One main important point in pump failure is not proper handling of tools, spare parts and problem detection. Tools and spare parts are to be kept in a safe place so that they are available when they are needed for maintenance or repair. In case of loss or damage, then the community will have to replace them. It is recommended to buy and store spare parts.

It is good habit to keep records for the trouble occurred. It makes easier to record each problems on time and find solution for the causes for recorded problems.
Use the pump properly

Everyone should learn the operating system of the pumps, including children, how to use the pump properly. This will prevent the pump from being damaged and will save community lots of money on parts and repairs. Community level meeting and agreement is critical. Everyone should know rules for how the pump should be used. The following is an example of some of the rules should be agreed:

- When pumping, stand directly behind the pump
- Use full strokes, not short strokes
- Don’t bang the handle
- Do not let children play on or around the pump
- Do not let animals near the pump. Fence around the pump to prevent animals getting near.
- Do not allow clothes washing at the pump. This should be done away from the pump.
- Do not allow bathing at the pump. This should be done somewhere else.
- If children are going to collect water, then put a block for them to stand on when pumping.
- If the pump is showing signs of a problem, stop using it until the problem is identified and solved.

VI. **Maintain the well site**

A pump site that is in good condition will ensure that pump users can get water easily and safely. On the other hand, if a pump site is in bad condition, the pump will become damaged, the water in the well could become contaminated and people could become sick from using the pump. Hence the following actions should be taken

- Keep the well site clean
- Drain spilled water away from the well site
- Protect the concrete apron and drainage and
- Keep well site closed and protected fencing

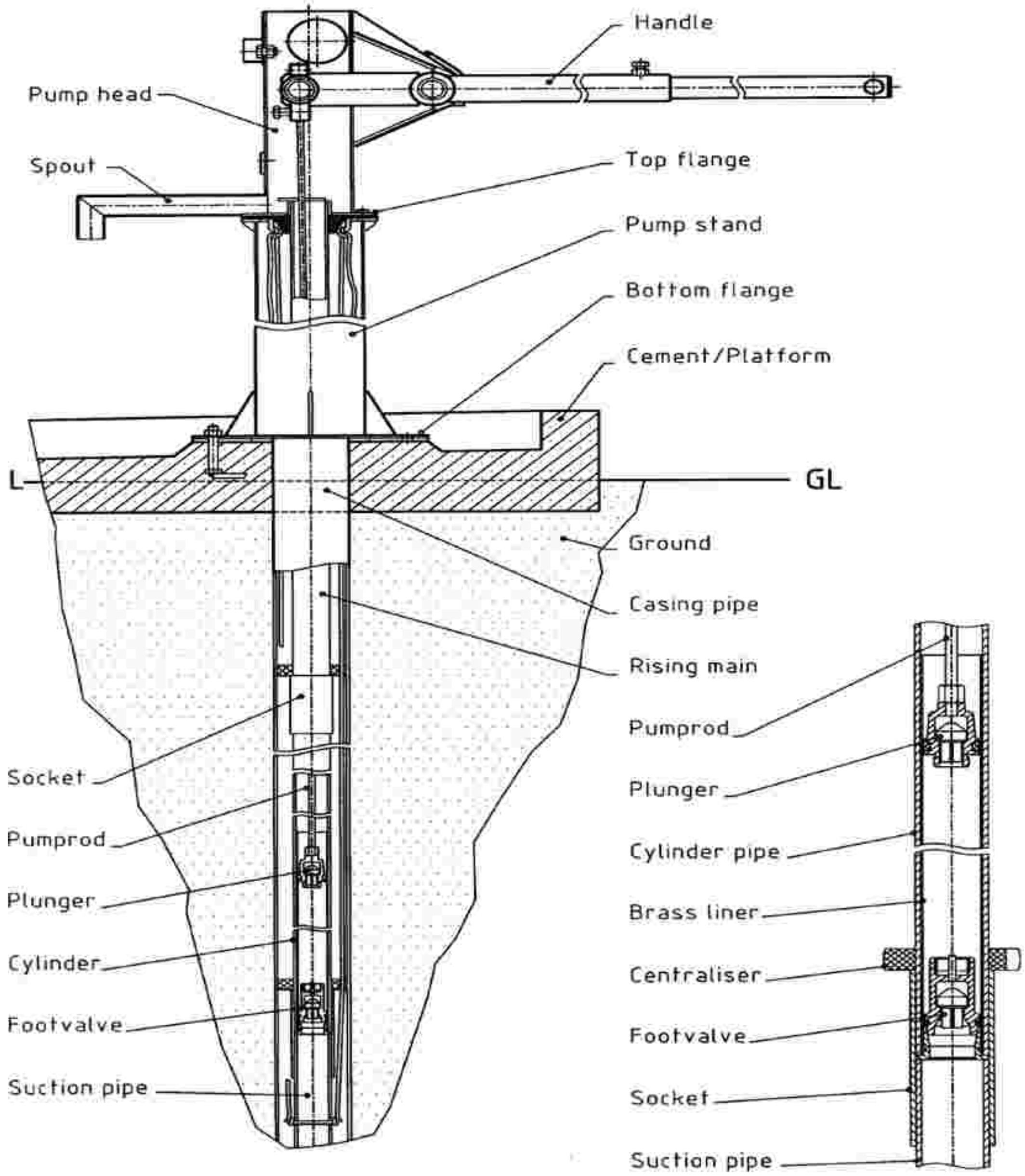


Figure 3 . 11 Afredive pumps system detail (Source: 1-2003 by Karl Erpf)

3.9. DESIGN AND CONSTRUCTION CONSIDERATION OF FUNCTIONAL SANITATION SCHEMES IN RURAL AREAS

Sanitation generally refers to the provision of facilities and services for the safe disposal of human urine and faeces. Inadequate sanitation is a major cause of disease world-wide and improving sanitation is known to have a significant beneficial impact on health both in households and across communities. The word 'sanitation' also refers to the maintenance of hygienic conditions, through services such as garbage collection and wastewater disposal (WHO, 2009).

Groundwater contamination is a risk associated with the use of on-site sanitation. There is a risk of exposure to biological or chemical agents where the community's water is sourced from an aquifer close to the surface. This contamination is normally due to infiltration of these agents from latrines, leaching from solid-waste disposal sites or infiltration of domestic wastewater (ACF, 2005).

Sanitation systems worldwide can be classified into two major categories, namely: offsite and on-site sanitation systems. The off-site systems include: the conventional sewerage system with proper treatment and disposal, and small-bore sewers. The on-site systems include a number of technology options: dry pit latrines, borehole latrines, ventilated improved pit latrines, eco-san latrines, and pour-flush latrines with single or twin pits, aqua privies, composting latrines, and septic tanks (UNICEF, 2009).

3.9.1. The Most Common On-Site Sanitation System in Chencha Woreda

Health extension is indentified as one of the priorities by the Growth and Transformation Plan (GTP) of the government. The policy documents stipulate that extensive water, sanitation and hygiene will be implemented all over Ethiopia. Following the policy, Chencha Woreda Health Office has exerted efforts for its implementation. The data unfolds that from 45 rural kebeles in Chencha woreda, 32 kebeles have got the certification for house hold level pit latrine usage certificate. In these 32 kebeles more than 90 % of households have constructed with simple pit latrine. The rest 13 kebeles are under transforming from open defecation to household level simple pit latrine (SNNPR, 2013).

The transformation from open defecation to household level simple pit latrine is advancement for entire protection of ground water and surface water from direct impact of pollutants. To make simple pit latrine more sustainable, there are a plenty of methods to be practiced (UNICEF, 2009)

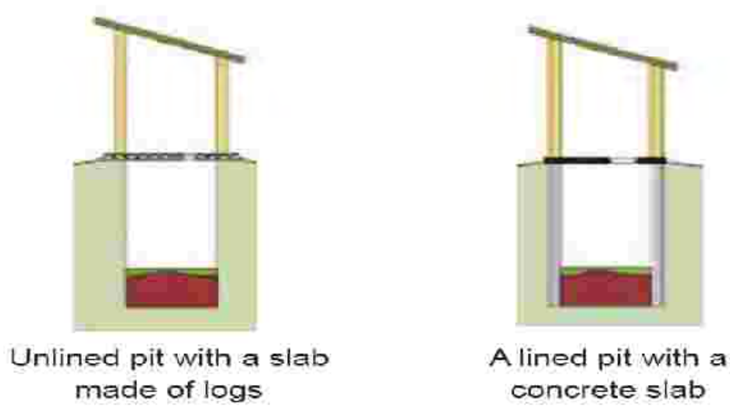


Figure 3 . 12 Simple Pit Latrine Source: DFID

3.9.2. Construction of Simple Pit Latrine (ILO, 2011).

Location

It is important to locate a latrine downhill form water sources wherever possible. Pit latrines should not be built uphill of a well, particularly in areas of fissured rock such as limestone, since faecal pollution may be carried directly through cracks and joints in the rock to the well. The latrines pit should not penetrate ground water and should be at least two meter above the water table. The site should well drained and above flood level.

Latrine should be constructed minimum safe distance from the nearest water sources on the basis of local hydrological and hydrogeological conditions. A distance of 30 meters has been suggested.
The latrine should be minimum distance of 6 meter from house, so that it easy to reach during bad weather and but will not causes problems of odour in the house.

Problems with fly

Flies are attracted by light and odor, and avoid darkness and dark surfaces. All opening leading to the excreta, including the seat or squat-hole, must kept clean and closed when not in actual use (WHO, 2009).

Mound-built latrines

The presence of solid rock or high water table near the ground surface generally prevents the construction of pit latrine. In such circumstances, the latrine can be built on mound. The pit walls need to build up at least 1.2 meters before the mound is constructed. The pit should be full lined with stone, brick or concrete masonry and this lining continued above the ground to the top of the mound. Steps should be built up the outside of the mound using cement mortar.

Lining the pit

A wide variety of materials can be used to line the pit. Concrete blocks, bricks. Cement-stabilized soil blocks, masonry, stone rubble, perforated oil drums, and rot-resistant timber. Where blocks, bricks, masonry or stones are used, the lining joins should be fully mortared in the top 0.5 meters of the pit. Below this, the vertical joints should be left dry masonry or none mortared to allow the liquid part to the excreta to infiltrate into the soil.

The base of foundation

The base or foundation serves as a solid, impervious foundation upon which the floor (or squatting plate) can rest. It prevents the flooding of the pit by surface water and also helps to prevent the escape of hook worm larvae (which climb up the pit walls) and the entrance of burrowing rodents into the pit. The base should be high enough to raise the floor at least 100 to 150 millimeters above the level of the surrounding ground to protect the pit from flooding.

The floor or slab

The floor or slab supports the user and covers the pit. It should fit tightly and be flush with the outer edge of the base. The slab must be larger than the pit and rest firmly on the foundation or base to avoid the danger of collapse.

The floor or slab can be made from reinforced concrete, rot- resistance wood or bamboo covered with layer of mud and cement mortar. The slab should have a smooth surface and slope towards the squats hole to provide easy drainage for urine and water used for cleaning the floor. Causes for non functionality related to simple pit latrine

The floor slab may be of the squatting type of provided with raised seat. The opening should be no bigger than 250millimetres, so that it is too small for young child to tall through.

The shelter

The shelter is for privacy and protects the user and the latrine form the weather. The shelter can be made from any suitable materials.

The shelter is placed on the base of the latrine. The shelter should be high enough for comfort. The heights will depend on the users of the latrine. Opening of 100 to 150 millimeters width should be provided at the top of the shelter walls for constant ventilation.

The roof should cover the shelter completely and have a large overhang to protect the mound and the walls from rain or roof drainage.

3.9.3. Routine maintenance

Simple pit latrine should be maintained every time and its maintenance fulfill the following basic criteria (WHO, 2009).

- Any grass or plants growing around the latrine should be kept well cut.
- Make sure that the door is kept closed
- Keep the latrine floor clean by cleaning daily using water or ashes.
- Do deposit tins Grass or plastic inside the pit.
- Household waste, such as vegetable or fruit peel, And organic matter, such as sawdust and leaves, may be placed in the latrine and can help to reduce odours, but will decrease the life of the pit.
- When contents reach a level of 0.5 metres from the surface, then the contents of the pit should be covered over with soil and a new pit should be dug
- During an epidemic, the floor of the latrine should be cleaned daily with a disinfectant such as bleach (sodium hypochlorite)
- To stop mosquitoes breeding in pits, pits should be kept as dry as possible. If too much water enters, ashes or dry horse or cow dung thrown in helps to absorb water and odours.
- No disinfectant should be added to the pit.

CHAPTER FOUR

4. MATARIALS AND METHODOLOGY

4.1. GENERAL

Scientific research method was employed in scanning existing functionality status and thereby unfold overall situation of water sanitation infrastructures. The research was carried out in cooperation with the respective stakeholders. Different data collection methods were used such as structured questionnaires, observations and interviews, etc. The main aim of deploying observation and interviewing is strengthen and examine the result found from questionnaires.

4.2. RESEARCH DESIGN AND TYPE OF STUDY

Non functionality is believed to happen at different stage of the schemes life. Research Methodologies deployed to extract the main reason for non functionality of water and sanitation infrastructures and put way forward troubleshooting non functionality at the stage of feasibility study, designing of the projects, construction of the infrastructures and eventually at time of service period.

Primary and secondary data were collected from different sources and three scientific research methods were used. To maintain the accuracy, data were collected in four methods:

First, secondary data were collected from different offices. This includes assessing all water schemes in Chencha in 2011, which is national wide inventory of water schemes.

Second, primary data was collected by implementing questionnaires. Questionnaires are formulated in such away to give clear picture about the functionality of water and sanitation scheme in rural areas. Questionnaire content and design system was taken from "Integrated Decision Support Tools for Rural Water supply based on Ethiopian Case-Studies" *(Gebrie, 2012).*

Third, primary data was collected using observation methods. Observation was implemented all over selected schemes of Chencha woreda. Observation is the center of extraction of non functionality of water and sanitation infrastructures. Sanitary observation was also implemented based on WHO format.

The final and the fourth data collection method were interviewing. Interviewing and focus group discussion (FGD) were arranged in three groups. Semi-structured questions were prepared and used in the FGD. The group comprises representatives from woreda water resources developments expert and professionals, local government and other public sector representatives and rural community water and sanitation users and committee members.

4.3. SAMPLING

In the woreda rural areas, five types of water and one common type of sanitary infrastructures are available. Namely,

1. Seventy-eight Spring at spot;
2. fifty Spring with gravity distribution;
3. Thirteen hand dug well fitted with hand pump;
4. More than 600 hand dug well fitted with rope pump;
5. Sixteen shallow well; and
6. Simple pit latrine, almost all households in 32 kebeles of the woreda

This study is based on four types of water technology and one sanitary scheme. Hand dug well fitted with rope pump had been omitted from public water potable service and more in use at house hold level for irrigation and domestic purpose, but rare for drinking.

4.3.1. Secondary Data Sample Size

A national level water schemes inventory was conducted in 2011. Functionality and non functionality were clearly indentified. Secondary data's were collected from Ministry of Water and Energy, Bureau of southern region, office of Gamo Gofa Zone and office of Chencha woreda.

During the inventory nine major type of water schemes were itemized. These are Hand dug wells fitted with Rope pump, Hand dug wells fitted with hand pump, Shallow wells fitted with hand pump, Deep wells with distribution, springs with distribution, River Intake with distribution, Dams with distribution and Spot springs.

In southern region a total of 16,354 water schemes were inventoried. In Gamo Gofa zone 1710 were recorded. In Chencha woreda 166 water schemes were inventoried. Furthermore in 2012 water schemes inventory was revised in southern nation. In this study 167 water schemes were registered in Chencha woreda. Hence my secondary data analyses were based on this 167 recorded water schemes in Chencha woreda.

4.3.2. Sample size for questionnaire

The sample size was formulated in two methods. First by using sample size operation formula and secondly by sample size online calculator.

Sample size calculating formula
Here are the formulas used in our Sample Size Calculator:
Sample Size

$$? = \frac{* \quad * (1 - \quad)}{}$$

Where:
Z = Z value (1.96 for 95% confidence level)

My confidence level corresponds to a Z-score. This is a constant value needed for this equation. Here are the z-scores for the most common confidence levels:

- 90% – Z Score = 1.645
- 95% – Z Score = 1.96
- 99% – Z Score = 2.326

p = percentage picking a choice, expressed as decimal
(.5 used for sample size needed)
c = confidence interval, expressed as decimal
(.04 = ±4)
Correction for Finite Population

í í = $\frac{}{1 + \frac{- 1}{}}$

Where: pop = population

(Creative Research system web page http://www.surveysystem.com/sample-size-formula.htm)

Second method is Sample size online calculator

This online sample size calculator is obtained from the following web address.
http://www.resolutionresearch.com/results-calculate.html

Final outputs in both techniques

Table 4 . 1 Questionnaire Sample Size

Total number of scheme in rural areas 2013	157
Confidence Level	99%
Confidence Interval	3%
Sample size	145 or more

- Hence the study utilized **148** water schemes for questionnaire analysis for the study.

4.3.3. Sample size for interviewing

Interviewing and focus group discussion was arranged in three group of population

1. Woreda water resources developments expert and professionals
2. Local government and other public sector representatives
3. Rural community water and sanitation user and committees

From the total sample 60% of interviewing participants were women and girls. From woreda water office 7 experts were interviewed in general water and sanitation schemes functionality and non functionality. From the second groups, local government and public sector representatives 12 people were randomly selected in three phases. From the third group rural community water and sanitation committees and water users 251people were interviewed at 49 schemes.

First, interviewee sample size was determined based on stratified on groups. At stage of round one from five scheme types, random sampled population was interviewed. The same method was also used for interviewing the second rounds. Finally, after recording of redundant data in the second and third round, the interview process were stopped. The following table 4.2 gives the detail for interviewing process.

Table 4 . 2 Interviewing Sample size

No	Focus group		Interviewing Process			Interviewed sample size
			Round one	Round Two	Round Three	
1	Woreda water resources developments expert and professionals		4	3	0	**7**
2	Local government and other public sector representatives		7	3	2	**12**
3	Rural community water users and committees members	HDW person(scheme)	25(4)	17(2)	0	**42**(6)
		SHW person(scheme)	30(6)	20(3)	0	**50**(9)
		SPRgd person(scheme)	22(7)	15(2)	5(2)	**42**(11)
		SPRspt person(scheme)	43(7)	20(3)	5(1)	**68**(11)
		SPL person(scheme)	20(8)	8(3)	2(1)	**30**(12)
	Total	person(scheme)	**151**(32)	**86**(13)	**14**(4)	**251**(49)

4.3.4. Sample size of Observation

Observation Sample size focused on four stages of water and sanitation project developments, namely

1. Projects in feasibility and design stage study
2. Projects under construction
3. Functional water projects and
4. Non functional water schemes

Observations started from office level. Feasibility study, design and different drawing were collected from woreda water office and woreda health office. Table **4.3** gives the detail for observation process.

Table 4 . 3 Observation sample size

No	Water and sanitation scheme	Observation sample size				Sub total
		Projects at feasibility and design stage	Projects under construction	Functional	Non functional	
1	Hand dug well			2	1	**3**
2	Shallow well	1	1	2	3	**7**
3	Spring with gravity distribution	1	2	4	3	**10**
4	Spring at spot	1	5	5	4	**15**
5	simple pit latrine	2	3	8	2	**15**
	Total	**5**	**10**	**22**	**13**	**50**

4.3.5. Sample size of Sanitary Observation for water schemes

Sanitary observation technique was directly taken from WHO predefined sanitary inspection of water schemes-adapted from WHO Guidelines for drinking-water quality (WHO, 1999)

Sanitary observation had been implemented on functional water schemes only. This allows investigation on the present and future water functionality based on quality of water schemes from the beneficiary perspective- attention or ignorance for non Health water schemes. Table 4.4 given the detail sample size for each water scheme.

Table 4 . 4 Sanitary Observation sample size

No	Water schemes	Sanitary observation sample size			Sub total
		round one	Round two	Round three	
1	Hand dug well	5	2	0	**7**
2	Shallow well	3	2	1	**6**
3	Spring with gravity distribution	7	4	2	**13**
4	Spring at spot	8	5	0	**13**
	Total	**23**	**13**	**3**	**39**

Table 4. 1 Observed Simple Pit Latrine Size during Sanitary inspection respect to Kebeles

No	Water schemes	Observed Kebeles Size For Simple pit Latrine	Observed Simple pit Latrine Size
1	Hand dug well	**5**	**60**
2	Shallow well	**5**	**80**
3	Spring with gravity distribution	**10**	**128**
4	Spring at spot	**12**	**184**
	Total	**32**	**452**

4.5. SECONDARY DATA AND COLLECTION METHODS

Ethiopia National and Regional WaSH inventory result in 2011, 2012 and 2013 is the primary source of secondary data. In the National inventory data non functional schemes and their causes of non functionality had been examined. However, in southern region such analysis reports have not been released. Among the reasons is inconsistency in data collection systems in most woreda.

Secondary data was collected from all levels of government-Federal, state, and woreda level in the period from the month of February up to April 2013. All secondary data was collected by the author. Below are the list of governmental and two NGOs where secondary data had been collected;

a) Ministry of water and Energy, Federal Republic of Ethiopia, Addis Ababa
b) SNNPRS Regional Bureau of water and Energy, from regional Capital city, Hawassa
c) Gamo Gofa Zone water and Energy office, ArbaMinch
d) Chencha woreda Water and Energy office, Chencha
e) Chencha woreda Health office, Chencha

f) Care Ethiopia, Addis Ababa
g) United nations children fund(UNICEF), Addis Ababa
h) Water aid, Addis Ababa

Secondary data have the following type and form.

- National and Regional WASH access for 2011, 2012 and 2013 biannual
- Number of water supply schemes on functional and non functional data
- Part I rural water supply UAP, December 2011
- Part II urban water supply universal access plan (UWSPUAP) 2011-2015
- Southern Nation Water Supply Access by Zone and woreda-Based on NWI(2011)

4.6. PRIMARY DATA COLLECTION METHOD AND PROCEDURE

Primary data was collected from December 2012 up to May 2013. During these periods water and sanitation projects were investigated at the stage of feasibility study, design, site selection, construction and at service stages.

Primary data was collected from all rural Kebeles of Chencha woreda in four different research operations. Chencha woreda has a total of 50 Kebeles. From the fifty kebeles forty five kebeles are rural and the rest five kebeles are urban.

4.7. QUESTIONNAIRE DATA COLLECTION METHODS

Questionnaire type and design system was taken from “Integrated Decision Support Tools for Rural Water supply based on Ethiopian Case-Studies” (Gebrie, 2012). Questionnaires were adapted to allow extraction of non functionality causes of water and sanitation schemes. Besides, collected questionnaire also provide inputs for further research related to water and sanitation in Chencha rural areas.

The questionnaires were collected by six experts from woreda water office. Short period brain storm training was given on the objective, contents, and methods of responding. The good luck was that the selected experts have had deep knowledge and skill for all water and sanitation activities in the woreda as they work on rotational basis across the kebeles. Furthermore the researcher re collected questionnaires for all non functional water schemes, to strengthen the findings.

Questionnaires were formulated to give the clear situation of functionality and non functionality of water and sanitation scheme in rural areas. The questionnaires categorized in eight basic groups. It was prepared on scheme based assessments. The sample population is from all walks of life-educated persons, water committee, illiterate person, male, female, students and for a person long life around the water and sanitation schemes. Detail questionnaire type and form was given in Appendix “A”.

The major parts of the questionnaire are:

§ General information of water schemes;
§ Design period and discharge of the source pre and after construction;
§ Functionality property throughout the design period;
§ Non functionality property and its causes of non functionality;
§ Management and finance activities;
§ Water quality and Environmental issues;
§ Gender involvement and participation; and
§ Institution set up

4.8. QUESTIONNAIRES FOR SCHEME SYSTEM COMPONENTS CAUSES ON NON FUNCTIONALITY ASSESSMENTS

System component causes for non functionality is constitutive based by part study of single schemes in system component parts. The failure of one component in large scheme results the whole scheme become non functional. The questionnaire data was formulated on system component based causes on non functionality.

There are three main aims and advantages for classification of non functionality causes in system component based strategies such as.

I. Easily investigating and detecting causes for non functionality and troubleshooting the problems in scientific methods.
II. Imposing and magnifying water system structural problem in design, construction and service phases due to each structure has its own design, construction and care taking methods.
III. To aware how to managing by part water system structures in accordance with their sensitivity toward failure.

System component causes of non functionality are classified in twelve major scheme components. The detail descriptions of system component causes of non functionality were given in Appendix F. These are

1. Spring capping
2. Spring box/wet box
3. Pipe line
4. Reservoir
5. Water points
6. Pumping system
7. Well structure
8. Construction Materials
9. Management/financial
10. Not enough water (Quantity)
11. Quality
12. Others

Non functionality causes have their own relationships among scheme system components. The above twelve causes of functionality verses scheme type is given in Table 4.5

Table 4 . 5 Relationship between non functionality causes and water supply scheme

No	Causes for non functionality	Water supply schemes types
1	Spring capping	SPRgd and SPRspt
2	Spring box/wet box	SPRgd and SPRspt
3	Pipe line	SPRgd
4	Reservoir	SPRgd
5	Water points	SPRgd
6	Pumping system	HDW AND SHW
7	Well structure	HDW AND SHW
8	Construction Materials	SPRgd, SPRspt, HDW AND SHW
9	Management/financial	SPRgd, SPRspt, HDW AND SHW
10	Not enough water	SPRgd, SPRspt, HDW AND SHW
11	Quality	SPRgd, SPRspt, HDW AND SHW
12	Others	SPRgd, SPRspt, HDW AND SHW

4.9. OBSERVATION DATA COLLECTION METHODS

Data were collected by the author in different Observational techniques. Observation was the major tool for extraction of non functionality causes of water and sanitation infrastructures. The detail assessment had been taken during observation process. It was implemented according to the following categorical criteria.

The following are the main observational methods for extracting non functionality cause for water and sanitation schemes in rural areas.

- Feasibility study of the projects
- Design of the schemes which is already in the woreda
- Location of the water and sanitation scheme.
- Settlement of the population,
- Water and sanitation project catchment area
- Capping structure of spring
- Studying the status of water and sanitation scheme.
- Studying the scheme contamination factors (drainage, latrine, etc)
- Community management system of the project and handling activities
- Observing surrounding spring protection work
- Investigate environmental protection activities
- Observing selected Water and sanitation schemes previously constructed
- Construction process if any under construction
- Strengthen the observation by taking picture and video

Observation category

To make observation systematic, water and sanitation schemes categorized in three main groups. It was based on structural similarity between the schemes (Appendix B).

A. Category one: spring at spot and spring with gravity distribution
B. Category two: Hand dug well and shallow well
C. Category three: Simple pit latrine

4.10. SANITARY OBSERVATION DATA COLLECTION METHODS

Sanitary observation was held by the author. Different sanitary inspection forms can be developed depending on the water system. A form was adapted to specific situations and contexts. The form was developed for the following five types of water schemes. This format shows water schemes are weather exposed or not for sanitary risk (Appendix C).

- Groundwater: open well, well/borehole with Handpump, well/borehole with motorized pump system
- Protected spring
- Roof rainwater harvesting
- Water trucking
- Piped supply

4.11. INTERVIEWING DATA COLLECTION METHODS

A total of thirty-two Interviewing questions and focus group discussion were arranged in three group of category by the author. Structured and standardized interviewing questions were prepared and interviewed. Interviewed questions were directed according to specific groups.
Interviewing and focus group discussion was arranged in three group of population size including;

A. Woreda water resources developments expert and professionals
B. Local government and other public sector representatives
C. Rural community water and sanitation user and committees

Interviewees were pre-sampled to make detail investigation during interviewing. Intensive and detail interview was conducted. The interviewing methods and structures are given below in Appendix D.

CHAPTER FIVE

5. DATA ANALYSIS RESULTS AND FINDINGS

5.1. GENERAL

Functionality of water and sanitation schemes could be sustained mainly by finding out causes of non functionality and solving major and minor problems associated with it. This chapter presents findings from primary and secondary data unfolding the actual causes of non functionality of the schemes. First secondary data have been analyzed and following the information from primary data were analyzed per scheme type.

5.2. FUNCTIONALITY AND NON FUNCTIONALITY FROM SECONDARY DATA

5.2.1. Water supply schemes secondary data analysis

Secondary data formulated based on water scheme inventory undertaken in 2011. Some updates were made at the FGD with woreda water resource office experts based on data at the woreda water bureau.

5.2.2. Functionality and Non Functionality in Southern Nation.

From the total of 16,354 water schemes 11,941 are functional and 4,413 water schemes are non functional. In SNNPR percent of functionality and non functionality is given in figure 5.1 below shows 27% schemes are non functional (Appendix E).

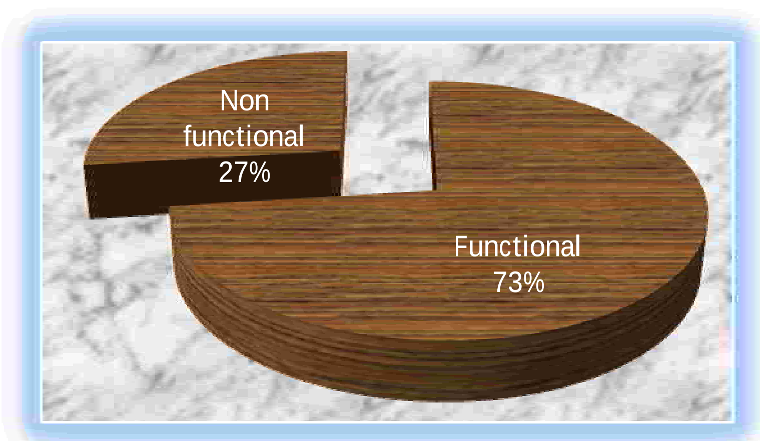


Figure 5. 1 SNNPR functional and non functional schemes rate

5.2.3. Non functionality rate per scheme type in Southern Nation

Rate of non functionality is different among schemes type. There are so many reasons for failure of water schemes before the design period and the non functionality rate per scheme type. Figure 5.2 shows rate of non functionality per scheme type.

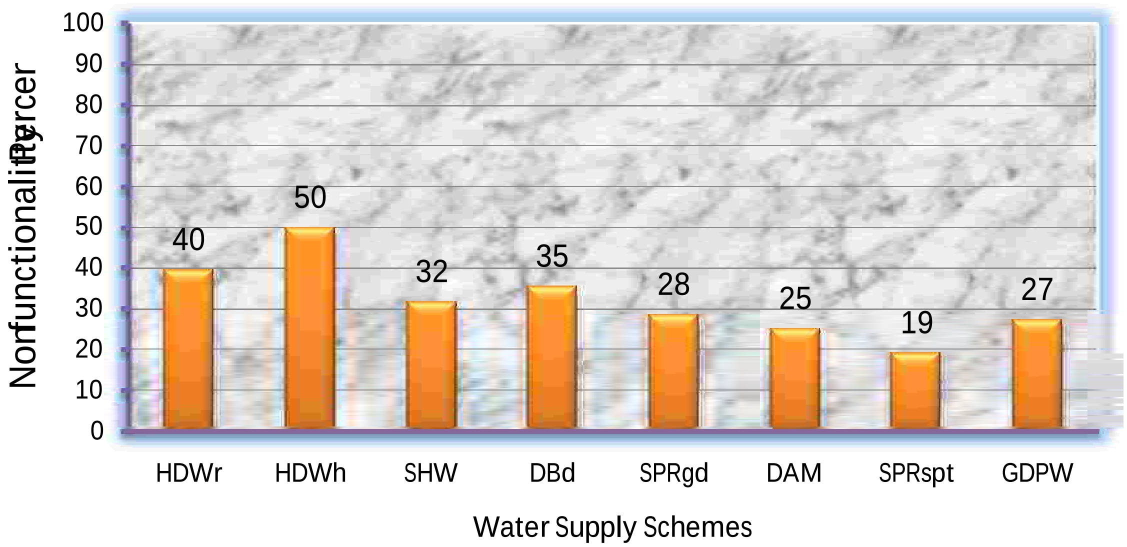


Figure 5. 2 SNNPR Non functionality percent in scheme type

5.2.4. Functionality and Non Functionality in Gamo Gofa Zone

Gamo Gofa zone water supply schemes were analyzed for functionality and rate for non functionality per schemes type. From the total of 1710 water schemes 1245 are functional and 465 water schemes are non functional (Appendix E). See figure 5.3 below.

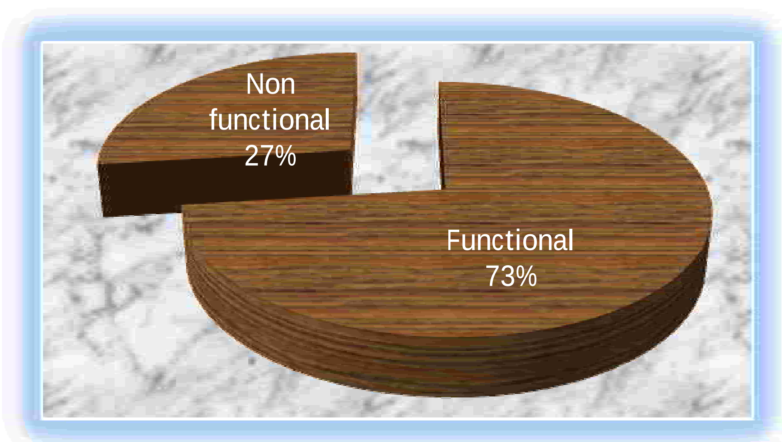


Figure 5. 3 Gamo Gofa Zone Functional and non functional schemes rate

5.2.5. Non functionality rate per scheme type in Gamo Gofa Zone

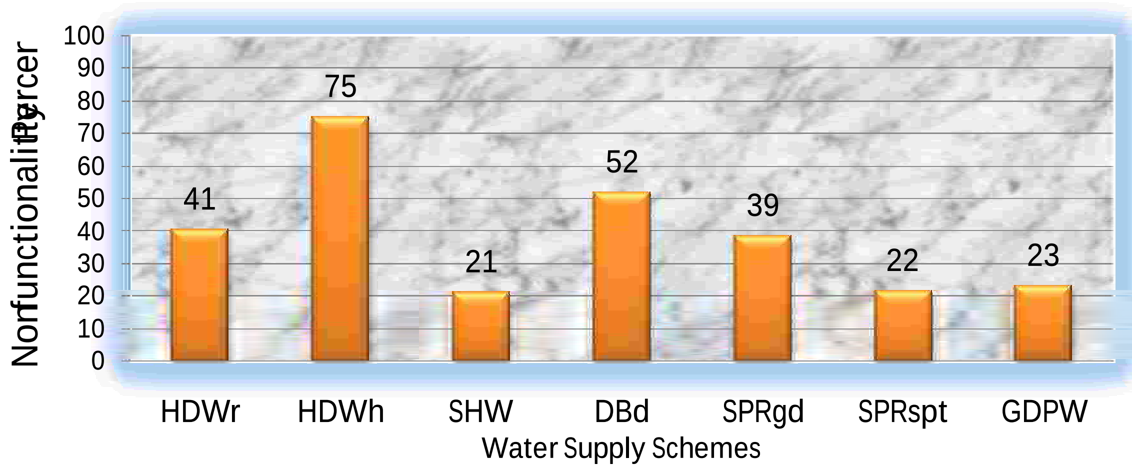


Figure 5. 4 Gamo Gofa Zone Non functionality percent in scheme type

5.2.6. Functionality and Non Functionality in Chencha Woreda

After collection of secondary, water supply schemes were analyzed for functionality and rate for non functionality per schemes type in Chencha Woreda. From the total of 166 water schemes 40 water schemes are non functional, which is 24% schemes are non functional (Appendix E).

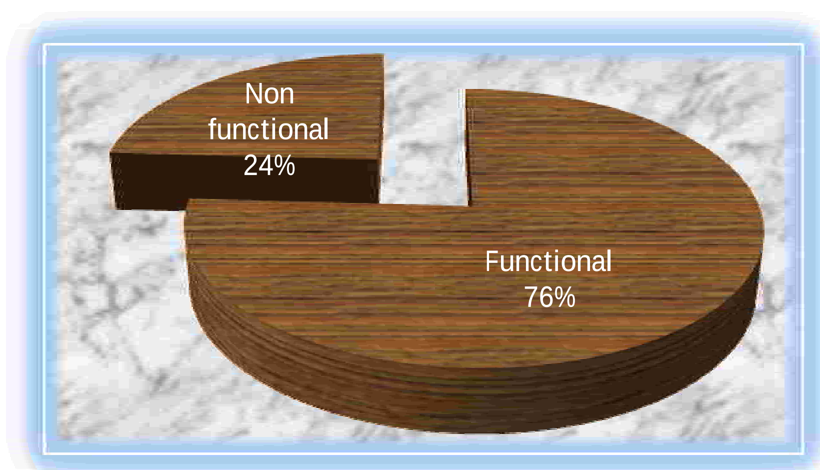


Figure 5. 5 Chencha Woreda Functional and non functional schemes rate

5.2.7. Non functionality rate per scheme type in Chencha Woreda

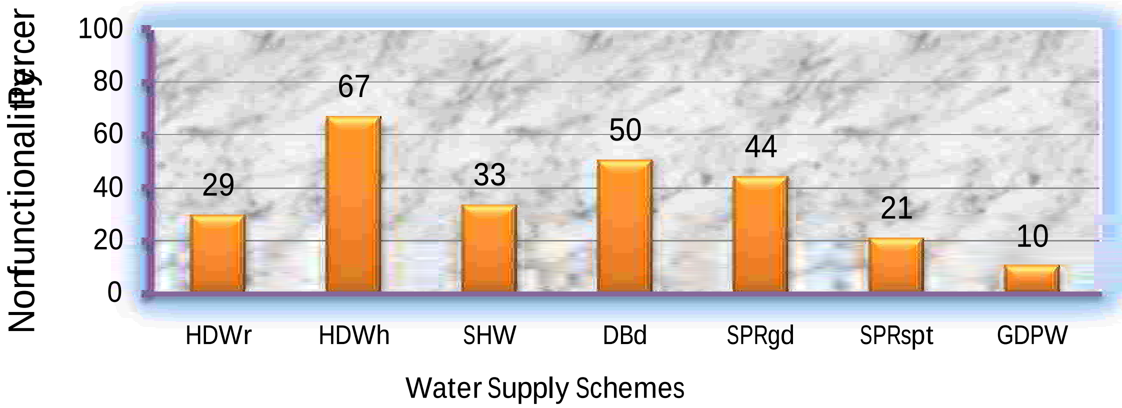


Figure 5. 6 Chencha Woreda Non functionality percent in scheme type

5.3. FUNCTIONALITY AND NON FUNCTIONALITY FROM PRIMARY DATA

5.3.1 Rural water supply schemes in Chencha Woreda

Regional water supply scheme inventory included both urban and rural water schemes. The research focused on water supply schemes on only in the woreda rural areas. From existing seven water schemes, only two water schemes namely deep borehole and public water tap exist in urban areas. The rest five water schemes are available in rural areas. The study focused on four water schemes category only. Hand pump fitted with rope pump is excluded. It is usually practiced for house hold level and rope pump technology mostly advised for irrigation system rather than for drinking.

5.3.2 Functionality and non functionality rate

The resulted from the questionnaires are presented in figure 5.7 below.

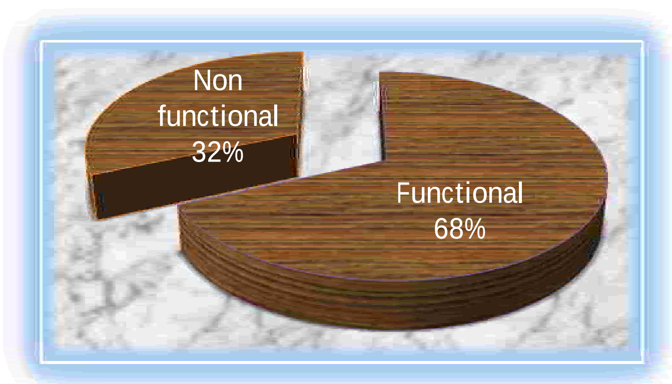


Figure 5. 7 Functional and non functional schemes rate

One easily sees that the non functional rate is higher for the woreda than any other level of government (federal or regional). That is 68 % of water schemes or 101 water schemes are functional and the rest 32 % or 47 water schemes are non functional currently in the woreda. The primary data result in figure 5.7

and regional level secondary data in figure 5.5 has a difference of 8 %. This difference could due to inventory problem and increment of non functionality rate after the inventory.

5.3.3. Non Functionality Rate per Scheme Category

Non functionality is one of the most reasons for decreasing pure water coverage in the woreda rural Kebeles. Non functionality rate differs among different scheme types. The following figure 5.8 shows non functionality rate per scheme type.

Table 5 . 1 Non functionality rate per scheme category

	Scheme Type	Total Water scheme in rural	Sample Size			
			Total	Functional	Nor Functional	Nor Functionality Percentage
1	Hand dug well	13	13	7.0	6.0	46
2	Shallow well	16	16	9.0	7.0	44
3	Springs with Gravity distribution	50	48	30.0	18.0	38
4	Springs at spot	78	71	55.0	16.0	23
	Total in rural	**157**	**148**	**101.0**	**47.0**	**32**
	Percentage (%)			**68**	**32**	

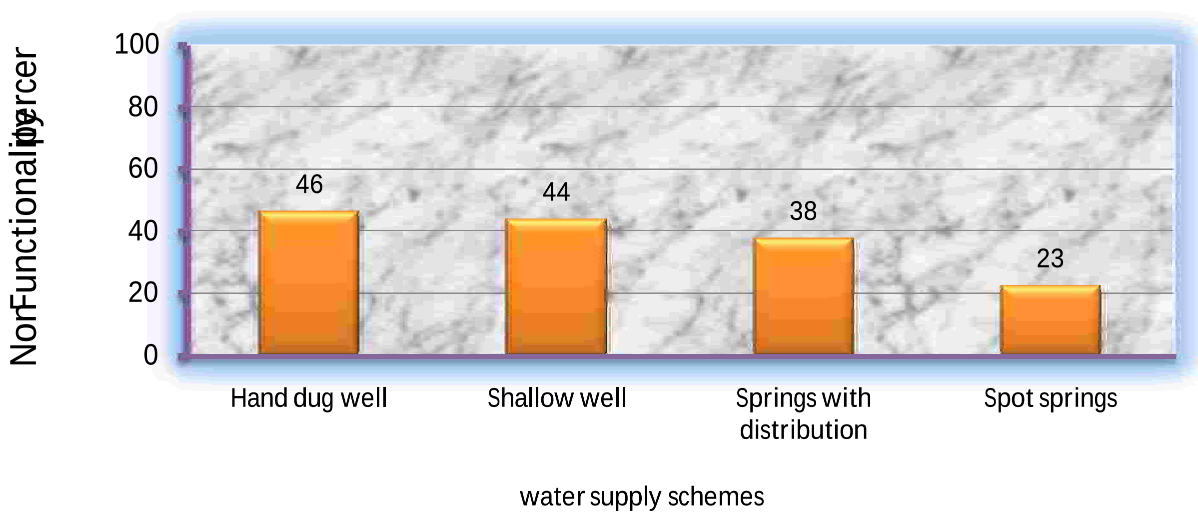


Figure 5. 8 Non functional rates per schemes type

5.4. ANALYSIS TO RATE OF NON FUNCTIONALITY CAUSES PER SCHEME TYPE

This sub-section presents finding on non functionality per scheme type in detail. Each water supply schemes have its specific causes for non functionality.

The analysis has been made against the major twelve causes of non functionality of water schemes over forty-seven non functional water schemes. Furthermore, these causes were weighed in each scheme type and their risk is rated in their order of significance - from high significant rate to very low significant rate.

5.4.1 General Causes Non Functionality Frequency Analysis

Based on the questionnaire research method mentioned on chapter four, system component causes of non functionality implemented and causes for failure of water schemes have been examined. The failure frequencies are given in percentage- scheme non functional causes due to rate of system components failure. Figure 5.9 below gives the five identified principal causes of non functionality. These are namely, from the highest to the lowest non functionality are:

1st twenty-five schemes became non functional due to spring capping failure, rated = 53%.
2nd twenty-three schemes causes of failure were management and finance problems, rated = 49%
3rd twenty-two schemes fronted poor quality of water causes of non functionality, rated = 47%
4th fifteen schemes have construction materials causes of failure, rated = 32%
5th fourteen schemes have poor yield (not enough water) causes of failure, rated = 30%

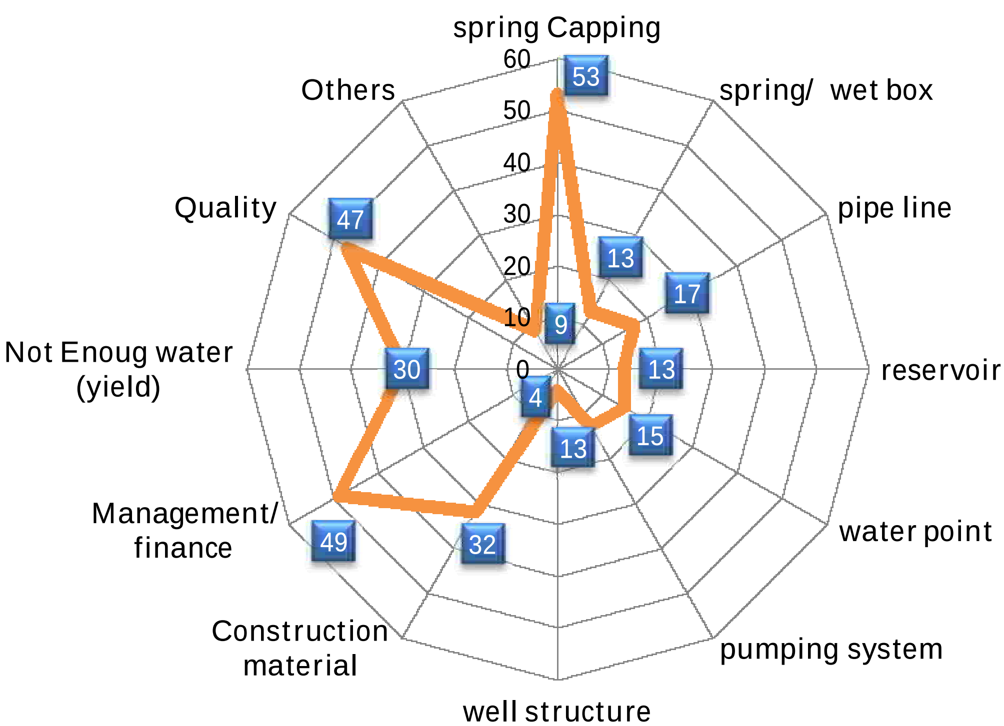


Figure 5. 9 Percentage of system component causes of non functionality in water schemes

5.4.2. Hand Dug Well Components Non Functionality Causes Frequency Analysis

Each water scheme has its specificity in explaining its failure. Here, the hand dug well causes are presented.

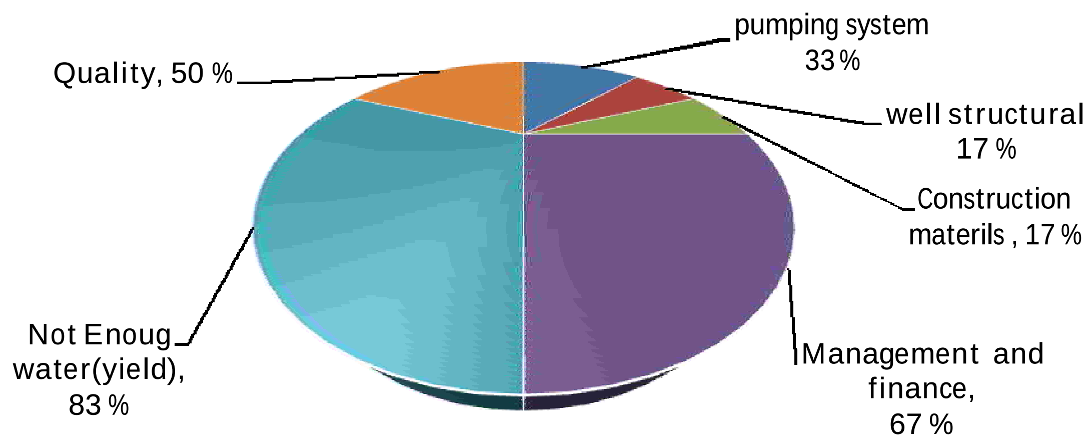


Figure 5. 10 Hand dug well components percentage rate of causes of non functionality

The above graph shows the main causes of failure in hand dug well:

I. Yield (not enough water) is the main causes for non functionality. It scored 83% in the above figure. It means from six non functional hand dug well five hand dug wells have had not enough water. In Chencha woreda ground water level is drops below 14 meters from ground level, in which hand dug wells become water free at in most dry seasons.

II. Management and finance (67%) problems is the second main problems. In other word out of six hand dug wells, four wells have management and financial problems.

III. Three hand dug wells have Poor quality water. It is the third most functionality problems; it is half or scored 50%. Most hand dug wells located in the village, where it exposed for sanitary risk due to on site sanitation in public simple pit latrines.

5.4.3. Shallow Well Components Non Functionality Causes Frequency Analysis

Shallow well characteristic for non functionality is not similar to that of hand dug well.

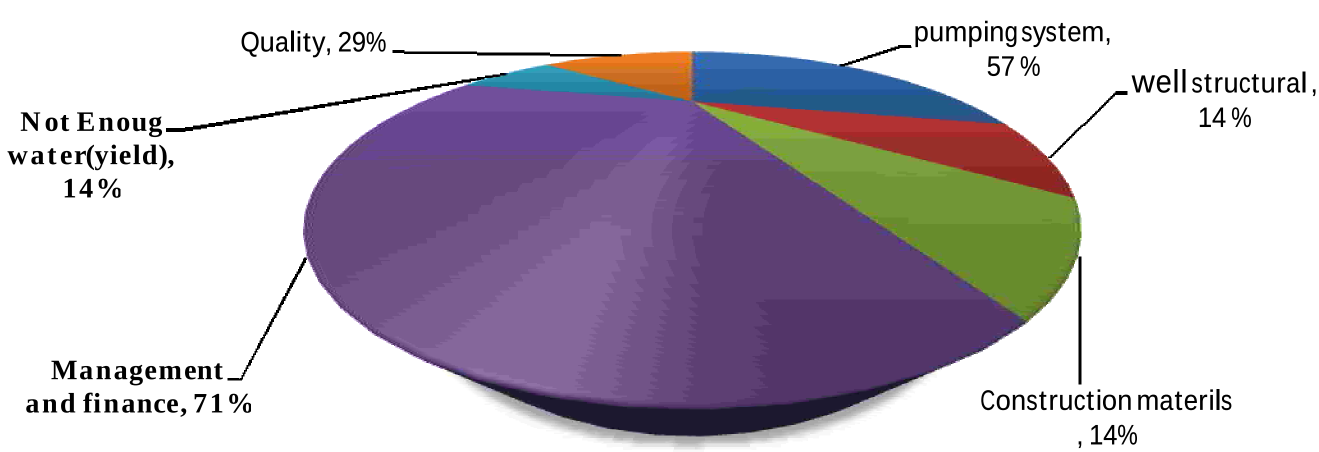


Figure 5. 11 Shallow well components percentage rate of causes of non functionality

As indicated in the graph above, the main problems for failure of shallow well are:

I. Management and finance problem is the main causes for non functionality. It scored **71%** or it means from seven non functional shallow wells five have the problem.
II. Four shallow wells have Pumping system causes on non functionality. It is the second main problem and rated **57%**.
III. Two shallow wells have poor quality causes on non functionality. It is the third cause of failure and rated 29%.

5.4.4. Spring with Gravity Distribution Non Functionality Causes Frequency Analysis

Spring with gravity distribution characteristic for non functionality is more or less similar to the above two. Figure 5.12 below gives the causes. .

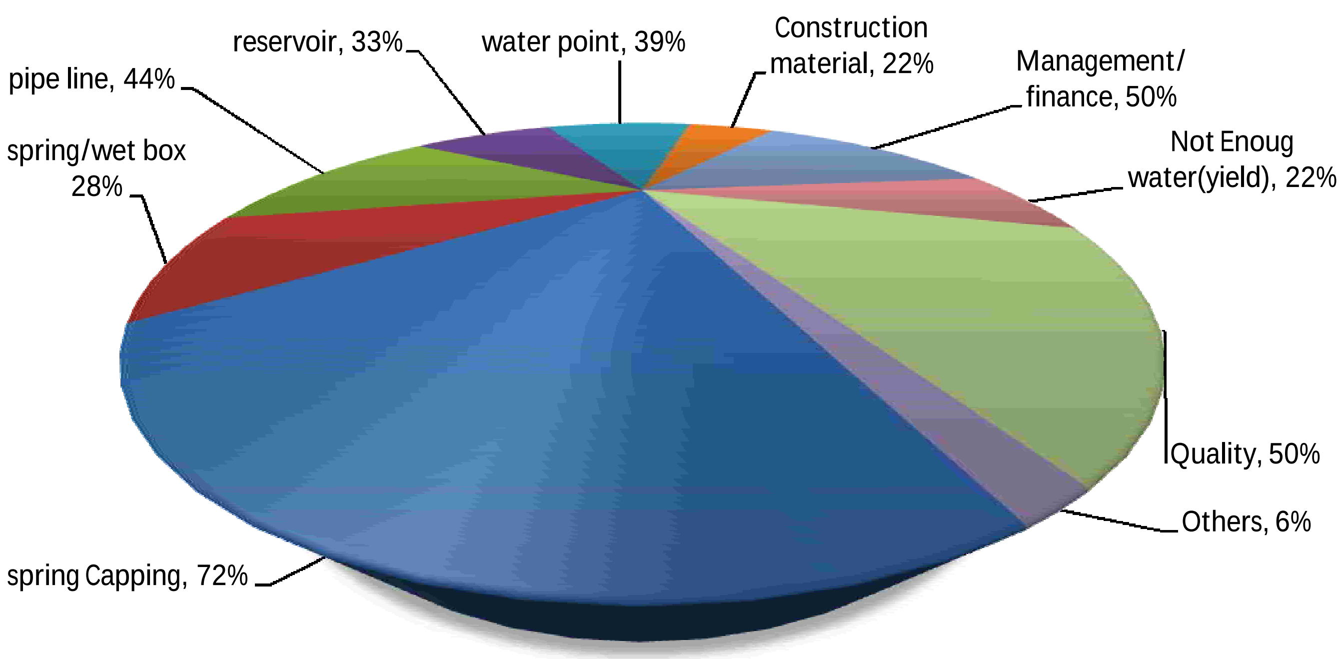


Figure 5. 12 Spring with gravity distribution components causes of non functionality rate

In the above graph, the main problems for failure are:

I. Spring capping failure is the primary causes for non functionality. It scored **72%** in the above figure. From eighteen non functional springs with gravity distribution thirteen schemes have had spring capping failure.
II. Poor Management, financial and quality recorded the same percentage and both equals to **50%** and recorded for the second major caused for non functionality. It means from eighteen non functional spring with gravity distribution nine schemes have had the problem.
III. Eight springs with gravity distribution schemes have Pipe line failure. It is the third common problem and rated **44** %

5.4.5. Spring at spot Non Functionality Causes Frequency Analysis

Spring at spot characteristic for non functionality is more or less similar to spring with gravity distribution.

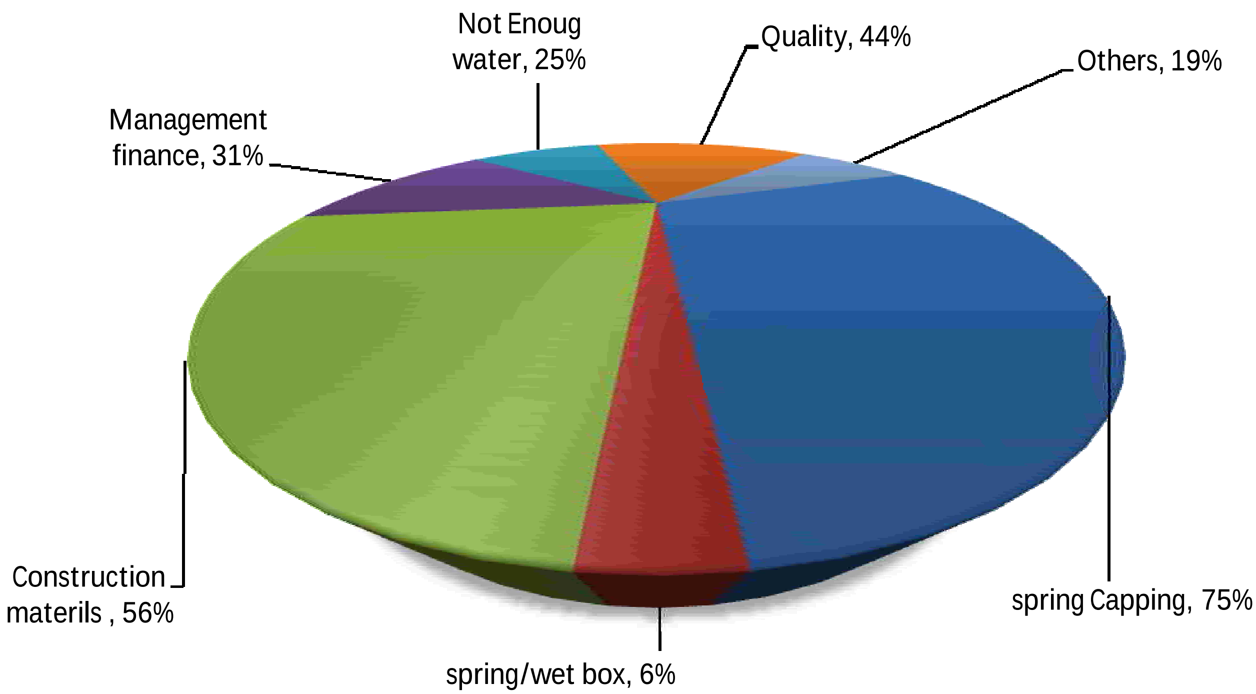


Figure 5. 13 Spring at spot components percentage rate of causes of non functionality

The findings as presented in figure 5.13above shows the main causes of failure. These are:

I. Spring capping failure is the primary causes for non functionality. It scored **75%** in the figure below. From sixteen non functional springs at spot, twelve schemes have had spring capping failure.

II. Nine springs at spot have constructed with Poor construction material. It is the second major causes non functionality and rated 56%.

III. Seven springs at spot have Poor quality of water. It is third common problem, rated **44** %.

5.4.6. Simple Pit Latrine Non Functionality Causes and Analysis

The most common practicing Latrine in Chencha woreda is simple and none lined types of simple pit latrines. To have the advantage of governmental health extensions policy in rural kebeles in the woreda all household should have pit latrine. Due to the result of the strategy and with strong devotion of respective experts, thirty-two kebeles graduated for completion of household level simple pit latrine in 2013.

Almost all household in each kebele have simple pit latrines. In 2012 eleven kebeles and up to April 2013 ten kebeles has been graduated in full completion of simple pit latrine. Up to the end of 2013 the rest thirteen kebele will be graduated. Graduated thirty-two kebeles almost all households have constructed pit latrine.

In general from 32 kebeles 452 simple latrines studied, that was constructed in the principle of changing from open defecation to household latrine. From the rest kebeles 27 simple pit latrines studied in randomization methods. In these 479 simple pit latrines has been studied. Studied household simple pit latrines could represents household latrines in the woreda. It is due to that similar results found from randomization sampling method and most simple latrines have similar construction method and materials used.

Construction materials

- All constructed pit latrines are simple and unlined pit latrine.
- Floor slab made of wood and/or bamboo.
- Well materials are wood, mud, straw, bamboo, and plastic.
- Roof material, corrugated iron sheet, straw, bamboo, and plastic cover.
- Holes uncovered or very wide.

Causes for non functionality related to simple pit latrine such as:

- **Privacy problems, Poor doors, unfit doors or no doors at all-** uncomfortable for male and female usage.
- **No ventilation-** bad small polluting the surroundings.
- **Pit visibility –** uncovered holes pit visible and give unintended services as a breeding ground for flies.
- **Materials-** wood part exposed for moisture easily decay.
- **Breading of insects-** insects makes them life time short **and hurts human.**
- **Poor cleanness-** rough wood floors make cleaning difficult.
- **Most pits filled with water-** constructed without examined ground water level.
- **Location-** most pits constructed in place that polluting ground water and nearby water schemes.

5.5 DESIGN PERIOD AND FUNCTIONALITY RELATIONSHIP

The questionnaire surveys conducted in 148 districts water schemes in the past 20 years, since 1986. In figure 5.14 from forty-seven non functional 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 six water schemes is seven years. From non functional water schemes six water schemes could only pass ten years on functioning after construction. The average non functionality period of schemes in Chencha woreda is between six and seven years.

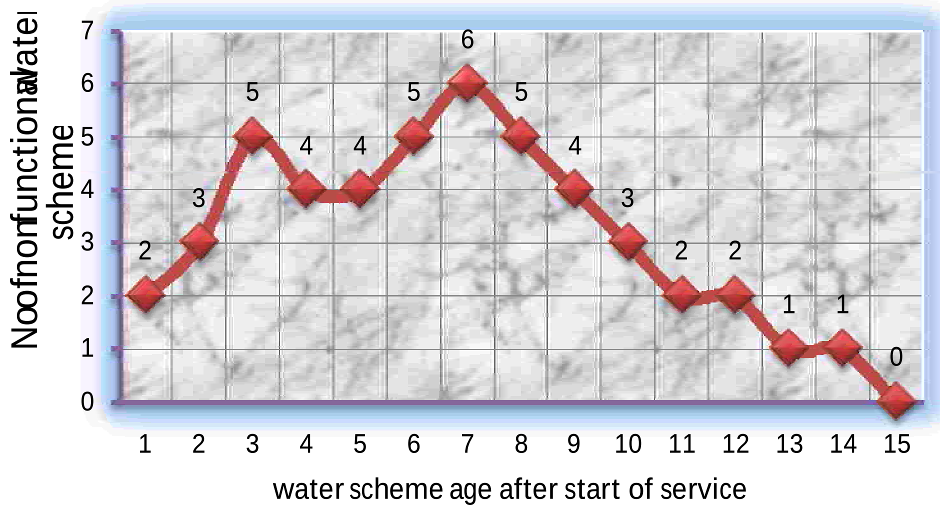


Figure 5. 14 Life age of water scheme after construction

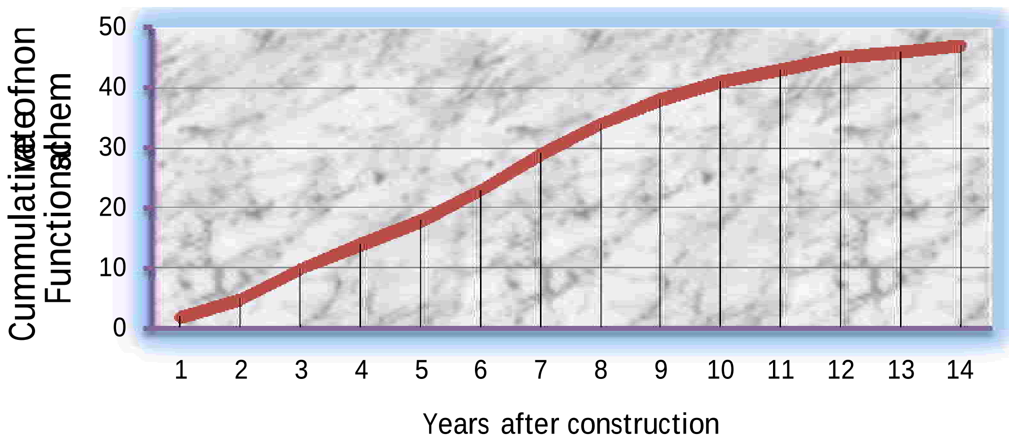


Figure 5. 15 Cumulative Non functionality and design period interrelation

The above chart shows that in the first five year, 18 water schemes failed. This shows that in Chencha woreda about 40% of non functional schemes fail within the first five years of construction. Non functionality increases thereafter. For example, by year 10 total of 41 water schemes became non functional. This is around 87 % of non functionality occurred within 10 years after construction.

Generally, most non functionality occurs much lesser than expected design periods. One third of water schemes fail lower than a minimum design period, which is 15 years (table 3.1)

5.6. INTERVIEW RESULT ANALYSIS FOR NON FUNCTIONALITY AND CAUSES FOR NON FUNCTIONALITY

After conducting and collecting relevant information from interviewing process, analysis for each focus group response has been done. The findings, arranged for the three group of population, are presented below following a brief overview of the woreda.

5.6.1. Woreda Water Resources Developments Expert and Professionals Interviewing Analysis

Chencha woreda water office experts had been interviewed and their responses had been analyzed. Causes of non functionality, according to these groups, are:

Design period of non functionality:-the average design period of non functionality is medium and ranges from six year up to ten years. Most non functionality, around 75% was recorded at indicated years since after the end of construction.

Water and Sanitation Technologies Available in Rural Areas:-A type of water technologies available in rural areas are spring at spot, hand dug well fitted with rope pump, hand dug well fitted with hand pump, shallow wells and spring with gravity distribution.

Technology selection:- hand dug wells were less likely selected by woreda water resources expert, it was rated less than 10%, by contrary spring at spot and spring with gravity distributions are the best alternative, it rated 32% and 33% respectively. This is mainly due to maintenance, quality and quantity of water the schemes.

The most common type of sanitary technology is simple pit latrine. Almost all rural people uses simple pit latrine. This is because of easy to construct and low or minimum investment cost required. Pit wall is not lined, so it is highly exposed for polluting the surrounding water sources

Status of Pure Water Service, Coverage and Accessibility:-Pure water service, coverage and accessibility are less satisfactory. Woreda water didn't satisfy the need of community. The location of pure water schemes are 1.5 to 3 kilometers far in most villages. Potable water coverage is only 19.5 % at recent time (SNNPR, 2011).

The main causes of non functionality for water schemes:-In most cases contractors don't cap the spring eye in full capacity and per scheme type design techniques. Spring capping fails shortly after few period of construction finished. That is, construction of spring eye is below the standard. This mainly due to low knowledge and skill gap of water projects contractors. In short, immediate failure of spring cap is the major reasons for non functionality for spring at spot and spring with gravity distribution.

Rural water institutional set up is the second most causes for non functionality. Water beneficiaries are not willing to pay for water. There is no user fee i.e., no minimum revenue collection to conduct basic maintenance. The unwilling to pay rate is high. They turn towards another option rather than paying for water. Alternative water source options are river, unprotected springs and unprotected household level dug wells. This water sources exposed the community for water bore diseases. Water related diseases are most common in the woreda.

Mostly hand dug well is exposed for sanitary problems. Hand dug well took the first place in this problem mainly due to its location and drainage anomalies. According to the woreda health office, 41% of diseases in the woreda are caused by water bore and water related diseases

Maintenance:-Woreda office water related experts' takes first operation and maintenance of water schemes. In principle, trained caretakers should operate and maintain minor problems. Training of water and sanitation committee is one of the most parts in projects implementation. Instead WATSAN committees manage and control all the activities. This is due to reasons such as training gap, mobility of residents, and displacement of trained committee. There is very minimal and insignificant rehabilitation activities observed.

Executants' organ for construction and supervising of water projects:-Minimum level experienced contractors take the first place for constructing water and sanitation infrastructures. Contractors may have the skill to build, but most time these contractors have knowledge gap. Most of them were not educated. They build only by acquired skill which results in short life span for the scheme.

At time of the study Chencha woreda water office have no water engineer. Projects have not been supervised. There is also a big gap for feasibility and design of water and sanitation projects. One project design is used to be implemented three to four projects in the woreda. In most cases the feasibility study is not conducted.

Budget allocation for water projects:-Nongovernmental organizations (NGOs) are the major sources for budget to water and sanitation projects. More than 90% water and sanitation projects have been executed by NGOs. The government part is limited for constructing spring at spot. Sadly, most nonfunctional schemes are waiting for NGOs supports for resuscitation.

Gender participation:-Low gender involvements are observed at all levels. For example, more than half committee members are men. Women and girls mostly tied with fetching water and house chores.

5.6.2. Local Government and Other Public Sector Representatives

This sub section presents findings from the woreda local governmental office experts.

Potable water coverage and accessibility:-Potable water service, coverage and accessibility are less satisfactory. Woreda pure water sources didn't satisfy the need of community. The availability of water is conditional. In dry seasons, frequent water shortage occurs in the woreda - almost for 45% of the population. That is, it is not uncommon to see people searching of pure water in these seasons. The seasons ran from December up to March.

Attention and budget allocation given for water sectors comparing with other sectors:-Water resources development office has given high attention like other offices in the woreda. Woreda budget and benefits equally distributed among all office. Unpacking it reveals the aforementioned problem. The allocated budget up to 20,000 birr is not even enough to construct single water scheme. Out of this, administrative cost share is 85%. Hence, very few maintenance activities have been implementing by woreda water office level.

Design period of non functionality:-the average design period of non functionality is medium and ranges from six year up to ten years. Most non functionality was recorded at indicated years since after the end of construction. Its rate of non functionality is 84% between the medium class intervals.

Disease related to potable water:-Diseases related to potable water are high in the woreda. Most are water bore and water related diseases. Some water schemes had been closed due to sanitation problems or ignored by the community. The evidence from woreda health office shows 41 % disease is caused by water borne and water related diseases.

5.6.3. Rural community beneficiaries and water and sanitation committees

The following are the main findings inquired from Chencha Rural community and water and sanitation committee's members in interviewing.

The main causes of non functionality for water schemes:-spring capping failure is the most common type of causes for non functionality. In most cases contractors don't cap the spring eye in full capacity and per scheme type design techniques. Spring capping fails shortly after few period of construction finished. That is, construction of spring eye is below the standard. This mainly due to low knowledge and skill gap of water projects contractors. In short, immediate failure of spring cap is the major reasons for non functionality for spring at spot and spring with gravity distribution.

Technology selection: - hand dug wells were less likely selected by rural community water users and committee members, it was rated less than 12%, by contrary spring with gravity distribution was selected the best water supply technology and rated 68% of the total water schemes.

Kebele level pure water service, coverage and accessibility:-Potable water service, coverage and accessibility are less satisfactory. Rural Kebeles pure water sources didn't satisfy the need of community. There is an average of 2 to 3 kilometers traveling to location of water sources especially in dry seasons which logically lesson in summer seasons.

Design period of non functionality:-the average design period of non functionality is at short and medium ranges from three year up to ten years. From this 40% was recorded in three to five years interval and 46% was recorded in medium class between six year up to ten years.

Water committee activity and participation:-Water committee activity is very low. Only 25 % WATSAN committees are active during the first one and two years of the project constructed or only active if the water scheme is functional. If the water scheme is non function, they stop their activities.

Water revenue and tariff collection system:-Water revenue return and tariff collection is only active for sometimes only. There is no a continuity in tariff collection in most Kebeles. Even when collected, the sum collected is very limited. For example, the average monthly charge in newly constructed water schemes is less than 50 cents. So the communities are not willing or use to user fees.

Community participation for water and sanitation activities:-Community participation in water and sanitation activities is very low. Rural water schemes are not well protected. Environmentally water schemes are not in safe way. A lot of them have no fence around them.

5.7. OBSERVATIONAL DATA ANALYSIS FOR CAUSES FOR NON UNCTIONALITY

Collected observational data have been analyzed in different techniques. Observation was the center of extraction of causes of non functionality of water and sanitation infrastructures. The detail assessment had been taken during observation process. The finds are presented as follows.

5.7.1. Spring at Spot and spring with Gravity Distribution.

I. Spring Capping:

Twenty-five capped springs have been investigated in detail. The following are the main issues for non functionality and failure of water schemes before the design period.

- **Design: -** most designs of spring capping are similar and copied from one to another. Most water supply structural designs are prepared at regional level or zonal level and disseminate to woredas. This designs lacks basic engineering and social parameters(soil type, earthquake, wind load, social , cultural and etc)

- **Spring catchment and surrounding area:-**spring catchment area was not well protected. Most capping structures exposed for animal and human spoiling agents. No protecting fence around the spring. Drainage canal was not constructed. Flooding and rain water enter through the capping. In general most capping areas have been poorly handled. The spring source is easily contaminated and it could be causes for waterborne and water related diseases.

- **Environmental protection activities:-**From the investigated twenty-five capping structures more than half have no environmental protection activities**.** Ground water recharging areas have been highly affected by deforestation and over grazing. Water sources around the community have faced a problem of contamination by simple pit latrine excavated with a radius less than a minimum of 30 meters (RWSHP 2007).

- **Spring eye:-**in most capped springs, the spring eye was not correctly capped. Excess water is flowing around the capping structure. This is the main causes for decreasing discharge of spring after construction. In some capping the sources completely disappeared. Constructing capping structure depends on a type of spring. Artesian spring capping is not similar to free flowing spring eye. But what was observed shows that incorrect spring capping has been done in some places (PSU 2007).

- **Undermining and piping:-**Most spring capping structures tampered by undermining and piping problems. The water is freely flowing under the foundation of capping walls. In some places during the rehabilitation process, they tried to block the piping of water though the foundation. But seepage and leakage has been observed. For example, in cases of two specifically observed capping, springs water is fully flowing under the bed, without capped.

Figure 5. 16 Completely failed spring cap in Doko Shaye keble

In figure 5.15 above shows the spring cap constructed on permeable base. Capping efficiency totally lost due to piping and undermining, leakage through the capping structure, improper pipe setup system and other directly related to capping structure, improper pipe installation system (inlet and outlet) and capping structure construction problems. The structure was constructed on permeable foundation.

Figure 5. 17 Non functional spring cap and failed spring box in Ezo Otte

Figure 5.16 distinctly shows almost all spring water is passing through the foundation. No water was capped. The pictures also shows spring area was not well protected and fenced.

§ **Pipes (outlet, drainage and overflow):-**It is found that emerging point of spring eye head is lower than outlet pipes. Some spring capping constructed with wrong head positioning alignment with relative to outlet and overflow pipes setup. This is the primary causes for elimination of spring eye. Backwater pressure destroys the emerging point of spring eye. Wrong Installation of pipes was also detected.

- **Quality of capping structure: -** Almost all spring capping has not been washed and cleaned since constructed. Drainage pipe is not working in most cases. It is also observed that micro organism developed in capping structures. Moreover, some aquatic insects developed and comfortably inhabit there.

II. Pipe line

- **Trench excavation and back fill:-**Most pressure and distribution pipes exposed and lie down on ground surface. The default soft soil excavation standard 80cm depth and 60cm width (0.8x0.6 cm) were not carried out in most pipe alignments. Due to depleted trench excavation and installation of pipes under the required depth; pipes were broken, cracked, out of use and water supply system was stopped.

  In newly installed pipe lines backfills were not compacted correctly. In some places erosion have been destroying backfills.

- **Valves and fittings: -** There is rampant miss fitting of valves. Air release valve should be installed along the line for release of air from the pipeline during the filling process and to prevent the development of a vacuum. Washout valves were not installed in lower place to remove accumulated sediments. Pressure relief valves were not installed at the point of high pressure pipe line direction.

- **Bending and joints and Anchor blocks:-**Improper bending has been detected. Anchor blocks were not installed where pipe line crossing the barriers.

- **Break pressure tank:-**These are structures where the hydrostatic pressure of water is allowed to drop to zero. It therefore acts as a break in the buildup of hydrostatic pressure. Four gravity distribution pipe lines need to construct break pressure tank. Due to the neglected break pressure tank, eight water points continuously happens faucet breaking.

III. Reservoir, water points, spring box (wet reservoir) and valve chambers

- **Design work**: **-** similar designs implemented in different location. Not considering soil type, temperature, humidity, and other engineering parameters.

- **Foundation work:-**One reservoir, three wet box (collection chamber) and one two water point foundation structure is under unstable condition. One collection chamber is sliding down and out of service now. Stability of hydraulic structures is underrated.

- **Construction materials:-**Cement sand and gravel are the main construction materials. Most hydraulic structures constructed from poor quality sand. In Chencha woreda “Kulfo” River sand is the main construction materials for water schemes and any other constructions. This is one of the causes for non functionality of water structures in the woreda. “Kulfo” river sand is highly mixed with silt and humus. The study examined that hydraulic structures constructed from Kulfo river sand have encountered with cracks and leakage.

Figure 5.18 below shows how poor design and construction malfunction water supply structures like, water points, wet wells, reservoir and pine line systems.

A. Non functional reservoirs in Losha and Ginko kebele

B. Non functional water points in Woro and Gule kebele

C. Non functional wet well in Gendo and non functional pipe line Woro kebele

Figure 5. 18 Non functional Water supply system components

5.7.2. Hand dug well and shallow well.

I. Well and well areas

- **Well design: -** predetermined designs were implemented. Designs were not validated based on economical, social, environmental and technical aspect of views.

- **Well catchment area and surroundings:-**Water well surrounding areas were not substantially protected. Water well areas revealed for animal and human spoiling agents. More than 80% of observed schemes have no protecting fence around the well. Drainage canal was not constructed. Flooding and rain water easily influence the water well. In general most water well areas have poorly handled. Water well is easily contaminated and it could be causes for water born and water related diseases.

- **Environmental protection activities:-**Majority water wells surroundings have no or minimum environmental protection activities**.** Ground water recharging areas have been highly affected by deforestation and over grazing. Water sources around the community have faced a problem of contamination by simple pit latrine excavated with a radius less than a minimum of 30 meters.

Figure 5. 19 Hand dug well exposed for contamination in kale kebele

Hand dug well in figure 5.19 is non functional. This water scheme has been endangered for weak management system and Poor water source quality. The main reasons are stagnant water observed; house hold latrine interface within 30 meter distance; unclean surroundings; passive management and institutional set up observed.

- **Availability of water in the well:-**The average depth of hand dugs wells in the woreda is 10m. It ranges from 6m to 14m depth in different locations. Most hand dug wells have water free at the time of observation. Most of them became dry at summer seasons and regenerate at winter seasons. Fall of ground water level during summer seasons is the cause of minimum or no yield of water in the wells. But the influence of fall of ground water level didn’t minimize yield of shallow wells.

II. Well construction

- § **Gravel packing:-**the research identified that volume gravel packing materials inserted to the casing pipe had not been measured. Filling of gravel is stopped while it reaches to the surface level. This was wrong estimation. If there is any blockage throughout the well casing, it revealed for gaps and so it causes unfiltered water flowing into the well.

- § **Well developments:-**Unclear water observed from some shallow wells. This may be the indicator of not fully developed water wells where the sands and debris were not completely removed after construction. Clay and silt introduced during the drilling process as well as the finer part of the aquifer directly around the well screen should be removed from the well by acting well developments. In complete well developments results burn of pump impeller.

- § **Grouting:-**Some smalls and tests of shallow wells water is may probably due to poor grouting. Due to unconsolidated grouting of the most top part of the borehole, surface water easily joins ground water and results poor quality of well water.

III. Pump and head work

- § **Pump type: -** It is observed that Afredive hand pump are preferred than Indian mark II and III. They reason out that the former type is easily operate and maintained.

- § **Spar part supply chain: -** No spare part supply chain availability in the woreda and/or nearby cities. Every single piece of spare parts has to be purchased from Addis Ababa. Corollary, high cost of spare part and long time to maintain the broken parts is observed almost everywhere.

The main failure detected in figure 5.20 below are poor maintenance and operation, passive acting of water and sanitation committee, weak revenue collection method, and poor institutional set up, lack of gender involvement, insufficient equipment, absence of spare parts and poor water quality are recorded.

Figure 5. 20 Non functional shallow well in Doko Shaye kebele

5.7.3. Improved Pit Latrine and Simple Pit Latrine.

- **Improved Pit Latrine:-**In community level, there is no improved pit latrine at all. Improved pit latrine is only exists in rural institutional compound such as schools, Health center administrative offices. Hence improved pit latrine was excluded in this study.

- **Simple Pit Latrines: -** In rural areas of the woreda simple pit latrine is common. All are simple pit latrine and made of the same materials, the majority of the latrines have a wood slab and mud floor. The super structure was built from wood and some local materials. The wall was filled with straw and other local products. Pit wall is not lined and simply excavated. Simple pit latrines are considered to be an improved sanitation technology because they are private and hygienically separate human excreta from human contact.

- **Problems with Village Sanitation: -** The two problems with simple latrines are that the latrine floor is broken or the latrine pit is full. This is due to the materials used in construction- mud and wood floor that can easily deteriorate from the eroding action of water, weather, and general use, attack by termites, or rotting of the wood. The pit can spoil ground water in high probability. Water sources in the diameter less than 30m are infected by this simple pit latrine. Especially the water sources located downstream of the pit are highly influenced without doubt.

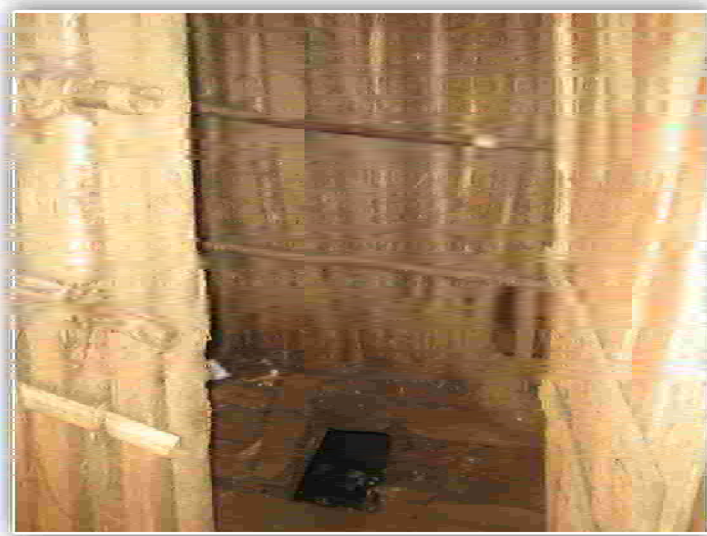


Figure 5. 21 Simple pit latrine filled with water

In figure 5.21 above, house hold level simple pit has high risk causes for non functionality. The pit was filled with ground water, smell and bad odour, uncovered, unclean slab, poor ventilation, urine spoiling over the slab and well and floor finishing materials roughness and exposed for breading of insects.

5.8. WATER SCHEMES SANITARY INSPECTION

Sanitary inspection for functional water schemes has been found out. Based on WHO guide line sanitation risk for rural water supply schemes has been indentified for selected functional water schemes. WHO format examines water scheme risk in percentage. That is water schemes with percentage of risk greater than or equal to 50 % falls under sanitary problem (Appendix C).

5.8.1. Hand Dug Well Sanitary Inspection

Seven functional hand dug well have been examined, whether they have sanitary problems or not. Hand dug well was evaluated using WHO standard ten risk identifying questions and the following are found.

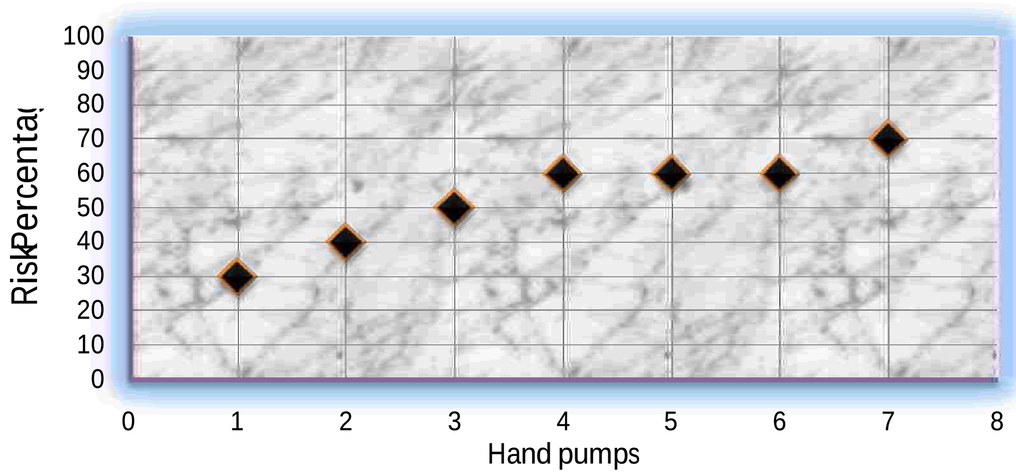


Figure 5. 22 Hand pumps sanitary risk percentage

The above graph shows that five hand pumps are under sanitary risk. Their percentage of risk is greater than 50%. Hence, in the woreda 71% hand dug well are exposed for sanitary risk.

5.8.2. Shallow Well Sanitary Inspection

Six shallow wells have been examined using WHO sanitary inspections. The figure below shows that two shallow wells are under sanitary risk. Shallow wells average percentage of risk is less than 50%. Its cumulative percentage is risk is 33%. Hence shallow wells are not having sanitary risk problems.

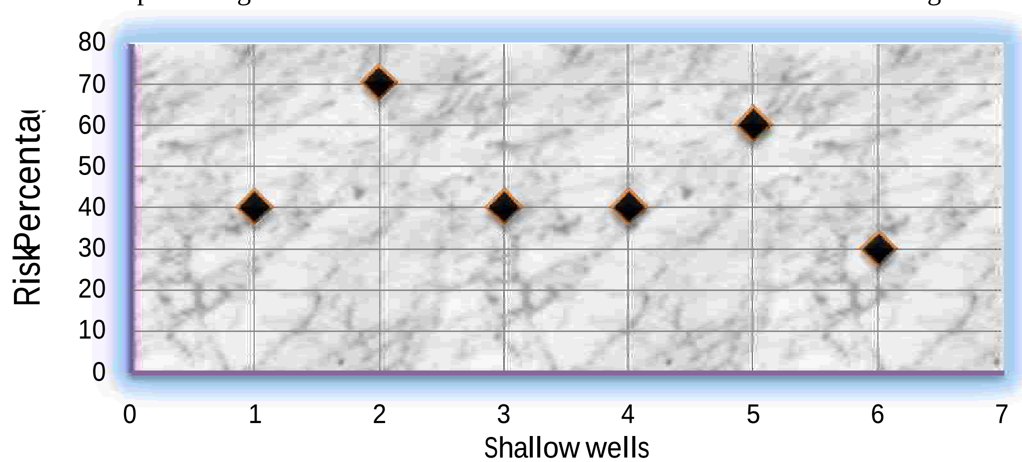


Figure 5. 23 Shallow wells sanitary risk percentage

5.8.3. Spring with gravity distribution Sanitary Inspection

Thirteen springs with gravity distribution have been examined, whether they have sanitary problems or not. According to the assessment executed the following findings have been formulated.

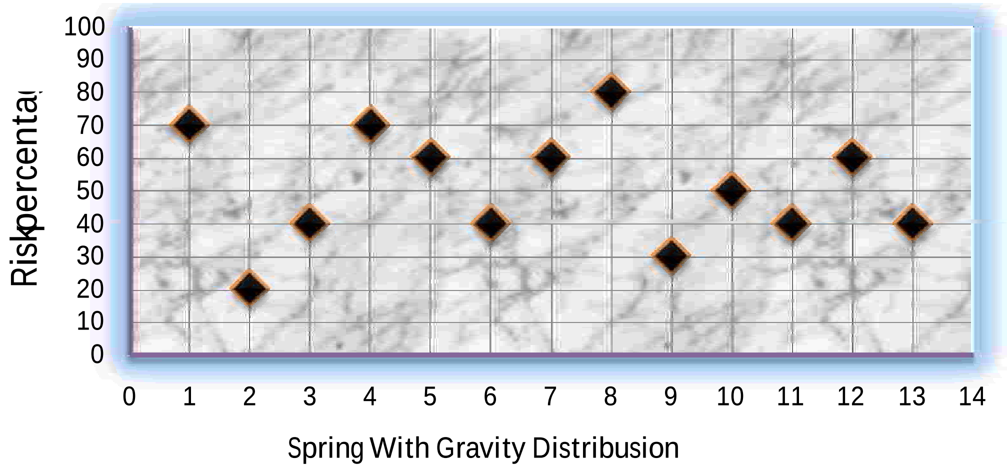


Figure 5. 24 Spring with gravity distribution sanitary risk percentage

The above graph shows that seven springs with gravity distribution are under sanitary risk. Spring with gravity distribution average percentage of risk is greater than 50%. Its cumulative percentage is risk is 54%. Hence springs with gravity distributions have sanitary risk problems.

5.8.4. Spring at spot sanitary inspection

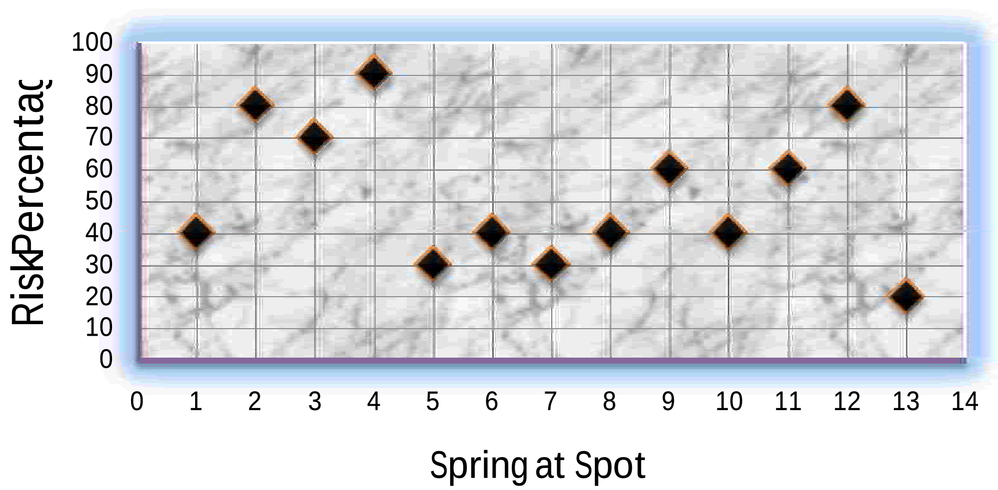


Figure 5. 25 Spring at spot sanitary risk percentage

In the above thirteen springs at spot average percentage of risk is less than 50%. Its cumulative percentage is risk is 46%. Hence springs at spot have low sanitary risk problems.

5.8.5. General Analysis of Water Schemes Relative Sanitary Inspection

In general water schemes in Chencha woreda have sanitary problems. The percentage of sanitary risk varies among the schemes. From the four water schemes, hand dug wells are highly exposed for sanitary problems and shallow wells having no sanitary risk. The following graph shows the differences among each water schemes.

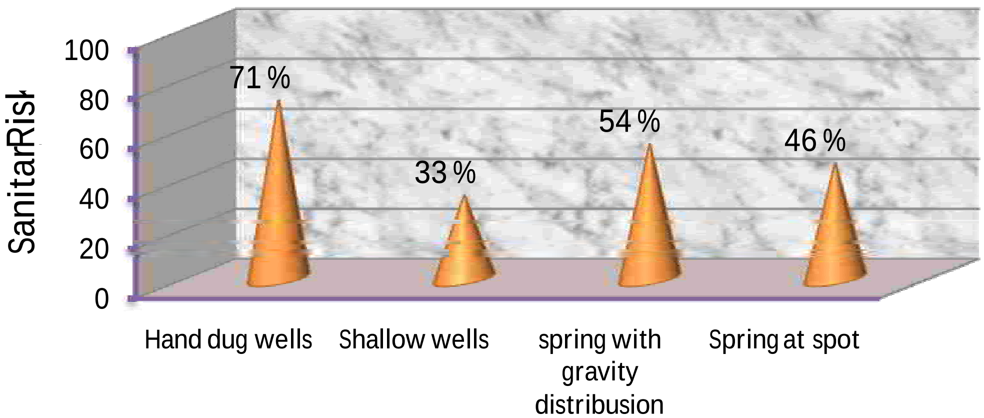


Figure 5. 26 General Relative Analysis of sanitary risk percentage for four Water schemes

5.9. 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 70% construction costs of schemes have known. The rest 30% 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 148 water supply schemes is 12,272,095 Ethiopian birr. From the total, non functional water schemes costs 4,788,164 birr. Capital cost lost due to non functionality is directly and indirectly affect local and national economy of the country.

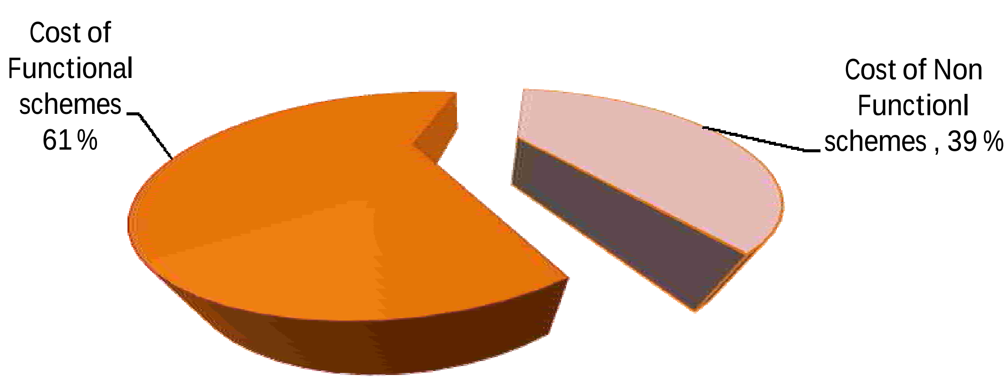
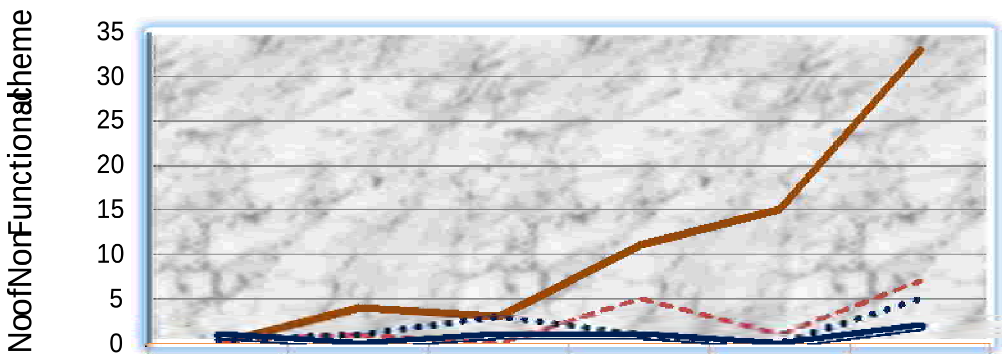


Figure 5. 27 water scheme cost and non functionality

Furthermore, there is no project cost recovery trend in rural water and sanitation projects. Generally there is no community and local budget cost contribution activity in the woreda. There are some separate institutions which are costing for rehabilitation of water and sanitation schemes. 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.

5.10. WATER SCHEMES TARIFF AND NON FUNCTIONALITY

Water scheme tariff setting and continuous tariff paying has direct impact on functionality of the water schemes. The present trend tariff setting for rural water schemes are not based on scientific method. A regular and actual tariff paying decreases non functionality.



	Tariff/Month	HDW	SHW	SPRgd	SPRspt	No of schemes
Zero Birr	0	4	3	11	15	33
0.25 Birr	0.25	1	0	5	1	7
0.50 Birr	0.5	1	3	1	0	5
1.0 Birr	1	0	1	1	0	2

Figure 5. 28 Non functional water schemes and tariff

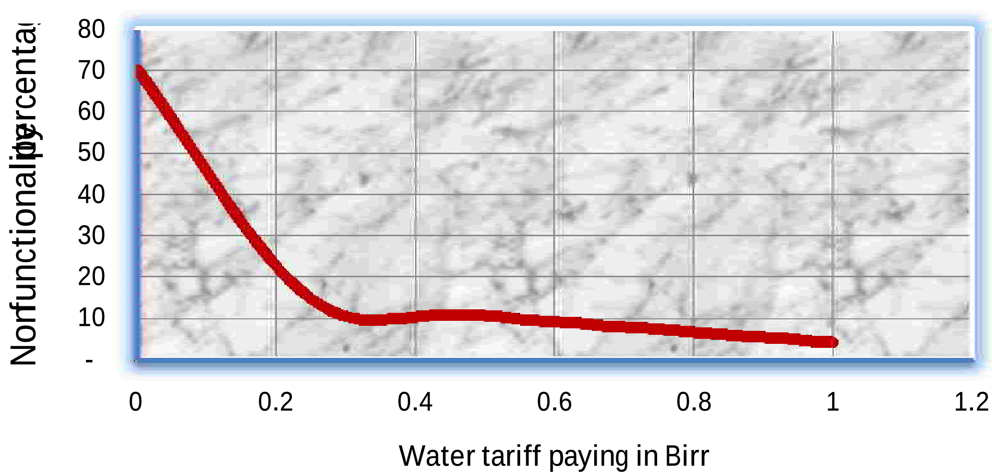


Figure 5. 29 Percentage of non functional decreases with water schemes tariff paying

Non functionality is inversely related to tariff paying of water scheme. Non functionality is decreasing with scheme tariff paying. Figure 5.29 shows the inversely proportionality of non functionality rate respect to tariff paying.

Figure 5.28 shows highest rate of non functionality was recorded for non tariff paying scheme. Out of 47 non functional schemes 33 water schemes have had none tariff paid schemes. Spring at spot recorded the highest non tariff paying scheme.

Generally set scheme tariffs couldn't afford maintenance and repairing cost of non functional schemes. Even, there is no guaranty for sustain functional water schemes. Furthermore there is no trend of measuring and selling water in M3/birr. There is no water tariff setting per scheme production and amount water.

5.11. WOMEN AND GIRLS PARTICIPATION AND NON FUNCTIONALITY

Women and girls involvement in committee member and water projects implementation has high impact on functional sustainability of water schemes. Water schemes with in women and girls participation recorded in less non functionality.

In most case water committees are seven in number. The study was based on the involvement of women and girls in decision position and committee member. In the woreda high rate of non functionality was recorded for water schemes which have very low participation of women and girls. Less non functionality recorded for the involvement of girls greater than 50% in committee member and decision position.

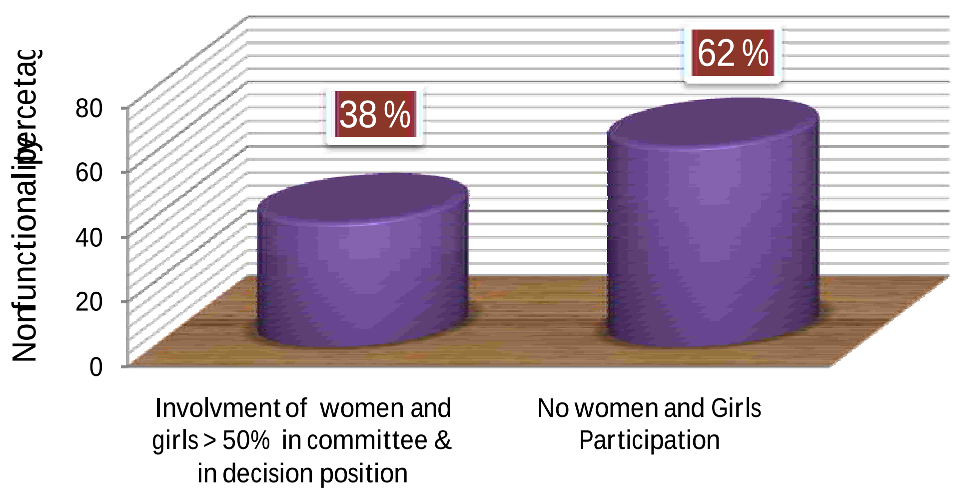


Figure 5. 30 percentage of non functionality per women and girls participation

CHAPTER SIX:

6. DISCUSSION, CONCLUSION AND RECOMMENDATIONS

6.1. RESEARCH FINDINGS

The research result and finding shows that non functionality of water and sanitation schemes is minimized or eliminated by determining causes and solutions for non functionality in each scheme system components at the stage of design, construction and service period.

The other research finding is the unfolding of the fact that the occurrence of scheme non functionality causes at the stage of designing and construction phase results permanent non functionality or not easily maintained and managed by the community level.

The research found that major to minor per scheme causes of non functionality. The study identified non functionality causes vary among scheme type.

The research proves that selecting appropriate type of technology for the specific area is inevitable to ensure functional sustainability. For example, hand dug well is not appropriate technology in the study area due to poor quantity and quality of water. On the other hand, spring at spot is the most efficient technology and lowest non functional scheme.

The most interesting part of research finding is that woreda rural water schemes mean period of non functionality is between six to seven years only. Nearly 87 % of non functionality was occurred less than ten years after construction.

The research found that water scheme tariff setting and continuous tariff paying has direct impact on functionality of the water schemes. A regular and actual tariff paying decreases non functionality. Furthermore women and girls involvement in committee member and water projects implementation has high impact on functional sustainability of water schemes. Active women and girls participation decreases non functionality

6.1.1. Functionality, Non Functionality and Rate of non functionality

Water and sanitation schemes non functionality is the main problem obstructing the provision of water and sanitation in rural Chencha woreda. The primary data collected shows that around one third (32%) of water schemes are non functional. But, the secondary data put the figure at 24% (SNNPR, 2011). But, data analyzed from questionnaire, observation, FGD and interview confirmed that non functionality rate is much higher than 24%. The research proved that the secondary data lacks consistency and suffers from poor data collection method.

Non functionality rate differs among scheme category. Hand dug well ranked first in non functionality with 46 %. It is followed by shallow well standing at 44%. The third and last place is for spring with gravity distribution and spring at the spot accounting 38 % and 23%, respectively. The result tally with the regional inventory which found that hand dug well fitted with hand pump has highest rate of non functionality and spring at spot has the lowest rate of non functionality (SNNPR, 2011).

6.1.2. Causes for Non Functionality

The main question and specific objective of this research is to identify causes non functionality and troubleshooting of non functionality. Hence the research identified the major causes of non functionality per scheme category. Ethiopia National water supply, Sanitation and Hygiene Inventory has investigated causes of non functionality in four main broad groups (NWI, 2011). These are broken, not enough water, management and financial problem and others. National level non functionality causes is more general complicated rather specif. This was why not filled up by woredas office experts.

This study set out advanced causes for non functionality per scheme and system component based classifications. The inventory data collected by the Water Resources Development bureau of SNNPR has been analyzed by Gebrie (2012) shows the degree of non functionality in the different types of schemes, causes for non functionality and the extent of maintainability. Four causes for non functionality has been identified. These are Mechanical, yield, quality and construction.

The study modified causes for non functionality in to twelve detail categories, which are more confirming tools for scanning non functionality causes.

6.2. SYSTEM COMPONENT CAUSES OF NON FUNCTIONALITY FINDINGS

In the study, four water schemes investigated for twelve causes of non functionality. The finding shows that spring capping failure is first main causes for non functionality and scored the highest (53%) rate for causes for non functionality. Secondly management/finance problem scored 49%. Thirdly most causes for non functionality is poor quality of water schemes equal to 47%.

The research indentified in general and scheme based main causes of non functionality in figure 5.9 and their troubleshooting methods from the highest to the lowest in the following sub topics.

Causes of non functionality are varying among scheme type. Table 6.1 clearly shows per water scheme main causes non functionality.

Table 6.1 Three main causes of non functionality per scheme categories

		Three Main Causes of non Functionality per scheme type					
	Rank	Primary Cause of NF		Secondary Cause of NF		Tertiary Cause of NF	
	Water Schemes (%)		%		%		%
1	Hand Dug Well	Poor quantity of water (not enough water)	83	Management and financial problem	67	Poor quality of water	50
2	Shallow Well	Management and financial problem	71	Pumping system problems	57	Poor quality of water	29
3	Spring with Gravity Distribution	Spring Capping failure	72	Management and financial problem and poor quality	50	Pipe line failure	44
4	Spring at Spot	Spring Capping failure	75	Construction material problem	56	Poor quality of water	44

6.2.1. Spring Capping failure

The research found that spring capping failure is the main cause non functionality in Chencha Woreda rural water schemes. Its rate of non functionality is 53% among studied water schemes in the woreda (Figure 5.9).
The research result shows that the occurrence of spring capping failure in spring with gravity distribution is 72% and spring at spot is **75%**. This clearly indicates that spring capping failure is the main cause of non functionality in both spring with gravity distribution and spring at spot (Figure5. 12 and Figure 5. 13)

The main problems observed for spring capping failure:-

I. **Spring eye:** in most capped springs, the spring eye was not correctly capped. Excess water is flowing around the capping structure. This caused decreases in discharge of spring after construction. In some capping, the spring source was completely disappeared.

II. **Undermining and piping:** Most spring capping structures tempered by undermining and piping problems. The water is freely flowing under the foundation of capping walls. In some places during in the rehabilitation process, they tried to block the piping of water through the foundation. But seepage and leakage has been observed (Figure 5. 16).

III. **Environmental protection activities:** Ground water recharging areas have been highly affected by deforestation and over grazing. Water sources located around the community have faced a problem of contamination by simple pit latrine excavated at a minimum length less than 30 meters

Potential solutions to address such problems could be:

- Detail assessments require for differentiating the type of spring. Naturally, three basic types of spring eyes occur. These are artesian, gravity and seepage spring type. Spring capping structures should be implemented in accordance with spring eye characteristics (RWSHP 2007).
- The objective of spring capping is to obtain maximum yield from the spring while protecting it from external pollution, especially from faecal origin. Every spring catchment has its own special method of construction. The two common productive spring capping methods are spring box capping structure and infiltration gallery capping structure (PSU 2007).
- Three spring capping rules should be strictly applied in order to get a reliable spring catchment (ACF, 2005)
    I. The catchment must never be subject to back-pressure
    II. The dam must be located on impermeable terrain
    III. The catchment must be protected

6.2.2. Management and financial problems

The result implies that management and finance problems are the second most causes of non functionality with 49 % (figure 5.9). With respect to scheme type, this problem is more magnified in shallow well assuming 71 %(figure 5.11)

The problems related to management and financial are multi discipline and very wide. This study produced results which corroborate with the findings of Harvey and Reed (2004) which expounds the integration of social, financial, technical, institutional and environmental factors to sustainability of the schemes. That is, Ensuring sustainable provision of rural water supply requires an integrated scheme based approach beginning from the inception of the scheme throughout the design period. This requires input from multi-disciplinary professionals, various stakeholders and the beneficiary community. Systematic handling of both quantitative and qualitative technical and non technical sustainability data is also required to materialize an integrated scheme based approach and utilize the integrated decision supporting tool (Gebrie, 2012).

Management and financial process are the general activities which integrates with all projects life stages of developments. Management and financial sustainability factors should evaluate at five sequential projects life stages: at stage of needs assessment, conceptual design, design and action planning, implementation, and operation and maintenance. Each stage is represented as an element in a sustainability matrix and scored according to specific guidelines (McConville, 2007)

6.2.3. Poor Quality of Water Schemes

The research detected that poor quality water is the third most cause non functionality in the Woreda rural water schemes. Its rate of non functionality is 47% (section 5.4.1). Furthermore the study indentified that poor quality of water is the second most causes of non functionality in spring with gravity distribution (50%) and the third causes on non functionality in hang dug well (50%), shallow well and spring at spot (44%). The detail mentioned on Table 6.1.

The results of this study shows water schemes are contaminated due to improper locations with respect to soil type and the proximity of contaminations sources. Many water sources have been polluted because they were located too close to a source of pollution, or are not properly constructed. Water schemes must be located so that it meets the minimum isolation distances known as “setback” or “separation” distances (Minnesota, 2010).

Water schemes to be contaminated, if they are located downhill from a source of contamination. For this reason, all sewage systems, barnyards, livestock pastures, and other sources of pollution must be located at least 30 m away from springs. Depending on the soils, geology, and slope of the land, an even greater distance may be needed. Also avoid extremely wet areas when locating a new spring, because saturated soil can’t filter out bacteria (RWSHP 2007).

6.2.4. Poor Quality of Construction materials

This is the fourth common cause non functionality in the woreda rural water schemes with 32% (Figure 5.9 or section 5.4.1). Moreover poor construction material is the second most causes of non functionality for spring at spot. Its rate of non functionality is 56 %(Figure5. 13)

The research found that water schemes were constructed from poor construction materials. Particularly sand quality is undesirable. Kulfo river sand is the most building construction material in Chencha and surrounding woredas. This is due to cost of Kulfo river sand is much lower than the any other alternative sands. However, Kulfo River sand is highly mixed with silt and humus. The study detected that hydraulic structures constructed from Kulfo River sand encountered with cracks and leakage.

The study also observed that poor grade and class of pipes, fittings, and gravel pack. To make water schemes functionally sustainability, appropriate materials standards to be employed (Arjen van der Wal, 2010).

6.2.5. Poor quantity of water, Yield (not enough water)

Water source yield declination is the fifth causes of non functionality in the woreda. Its rate of non functionality is 30%. Nevertheless, water source yield falling and disappearing is the primary cause of non functionality in hand dug wells rated at 83% causes (Figure5.10).

Results found from the observation confirm that most hand dug wells become dry at summer seasons. Hence hand dug well is not the appropriate technology in most part of the woreda. This is due to that fall of ground water level at the time of summer seasons. Hand dug well may only be productive, where high ground potentials area and need to construct the well depth up to 20m.

6.3. SPECIFIC SYSTEM COMPONENT CAUSES OF NON FUNCTIONALITY

6.3.1. Pumping System Failure

The research found that pumping system failure is the second most cause non functionality in shallow well schemes and rated causes of non functionality takes 57% (Figure5.11).

In the woreda most of hand dug well and shallow wells have been installed with hand pump. There are three types of hand pumps in use. The first and the most common is Afredive hand pump, 85 %. This is followed by Indian mark II/III. The third and old type of hand pump is mono pump. This is not included in this study. Because most of mono pumps constructed by Catholic Church before 25 years ago. At this time all mono pumps are non functional. This is due to shortage or disappearance of spare parts from the market and out of design period.

There are some possible methods to solve the above mentioned pumping system failure in shallow well developments (RWSHP, 2007 and Arjen van der Wal, 2010).

- It is very important to inspect and maintain the pumping system regularly so it is possible to see problems and solve them before they become too big. Regular checking will help to keep the pump in good working order and avoid big expenses for repairs
- It is more prudent to make routine maintenance to identify and solve problems before they become big and expensive. This means tightening loose nuts, welding locker pins back on (if they have fallen off) and replacing worn out parts.
- Keep tools, spare parts and record problems: One main important point in pump failure is not proper handling of tools, spare parts and problem detection. Tools and spare parts are to be kept in a safe place so that they are available when they are needed for maintenance or repair. If it may lose or damage, then the community will have to replace them.

6.3.2. Pipe Line Failure

The study investigated that pipe line failure is the third common cause of non functionality in spring with gravity distribution with 44% causes of failure (Figure5.12 and Figure 5.18C).

The common problems detected at the time observations are:

- **Trench excavation and back fill:** Most pressure and distribution pipes are exposed and lie down on ground surface. The water supply system was stopped due to depleted trench excavation and installation of pipes under the required depth, brakeage of pipes, and cracks. In newly installed pipe lines backfills were not compacted correctly.

- **Valves and fittings:** There is rampant misfit of valves. Air release valve should be installed along the line air from the pipeline during the filling process and to prevent the development of a vacuum. Washout valves were not installed in lower place to remove accumulated sediments. Pressure relief valves were not installed at the point of high pressure pipe line direction.
- **Bending and joints and Anchor blocks:** Improper bending has been detected. Anchor blocks were not installed where pipe line crossing the barriers.
- **Unsuitable class of pipe used.** Cracked and smashed pipes observed. These caused leakage and contamination of the system.

It is possible to solve the above mentioned pipe line failure in spring with gravity distribution construction. Standardized design and construction of pipe and fittings in water supply system has a great value for functional sustainability of water schemes. The following are some troubleshooting on pipe line construction and protection (ILO, 2011).

- Minimum and maximum trench widths and depth shall be done according to the contract specified.
- Valves, fittings, dividers and bend should be installed on appropriate place and location.
- Break pressure tank is installed where very high pressure is observed. These are structures where the hydrostatic pressure of water is allowed to drop to zero. This structure protects pipes and fittings from burst and break during high pressure.

6.4. SIMPLE PIT LATRIN CAUSES OF NON FUNCTIONALITY

The most common type of latrine in the woreda is simple and none lined types of pit latrines – simple pit latrine (figure 5.21).

The major non functionality causes are:

- High linkage and interconnection between pit and ground water resulting from pits fill with water and contaminating nearby water schemes.
- Water sources located in the length less than 30m and water sources located downstream of the pit.
- Poor doors or no doors at all, which leads to uncomfortable for male and female usage, particularly for the later.
- Pungent and bad smell, uncovered holes and pit visibility.
- Poor pit floor, wall and roof construction material and exposed for moisture, decay, undesirable for cleaning.
- The simple pit latrine became breading place and host for flies and insects

It is possible to make simple pit latrine more comfortable and safe. The transformation from open defecation to household level simple pit latrine is advancement for entire protection of ground water and surface water from direct impact of pollutants. To make simple pit latrine more sustainable, there are a plenty of methods to be practiced (UNICEF, 2009)

The current new transformation practice written in woreda Health Office Health extensions policy is the best method to have functional simple pit construction. But, the research found that such policy is not followed or implemented.

6.5. WATER SCHEMES SANITARY INSPECTION

This study determined that most water schemes in the woreda experience sanitary risk. The percentage of sanitary risk varies per scheme type. From the four water schemes, hand dug wells are highly exposed for sanitary problems. Its percentage of risk is 71%. This is followed by spring with gravity distributions schemes with risk percentage of 54%. Third is spring at spot (46%) and the least and low risk for sanitation are shallow wells 33% (figure 5.26).

It is possible to protect water sources from contamination. All sewage systems, barnyards, livestock pastures, and other sources of pollution must be located at least **30 m** away and located higher areas from water sources. Depending on the soils, geology, and slope of the land, an even greater distance may be needed. Also avoid extremely wet areas when locating a new water sources, because saturated soil can't filter out bacteria (RWSHP 2007).

As a general rule, water sources should be located upslope from, and as far away as possible from, potential sources of pollution. The safe distance depends on the nature of the subsoil, the depth to the water table, the slope of the land, the rate of pumping, and the size of the pollution source. Suggested safe distances are shown in the table 3.3 (Ireland, 2009)

6.6. CONCLUSION AND RECOMMENDATIONS

6.6.1. Conclusion

Water and sanitation schemes non functionality is the main problem obstructing the provision of water and sanitation in rural Chencha woreda. One third or 32% of water schemes are non functional. Non functionality rate differs among scheme category. Hand dug well ranked first in non functionality with 46 %. It is followed by shallow well standing at 44%. The third and last place is for spring with gravity distribution and spring at the spot accounting 38 % and 23%, respectively.

Ensuring functional sustainability of water and sanitation developments throughout the design period entails identification of causes of non functionality and troubleshooting per scheme system components at the stage of design, construction and service period.

The average non functionality period of schemes is much less than the minimum design period of the schemes, which is from 15 to 20 years. The woreda rural water schemes mean period of non functionality is between six to seven years only. Nearly 87 % of non functionality was occurred less than ten years after construction (section 5.5 and figure 5.14 and 5.15).

Selecting appropriate type of technology for the specific area is vitally necessary to ensure functional sustainability. Hand dug well is not appropriate technology in the study area due to poor quantity and quality of water. On the other hand, spring at spot is the most efficient technology and lowest non functional scheme.

Four water schemes were investigated for twelve causes of non functionality. Non functionality rate and causes varies among scheme types. Twelve system component causes of non functionality were determined from highest to lower level. Spring capping failure is first main causes for non functionality and scored the highest (53%). The second major problem is management/finance problem, scored 49%. Thirdly most causes for non functionality is poor quality of water scheme equal to 47 %(section 5.4 and figure 5.9).

The main causes of non functionality directly related to design and construction are spring capping failure, construction materials problems, not enough water, and poor quality of water, poor quantity of water and pipe line failures. To eliminate or minimize these problems every system component design and construction activity should be in accordance the applicable design and construction methods mentioned in the literature and validated and examined by experienced professional.

Most water sources are exposed for sanitary risk. Poor quality of water sources means poor functionality water scheme. To protect water source from sanitary risk, consider the location and position water schemes with respect of pollutants like latrines, drainage, livestock pasture and any other sources of pollutants. The location of water sources should be a minimum of thirty meter away from the source of pollutants and the position should be in higher areas from the source of pollutants. The location and position depends on the soil, geology, and slope the land.

Water scheme tariff setting and continuous tariff paying has direct impact on functionality of the water schemes. Regular and actual tariff paying step-down non functionality. Moreover women and girls involvement in committee member and water projects implementation has high impact on functional sustainability of water schemes. Active women and girls' participation have great impact to decreases non functionality.

The most common type of latrine in rural areas is house hold level simple and none lined types of pit latrines. Multi causes of non functionalities were identified. Ground water contamination, location of latrine upstream and much closer to potable water sources, design, construction method, poor construction material are some of major causes for non functionality of simple pit latrine.

Water and sanitary schemes are functionally sustainable, only when social, financial, technical, institutional and environmental factors integrated with every project life stages. At stage of needs assessment, conceptual design, design and action planning, implementation, and operation and maintenance to be considered and integrated.

6.6.2. Recommendation

Water and Sanitation schemes non functionality is cumulative result of causes for non functionality at the stages of Design, Construction and service periods. Mostly non functionality occurs much lesser than expected design periods. One third of water schemes fail lower than a minimum design period, which is 15 years. Non functionality causes occurs at stage of design and construction phase results permanent non functionality.

To eliminate or minimize non functionality, the following are remedial measures to be considered and implemented at the stage of design, construction and service period.

I. Designing phase

Permanent non functionality has been occurred and studied due to a result of under the standard design of water and sanitation schemes. Water and sanitation schemes design should be incorporate the following mandatory design components parts, which were not included at time of design phase in the woreda.

- ***Spring capping design should consider and incorporate the following fundamental design components***.
  - Capping design based on types of spring (Artesian, gravity, seepage)
  - Identifying Soil type and texture
  - Execute water quality analysis test for the source
  - Design discharge at minimum flow in critical dry seasons (minimum discharge best the past 10 years or more)
  - Special design for specific project(not copy of one project to another)
  - Environmental protection and mitigation measures.
- ***Pipe line should be designed in following considerations***
  - Providing structural and hydraulic design
  - Design with appropriate valves and fittings(air and pressure relief valves, etc)
  - Design and locate anchor block and trust block in appropriate places
  - Special design for specific project(not copy of one project to another)
  - Environmental protection and mitigation measures and others.
- ***Reservoir, water point and collection chamber design should hold the following mandatory design parts.***
  - Appropriate pipe installation design.
  - Specify bearing capacity of the soil and foundation stability.
  - provide structural and hydraulic design
  - Special design for specific project(not copy of one project to another)
  - Environmental protection and mitigation measures and others.

- ***Hand dug well and shallow boreholes design consideration.***
    - Design discharge at minimum yield in critical dry seasons
    - structural and hydraulic design
    - Execute water quality analysis test for the source
    - Appropriate pump selection
    - Specify location of well for any contaminates based on soil and land slope
    - Special design for specific project(not copy of one project to another)
    - Environmental protection and mitigation measures and others.

- ***Simple pit latrine design consideration.***

    - Select appropriate location of latrine site respect to drinking water sources
    - Design the system with Suitable privacies.
    - Design the latrine not to have smell and easily cleanable.
    - Design sub and super structures stable, not attacking by insects.
    - Determine and design the latrine depth and lining with respect to soil type, land slope and ground water level.

II. Construction phase

One cause for permanent non functionality occurred and studied is due to the consequence of under the standard construction execution and using poor construction materials. Water and sanitation schemes construction method and materials should comprise the following mandatory construction methods and materials.

- ***Spring capping construction and construction materials should consider and incorporate the following fundamental construction components and materials.***

    - The spring eye never be subject to back-pressure
    - Place the capping structure on impervious layer
    - Use standardized construction materials (sand, grave, cement, pipe, etc). Using Kulfo River sand for construction of hydraulic structures causes cracks and structural failure on sub and super structures.
    - Select project contractor in accordance with their knowledge and skill acquired.
    - Continuous supervision and evaluation of the project throughout construction period by appropriate professional person.
    - Construct fence around the source with firm gate.
    - Construct drainage channel blocking the flow and allowing stagnant water
    - Implement environmental protection and mitigation activities.

- ***Pipe line should be constructed in following considerations***

    - Construct with appropriate valves and fittings in appropriate place(air and pressure relief valves, etc)
    - Install pipes in right depth and back fills with right material and compression stress.
    - Use standardized construction materials (valve, fitting, pipe, etc)
    - Build anchor block and trust block in appropriate places
    - Implement environmental protection and mitigation activities.

ü ***Reservoir, water point and collection chamber construction and constriction material should hold the following mandatory activities.***

- § Collection chamber never be subject to back-pressure to the capping.
- § Appropriate pipe installation.
- § Use standardized construction materials (sand, grave, cement, pipe, etc). Using Kulfo River sand for construction of hydraulic structures causes cracks and structural failure on sub and super structures.
- § Construct on stable foundation
- § Implement environmental protection and mitigation activities.

ü ***Hand dug well and shallow boreholes construction requirements.***

- § Collect and arrange soil sample and drilling logs in aesthetically manner.
- § Positioning well screening in right aquifer place.
- § Use proper gravel pack, grouting and sanitary seals.
- § Make sufficient well development.
- § Install standardized pumping parts (piston, cylinder, raising main, rods, etc)
- § Construct fence around the source with firm gate.
- § Construct drainage channel blocking the flow and allowing stagnant water
- § Implement environmental protection and mitigation activities.

ü ***Simple pit latrine construction consideration.***

- § Appropriate location of the site respect to drinking water sources
- § Providing appropriate ventilation; make easygoing for cleaning; the latrine not create odour and reduce smell diffusion.
- § Construct latrine with appropriate privacy constituents
- § Floor slab, walls and roofs structures should firmly fixed; not exposed for wet weather condition and not easily attack by insects,
- § Sub and super structure should be stable
- § While pit excavation and construction, analyze pit depth with ground water level and leave safe depth differences of two meter deviate pit from ground water at wet and winter season.

III. Service phase

Water and Sanitation schemes service phase period is called Design period. This is from end of construction up to expect year of service. After the standard design and construction execution, service phase period is the pillar for functional sustainability of water and sanitation infrastructures.

Temporary and permanent non functionality has been found due to poor institutional set ups, poor management and financial activities in the service period. Every water care taker and committee member should be trained since designing up to service period. Water and sanitation schemes service phase management institutional setups should have incorporate with following mandatory implementation activities in all level of stakeholders.

- ***Spring capping management and protection activities should have incorporate the following fundamental components.***

  - Sustainable natural resources management activities to be carried out on the upstream water shade and around the source.
  - Protect the source from any contaminates. Latrine or any source of pollution should far away at minimum distance of 30 m and never be on uphill of the spring source based on soil type and ground water flow.
  - Inspect the capping structure for cracking of the structure, seepage and leakage.
  - Maintain and rehabilitate frequently any damage of the structure, pipes, drainage channel, fence, etc.
  - Continuous environmental protection and mitigation activities executions.

- ***Pipe line management system requires the following basic considerations***

  - Protect pipe and pipe line from any contaminates. Not mixing with drainage and sewerage systems.
  - Inspect the pipe line for exposing to the surface, cracking, seepage and leakage.
  - Maintain and rehabilitate frequently any damage of the structure, pipes, valves, gates, fittings, etc.
  - The executions of continuous environmental protection and mitigation activities.

- ***Reservoir, water point and collection chamber management should hold the following mandatory activities.***

  - Protect the structures from any contaminates.
  - Inspect the hydraulic structures for cracking, leakage, etc.
  - Retain the spare parts of continuous moving and wearing out parts.
  - Maintain and rehabilitate frequently any damage of the structure, pipes, fittings, drainage channel, fence, etc.
  - The executions of continuous environmental protection and mitigation activities.

- ***Hand dug well and shallow boreholes management requirements.***

  - Protect the source from any contaminates. Latrine or any source of pollution should far away at minimum distance of 30 m and never be on uphill of the water well based on soil type and ground water flow.
  - Retain the spare parts of continuous moving and wearing out parts.
  - Inspect the pumping system for cracking, breaking, disconnecting, scratching, leaking, etc.
  - Maintain and rehabilitate frequently any damage of the well structure, pumps, head work, drainage channel, fence, etc.
  - Continuous environmental protection and mitigation activities executions.

- ***Simple pit latrine management's consideration.***

  - Keep the latrine clean, odorless and well ventilated all the time.
  - Placing appropriate sanitary materials and make it easy for use (water, soap, etc).

- § Inspect sub and super structures for keeping its stability.
- § Maintain frequently, floor slab, walls, doors, privacy structures, etc.
- § Continuous environmental protection and mitigation activities executions.

ü ***Water scheme tariff setting and paying***

Less non functionality has been recorded for regular and actual tariff paying schemes. Hence to make the system sustain on financial issues give careful consideration for the following.

- § Set actual tariff for the schemes.
- § Habituate and Systematize regular and actual tariff paying trend

ü ***Women and girls participation***

Less non functionality has been recorded for the involvement of girls greater than 50% in committee member and acting in decision position.

- § Women and girls should be nominated in decision making position and committee member participation share is not less than 50%.
- § Involve women and girls in all stage of project implementation. Since designing phase up to service period.

ü ***water schemes sanitary inspection***

This study determined that most water schemes in the woreda experience with sanitary risk. Water schemes should be well protected from any contaminates. The special care should be taken for hand dug wells and spring with gravity distribution water schemes. Its percentage of risk is 71% and 54% respectively. It has great value for health to keep water resources quality from any type of contamination in all stage of project life period.

6.6.3. Limitation

This study is limited to four types of water technology and one sanitary scheme. Namely, hand dug well fitted with hand pump, shallow well fitted with hand pump, spring with gravity distribution, spring at spot and simple pit latrine. The most common and excluded water scheme is hand dug well fitted with rope pumps. Hand dug well fitted with rope pump was omitted as the households use it more for irrigation rather for potable water service which is the focus of the study. Besides, budget and time constraints limited exploration of more than 600 rope pumps.

6.6.4. Future study

It is recommended that further research can undertake rope pumps functionality and associated pros and cons and its compatibility to the study. Besides, the finds can be applied to other parts of the regional and the country at all by adjusting some part. Such a move will not only save the country from losing significant amount of money on scheme failure but also allow the people to enjoy improved sanitation and thereby by better and happy life. What is more, the further studies require investigating causes for non functionality for motorized water schemes.

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APPENDIX A. QUESTIONNAIRES

Item	Data Description	Unit	Data	Remark
1	Scheme Name	Type		
	Kebele	Type		
	Sub Kebele(Gote)	Type		
	Elevation	Meter		
	X:Coordinate	Degree		
	Y:Coordinate	Degree		
	Number of house hold	HH		
	Number of Beneficiaries	No		
2	Design period	Years		
	Year of construction	Year		
	Water source yield before construction	L/s		
	Current scheme yield	L/s		
	Scheme cost	Birr		
	Monthly tariff/household	Birr/hh		
	Tariff/m3	birr/m3		
	Operation and maintenance	birr		
	Capital cost recovery	birr		
	Demand per capita per day	L/C/D		
	Distance from the community	Km		
3	Is the scheme functional?	Yes/No		
	If not functional for how long?	Days		
	Does the system functional throughout the year/all seasons?	Yes/NO		
	Is functional only in rainy seasons?	Yes/NO		
	Causes on non functionality			
	CAPPING STRUCTURE	Yes/NO		
	Piping and undermining	Yes / No		
	Leakage through the capping structure	Yes / No		
	Disappearing of spring eye	Yes / No		
	Capping structure design construction problems	Yes / No		
	Improper filter material arrangement	Yes / No		
	Improper pipe setup system and other directly related to capping structure.	Yes / No		
	SPRING BOX(WET BOX)	Yes/NO		
	Improper pipe installation system(inlet and outlet)	Yes / No		
	Wet box construction and design defects	Yes / No		
	Wet box cover and related	Yes / No		
	RESERVOIR	Yes/NO		
	Improper pipe installation system(inlet and outlet)	Yes / No		
	Reservoir design and construction defects	Yes / No		
	Instability and foundation defects	Yes / No		
	PIPE MAIN LINE AND DISTRIBUTION SYSTEM	Yes/NO		
	Pipe leakage and broken	Yes / No		
	Incorrect pipe size, poor Pipe material and cracks	Yes / No		
	Incorrect Alignments	Yes / No		
	Trench excavation and back fill	Yes / No		
	Lacks of basic valves(pressure relief valve, washout valve, Air relief valve)	Yes / No		
	Improper anchor blocks, thrust block, Bending and joints	Yes / No		
	WATER POINTS	Yes/NO		
	Improper pipe installation system	Yes / No		
	Breaking or malfunction Faucets	Yes / No		
	Water point construction and design defects	Yes / No		

	Instability foundation defects	Yes / No		
	Improper drainage and protection	Yes / No		
	PUMPING SYSTEM	Yes/NO		
	Pumping system component			
	Piston, and cylinder problems	Yes / No		
	Lack of Spare parts	Yes / No		
	Valves and rings malfunction.	Yes / No		
	Rod and risen main disconnection, crack or broken and other related	Yes / No		
	CONSTRUCTION MATERIAL	Yes/NO		
	Poor quality cement sand and gravel	Yes / No		
	Poor quality of pipe, fittings, pumps and others	Yes / No		
	WATER WELL STRUCTURAL DESTRUCTION	Yes/NO		
	Water well design and construction problem			
	Improper filter material(gravel) pack	Yes / No		
	Improper screen positioning Insufficient well developments and related.	Yes / No		
	OTHERS	Yes/NO		
	Natural disasters like land slide, erosion etc.	Yes / No		
	Physical damage by human interfere	Yes / No		
	Closing of water site for construction or other purposes and related problems	Yes / No		
4	Is the water potable?	Yes/No		
	Drainage problem,	Yes/No		
	Water born and related diseases record	Yes/No		
	unprotected water scheme	Yes/No		
	Sanitary problem around the scheme	Yes/No		
5	Total scheme cost	Birr		
	Average daily consumption/household	Liter		
	Average monthly income/house hold	Birr/hh		
	Do user pay for water	Yes/no		
	Monthly tariff/household	Birr/hh		
	Tariff/m^3	birr/m^3		
	Does the tariff cover operation and maintenance and cost recovery of capital cost.	Yes/no		
	Community contribution cost	Birr		
	Local budget contribution	birr		
6	Is there any environmental protection activity	Yes/No		
	Surrounding project area is environmentally protected	Yes/No		
7	Is there water and sanitation committee?	Yes/No		
	Are community members paid? if so how much/month	Yes/No		
	Are there Women and girls in committee?	Yes/No		
	Number of women and girls in the committee(ration or No)	Type		
	Do they have regular scheduled meeting?	Yes/no		
	Do they collect and control the income from tariff?	Yes/no		
	Do they manage most of the maintenance?	Yes/No		
	Are there capable plumbers in locality?	Yes/No		
	Are there capable artesian in locality?	Yes/No		
8	Is there a separate institution responsible for water supply?	Yes/No		
	Has it basic equipments	Yes/No		
	Does it give training to community?	Yes/No		
	Does it assign budget for water sector?	Yes/No		
	Do they assist major maintenance?	Yes/No		

Name and signature ____________________________

APPENDIX B. OBSERVATION

Observation category

To make observation systematic, water and sanitation schemes categorized in three main groups. It was based on structural similarity between the schemes.

D. Category one: spring at spot and spring with gravity distribution
E. Category two: Hand dug well and shallow well
F. Category three: Simple pit latrine.

Observational specific structures

A. Category one: spring at spot and spring with gravity distribution. It was further divided in to three groups based on construction point of views.

I. Capping
II. pipe line
III. Reservoir, water points, spring box (wet reservoir) and valve chambers

I. Capping: component of capping structures

- Spring catchment area
- Site selection
- Environmental protection activities
- Spring surroundings
- Spring eye position and location
- Spring capping bed
- Spring capping protection well and slab
- Pipes(outlet, drainage and overflow)
- Filter media and materials
- Yield of spring before and after construction
- Quality of water

II. Pipe line

- Pipe material
- Velocity and discharge
- Alignments
- Trench excavation and back fill
- Pressure relief valve
- Wash out valve
- Bending and joints
- Anchor blocks

III. Reservoir, water points, spring box (wet reservoir) and valve chambers

- Location
- Foundation work
- Super structure
- Construction materials
- Pipe installation
- Valve champers
- Fittings

B. Category two: Hand dug well and shallow well. It was further divided in to three groups based on construction point of views.

I. Well drilling
II. Well Lining
III. Pump and head work

I. Well drilling

- § well catchment area
- § Site selection
- § Environmental protection activities
- § well surroundings
- § drilling activities

II. Well lining

- § Lining methods and materials
- § Gravel packing
- § Well developments
- § Grouting

III. Pump and head work

- § Pump type and model
- § Pump installation
- § Spar part supply chain
- § Head work construction

C. Category three: simple pit latrine.

- § Pit excavation
- § Pit lining
- § Super structure
- § Sub structures

APPENDIX C. SANITARY INSPECTION

Adapted from WHO Guidelines for drinking-water quality, Volume 3

I. Shallow borehole and Hand dug well

No		Yes	No	Recommended action
1	Is there a latrine or any source of pollution within 30 m of the well?			
2	Does the fence around the well allow animals in?			
3	Is the drainage channel less than 2 m long, broken or dirty?			
4	Is there stagnant water close to the well?			
5	Is the apron less than 1m wide all around the well?			
6	Are there any cracks in the well apron and headwall?			
7	Is the cover of the well unsanitary and closed?			
8	Is the well poorly sealed for 3 m below ground level?			
9	Is the water point dirty?			
10	Is the lift system in bad condition / are ropes and buckets dirty?			
	TOTAL SCORE OF RISK (number of “yes” points)			

I. Protected spring

No		Yes	No	Recommended action
1	Is there a latrine or any source of pollution within 30 m uphill of the spring?			
2	Does the fence around the spring allow animals in?			
3	Is the drainage channel blocking the flow and allowing stagnant water?			
4	Is the spring open to surface water contamination?			
5	Is the spring box cracked?			
6	Is the inspection cover cracked or unsanitary?			
7	Is the overflow pipe screen missing or unsanitary?			
8	Is the cut-off ditch above the spring blocked or non-existent?			
9	Is the water point dirty?			
10	Is there standing water at the collection point?			
	TOTAL SCORE OF RISK (number of “yes” points)			

II. Piped supply

No		Yes	No	Recommended action
1	Is the source well protected?			
2	Is there any point of leakage between the source and the reservoir?			
3	Is there any point of leakage between the source and the reservoir?			
4	If there are any break-pressure tanks, are their covers unsanitary?			
5	Is the storage tank cracked or leaking and the inspection cover or the air vent unsanitary?			
6	Is the storage tank dirty or not regularly cleaned?			
7	Are there any leaks in the distribution system?			
8	Are the areas around the taps unfenced or allowing access to animals?			
9	Is there inadequate drainage and standing water around the taps?			
10	Are the surroundings of the taps dirty and with possible contamination? Sources (excreta, refuse etc.)?			
	TOTAL SCORE OF RISK (number of “yes” points)			

APPENDIX D. INTERVIEWING

I. Woreda water resources developments expert and professionals

1	**What is the average year for non functionality of water schemes**				
a	very long (greater than 15 yrs	c	Medium(6-10 years)	e	very short(< 2years)
b	Long(10-15 years)	d	short (2-5 years)	f	others
2	**Which water scheme type is most common non functional scheme in rural areas and why?**				
a	spring at spot	c	hand dug well (Rope)	e	shallow well
b	spring with gravity distribution	d	hand dug well (handpump)	f	
3	**what is the status of pure water service, coverage and accessibility in Chencha woreda**				
a	very satisfactory	c	less satisfactory		
b	Satisfactory	d	Others		
4	**Which water scheme type is easily handled, maintained and managed by rural community and why?**				
a	spring at spot	c	hand dug well (Rope)	e	shallow well
b	spring with gravity distribution	d	hand dug well (handpump)	f	borehole
5	**Which water scheme type is highly exposed for sanitary problems and why?**				
a	spring at spot	c	hand dug well (Rope)	e	shallow well
b	spring with gravity distribution	d	hand dug well (handpump)	f	borehole
6	**what is the main causes of non functionality for spring at spot**				
a	management and finance	d	Spring capping	g	others
b	construction	e	quality	h	spare parts
c	Design	f	yield	i	Reservoir
7	**what is the main causes of non functionality for spring with gravity distribution**				
a	management and finance	e	Fitting and valves		others
b	construction	f	quality		Spring capping
c	Design	g	Wet well, chambers		Reservoir
d	yield	h	spare parts		Pipe line
8	**what is the main causes of non functionality for hand dug well and shallow wells**				
a	management and finance	e	Pumping system failure	I	others
b	construction	f	quality		
c	Design	g	Water well		
d	yield	h	spare parts		
9	**what is the main causes of non functionality for simple pit latrine**				
a	management and finance	e	Construction materials		others
b	construction	f	quality		
c	Comfort(pit visibility, smell, etc	g	design		
d	Ground water contamination	h	Privacy		
10	**Who do execute operation and maintenance and why?**				
a	Caretakers	c	experienced person		others
b	Water Engineer	d	woreda water related experts		

11	**who do execute Site selection for the projects**				
a	hydro geologist	c	decision by local government		other
b	woreda water experts	d	decision by local community		
12	**Who do construct most water projects?**				
a	Water Engineer	c	experienced person		other
b	local professionals	d	water related experts		
13	**Who do supervise and evaluate water projects under construction?**				
a	Water Engineer	c	experienced person		other
b	local professionals	d	water related experts		
14	**Who do execute feasibility study, and design of the water projects?**				
a	Water Engineer	c	experienced person		others
b	local professionals	d	water related experts		
15	**where is the main source of budget for water work projects**				
a	government	c	community		
b	NGO	d	individuals		
16	**Gender participation**				
a	Very high	c	Low		
b	High	d	Very low		

II Local government and other public sector representatives

1	**Chencha woreda pure water coverage and accessibility**				
a	very satisfactory	c	not satisfactory		
b	satisfactory	d	others		
2	**What is the average year for non functionality of water schemes**				
a	very long (greater than 15 yrs	c	Medium(6-10 years)	e	very short(< 3years)
b	Long(10-15 years)	d	short (3-5 years)	f	others
3	**attention given for water sectors compeering with other sectors**				
a	very high	c	low	e	Others
b	high	d	very low		
4	**budget allocation to water projects related to other woreda projects**				
a	very high	c	low	e	others
b	high	d	very low		
5	**disease related to potable water**				
a	very high	c	low		
b	high	d	very low		
6	**Which water scheme type is most common non functional scheme in rural areas and why?**				
a	spring at spot	c	hand dug well (Rope)	e	shallow well
b	spring with gravity distribution	d	hand dug well (handpump)	f	

III **Rural community and water and sanitation committees**

1	**Kebele level pure water service, coverage and accessibility**				
a	very satisfactory	c	not satisfactory		
b	satisfactory	d	others		
2	**What is the average year for non functionality of water schemes**				
a	very long (greater than 15 yrs	c	Medium(6-10 years)	e	very short(< 3years)
b	Long(10-15 years)	d	short (3-5 years)	f	others
3	**water committee activity and participation**				
a	very high	c	low	e	Others
b	high	d	very low		
4	**Water revenue and tariff collection system**				
a	continuously	c	never at all		Other
b	sometimes	d	How much per scheme		
5	**disease related to potable water**				
a	very high	c	low		
b	high	d	very low		
6	**Community participation for water and sanitation activities**				
a	very high	c	low		
b	high	d	very low		
7	**Who do execute operation and maintenance**				
a	Caretakers	c	experienced person		others
b	Water Engineer	d	water related experts		
8	**what is the main causes of non functionality for spring at spot**				
a	management and finance	d	Spring capping	g	others
b	construction	e	quality	h	spare parts
c	Design	f	yield	i	Reservoir
9	**what is the main causes of non functionality for spring with gravity distribution**				
a	management and finance	e	Fitting and valves		others
b	construction	f	quality		Spring capping
c	Design	g	Wet well, chambers		Reservoir
d	yield	h	spare parts		Pipe line
9	**what is the main causes of non functionality for hand dug well and shallow wells**				
a	management and finance	e	Pumping system failure	I	others
b	construction	f	quality		
c	Design	g	Water well		
d	yield	h	spare parts		
10	**what is the main causes of non functionality for simple pit latrine**				
a	management and finance	e	Construction materials		others
b	construction	f	quality		
c	Comfort(pit visibility, smell, etc	g	design		
d	Ground water contamination	h	Privacy		

APPENDIX E. SECONDARY DATA

Southern Nation total Urban and Rural Water Supply Schemes

		Scheme Type	Functional	Non functional	Sum	NF Rate
1	**HDWr**	Hand dug wells fitted with Rope pump	1030.0	673.0	1703.0	40
2	**HDWh**	Hand dug wells fitted with hand pump	76.0	75.0	151.0	50
3	**SHW**	Shallow wells fitted with hand pump	2053.0	947.0	3000.0	32
4	**DBd**	Deep wells with distribution	391.0	213.0	604.0	35
5	**SPRgd**	Springs with distribution	647.0	256.0	903.0	28
6	**DAM**	Dames with distribution	3.0	1.0	4.0	25
7	**SPRspt**	Spot springs	4620.0	1090.0	5710.0	19
8	**GDPW**	Gravity distribution public water (GDPW)	3117.0	1158.0	4275.0	27
9	**RIVER**	River Intake with distribution	4.0	0.0	4.0	0
	Total	**Total**	**11941.0**	**4413.0**	**16354.0**	**27**
		Percentage (%)	**73**	**27**	**100.0**	

Gamo Gofa Zone Water Supply Schemes

		Scheme Type	Functional	Non functional	Sum	NF Rate
1	**HDWr**	Hand dug wells fitted with Rope pump	57.0	39.0	96.0	41
2	**HDWh**	Hand dug wells fitted with hand pump	1.0	3.0	4.0	75
3	**SHW**	Shallow wells fitted with hand pump	153.0	41.0	194.0	21
4	**DBd**	Deep wells with distribution	25.0	27.0	52.0	52
5	**SPRgd**	Springs with distribution	174.0	110.0	284.0	39
8	**SPRspt**	Spot springs	334.0	92.0	426.0	22
9	**GDPW**	Gravity distribution public water	501.0	153.0	654.0	23
6	**RIVER**	River Intake with distribution	0.0	0.0	0.0	0
7	**DAM**	Dames with distribution	0.0	0.0	0.0	0
	Total	**Total**	**1245.0**	**465.0**	**1710.0**	**27**
		Percentage (%)	**72.8**	**27.2**	**100.0**	

Chencha Woreda Water Supply Schemes

		Scheme Type	Functional	Non functional	Sum	NF Rate
1	**HDWr**	Hand dug wells fitted with Rope pump	12.0	5.0	17.0	29
2	**HDWh**	Hand dug wells fitted with hand pump	1.0	2.0	3.0	67
3	**SHW**	Shallow wells fitted with hand pump	8.0	4.0	12.0	33
4	**DBd**	Deep wells with distribution	1.0	1.0	2.0	50
5	**SPRgd**	Springs with distribution	14.0	11.0	25.0	44
6	**SPRspt**	Spot springs	46.0	12.0	58.0	21
7	**GDPW**	Gravity distribution public water	44.0	5.0	49.0	10
8	**RIVER**	River Intake with distribution	0.0	0.0	0.0	o
9	**DAM**	Dames with distribution	0.0	0.0	0.0	0
	Total	**Total**	**126.0**	**40.0**	**166.0**	**24**
		Percentage (%)	**76**	**24**	**100**	

APPENDIX F. SYSTEM COMPONENT CAUSES OF NON FUNCTIONALITY

1. Spring capping

Spring capping is an initial source for spring development. Spring eye should be well capped to hold the spring emerging from the ground. Missed capping structure leads to failure and none functioning of all structures respectively. The following are selected and main spring capping problems.

- Piping and undermining;
- Leakage through the capping structure;
- Disappearing of spring eye;
- Capping structure design and construction problems;
- Improper filter material arrangement;
- Improper pipe setup system and other directly related to capping structure.

2. Spring box/wet well/collection chamber

It is a temporary storage and collection of capped water. Spring box can construct jointly of separately with spring capping. It is more advised to construct separate capping. Problems related to spring box/wet box are;

- Improper pipe installation system(inlet and outlet);
- Spring box/wet well structure design and construction problems;
- Wet box construction defects;
- Wet box cover and related.

3. Pipe line

It is a conveyance media for water for reservoir and for end users. Problems related to Pipeline are:-

- Pipe leakage and broken;
- Incorrect pipe size, cracks;
- Pipe line design and construction problems;
- Incorrect Alignments;
- Trench excavation and back fill and related.
- Lacks of basic valves(pressure relief valve, washout valve, Air relief valve);
- Improper anchor blocks, Bending and joints and related.

4. Reservoir

It is the main storage and collection of water for a long period in order to moderate and balance water distribution to the beneficiary. Water is normally stored in suitable holding capacity before transfer and distribution. Non functionality causes related to service reservoir are:-

- Improper pipe installation system(inlet and outlet);
- Reservoir construction defects;
- Reservoir structure design and construction problems;
- Instability and foundation defects and related.

5. Water points

It is the service point of end users in almost in all rural areas. It is a contact point of water with community beneficiary. Due to continuous and prolonged service reasons water points are easily broken or out of use. The major problems are;

- Improper pipe installation system;
- Breaking or malfunction Faucets;
- Water point design and construction defects;
- Instability foundation defects;
- Improper drainage and protection.

6. Pumping system

Pump is a machine which lifts and drags water from lower location or from depth water wells to higher locations or to the service points. During improper lifting system the pump and pumping units exposed for multiple functional failure. In Chencha woreda rural areas all hand dug wells and shallow wells were fitted with hand pumps. Afredive, Indian mark II and Indian mark III are the most commons. The major problems related to pump and pump units are given below.

- Pumping system design and construction problems;
- Piston, and cylinder problems;
- Valves and rings malfunction;
- Rod and risen main disconnection, crack or broken and other related.

7. Water well structure

While ground water flowing from aquifer to the well, first joins with gravel packs surroundings the well. Next it passes to the screen casing. And finally it reaches in to the well and cylinder. The major structural failure related to ground well structures are:-

- Water well structure design and construction problems;
- Improper filter material(gravel) pack;
- Improper screen positioning;
- Insufficient well developments and related.

8. Construction materials

Construction materials are materials use for constructing water supply schemes. The major four construction materials for water supply structures are Cement, Sand, gravel and water. The poor quality of construction materials leads to permanent failure of the structure. It includes;

- Poor quality cement sand and gravel;
- Poor quality of pipe, fittings, pumps and related.

9. Management/financial

Proper managing and financing water supply schemes is one of the major issues for sustainability. A quality management and administration of water schemes is fundamental for securing constructed structures during the design period. The most common causes for poor management and finance systems are:-

- Maintenance and operation problems;
- Poor monitoring and regulation;
- Deserving managing and administrating;
- passive activity of Water and sanitation committee;
- weak Revenue collection cost recovery system;
- incorrect pricing and water tariff setting;
- poor institutional setup;
- lacks gender involvements and related;
- In sufficient Equipment and Spare parts management;
- Skill and knowledge gap

10. Quantity of water

Some water supply schemes encountered with water shortage after construction and during the service period, which is less than the design discharge and capacity. This problem leads the community for breaking of pumps by prolonged stroking until sucking water; demolishing of the structure for searching pure water and others. The problems related to not enough water are:-

- Source yield is decreasing through time.
- Drying of the scheme during summer seasons
- Prolonged stroking for water well pumps

11. Quality of the scheme

The main target for constructing water scheme is to extracting pure and potable water from water sources. Due to dozens reasons quality of water became below the standards. Human activity and interface is one of the major reasons for declining water quality. The main reason for developing impurity in water sources and indicators for poor quality of water are:-

- Water borne and water related disease
- Poor sanitation system in the community
- Unprotected water schemes
- Drainage problems
- Poor environmental protection and other related

12. Others

Non functionality causes that are not related to the above category leis on others groups. Some non functionality problems don't be categorized in the above groups. Hence it is mandatory to distinguish it in to its own group. The following problems categorized under others groups.

- Natural disasters like land slide, erosion etc.
- Physical damage by human interfere
- Closing of water site for construction or other purposes and related problems.