JIMMA UNIVERSITY

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SCHOOL OF GRADUATE STUDIES

SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

SUSTAINABILITY ISSUE OF RURAL WATER SUPPLY SCHEMES: CASE STUDY IN SHASHEMENNE AREA OF WEST ARSI ZONE

A Thesis Submitted to the School of Graduate Studies of Jimma University in Partial Fulfillment of the Requirements for the Degree of Masters of Science in Hydraulic Engineering

By

Abebe Muleta

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Co-Advisor:- Ato Andualem Shegute (MSC)

March, 2016

Jimma, Ethiopia

Declaration

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

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Candidate	Signature	Date

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

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Advisor	Signature	Date

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Co-Advisor	Signature	Date

Abstract

Great effort has been put forth to increase the number of people with access to safe water supply, adequate sanitation and hygiene in the developing world. Access to safe drinking water supplies, sanitation services and the sustainability of rural water supplies in Ethiopia are among the lowest in Sub-Saharan Africa. In addition a number of newly constructed schemes fail to function soon after handed over to the community for use and thus, holding back coverage from meeting target plans.

This research therefore aims to assess the technical and management factors that affect the sustainability of rural water supply schemes in Shashemanne District, West Arsi Zone. Furthermore, it deals with the institutional, financial, technological and technical factors impacting sustainability of the schemes, deals with the sustainability analysis for the representative sample of rural water supply scheme and issues for best practice guidelines for development practitioners to bring about improved sustainability of the schemes.

Both qualitative and quantitative data were collected besides; reviews of archived document were carried out. A documentation review was carried out for all available documents regarding water scheme plans implementation as well as for monitoring and evaluation. Additional information to supplement the documentation review and to obtain a deeper understanding of the issues was collected through interviews and discussions conducted with those considered the main stakeholders. Accordingly, data collection activities were then divided into community (scheme) and District levels. At community level, FGDs for WASHCO and residents in each user community; WASHCO resource mapping; and key informant interviews and KAP surveys were conducted. At District level, institutional resource mapping; institutional mapping/analysis; and interviews and KAP surveys of the DWMEO were carried out.

Findings show that the District is currently accessed with 30 deep and shallow wells with distribution, 5 springs with distribution network, 21 springs on spot 20 hand dug wells fitted with hand pump and 120 water points. The District water coverage is found to be 86% at the year of 2015. In the study area, there is a high rate of scheme failure, with approximately 34% of schemes not in use. When scheme breakdowns occur, the speed of maintenance is slow. Maintenance on minor breakdowns is performed within 2 weeks, where as major breakdowns take a minimum of 2 month, at an average of 6 months.

The time taken to fetch water10 min to 5h (roundtrip), with an average of 2h and 15 min; which exceeded WHO and UAP recommended at 30 min of walking time for a roundtrip, equivalent to a distance of about 1km and 1.5km radius respectively. Queuing time varies from season to season. The average roundtrip including waiting time was found to be 5h in the dry season and 2h in the wet season. The average per capita per day water used found to be 10l

Generally, the findings on sustainability and service levels in Shashemane district reflect a critical situation. Poor scheme management, poor design and construction quality, poor status of O and M, feeble links between participatory planning, governance and scheme sustainability. The reliability of the sources is questionable owing to recurrent drought, annual rain fall drop and ground water depletion.

Enhance rehabilitation and maintenance of non-functional schemes, Strict follow-up and supervision during the design and implementation of newly constructed schemes, conserving the natural resources in order to minimize the groundwater depletion and monitoring the quality of water supply sources, insure the sustainability of water supply schemes.

***Key words**:-Sustainability issues; Rural water supply schemes; Sanitation and hygiene; Technical and management factors; Community awareness.*

Acknowledgement

Prior to all, Glory and honor to be the Almighty of God who helped me from the very beginning of my step to this destination. Surely, I can say if it had not been for his generous help I could not have reached to this step.

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I also want to appreciate the support and cooperation from the Water Sector organizations in Oromia Water, Mineral and Energy Bureau and Shashemanne District Water, Mineral and Energy Office especially, Water supply facility management division of head and staff members of both sides.

I give my genuine thanks to my loving family who believed in me and have supported me all the way and suffered a lot in my absence, I dedicate this piece.

Finally my grateful thanks go to all concerned staff members of Jimma University Institute of Technology for their assistance and giving full attention for the program in collaboration with Ministry of Water, Irrigation and Electricity.

Contents

LIST OF TABLE

LIST OF FIGURE

ACRONOMY

ACC	Accountant
ADB	Africa Development Bank
ADD	Average Day Demand
ADF	Africa Development Fund
BA	Bachelor of Art
BOWME	Bureau of Water Mineral and Energy
BOWR	Bureau of Water Resource
CDI	Center for Development Initiation
COMD	Community Development
DCI	Ductile Iron
DEVT	Development
DFID	Department for International Development
DPHE	Department of Public Health Engineering
DWMEO	District Water Mineral and Energy Office
EMT	Electro Mechanical Technician
ETB	Ethiopian Birr
FGD	Focal Group Discussion
GIS	Global Information System
GPS	Global positioning System
GSI	Galvanized steel Iron
GTP	Growth and Transformation Program
IMF	International Monetary Fund
IRC	International Rescue Committee
IWRM	Integrated Water Resource Management
JICA	Japan International Cooperation Agency
KAP	Knowledge Attitude Practice
l/s	Liter per second
LAR	Long-term Action Research
m/s	Meter per second

MDD	Maximum Day Demand
MDG	Millennium Development Goal
mH_2O	Meter of Water
MOWR	Ministry of Water Resource
NGO	Non- Governmental Organization
O & M	Operation and Maintenance
ONRG	Oromia National Regional Government
OWMEB	Oromia Water Mineral and Energy Bureau
PASDEP	Plan for Accelerate and Sustained Development to End Poverty
PHD	Peak Hour Demand
PRSP	Poverty Reduction Strategic plan
RWSS	Rural Water Supply and Sanitation
S/A	Saving Account
UAP	Universal Access Program
UNDP	United Nation Development Program
UNICEF	United Nation International Child Emergency Fund
US$	US dollar
USAID	United State of America International Development
VLOM	Village Level Operation and Maintenance
WAE	Water Aid Ethiopia
WASHCO	Water, Sanitation and Hygiene Committee
WHO	World Health Organization
WSS	Water Supply Service
ZWMEO	Zone Water, Mineral and Energy Office

CHAPTER ONE

INTRODUCTION

1.1 BACK GROUND

Water is essential for human life. It plays a vital role not only for the survival of human life, but also for all forms of life. So, every person possesses a subconscious concern to maintain preserve and defend the access to the water which they need for their own.

In 2008 it was estimated that 884 million people worldwide were living without access to safe water and 2.5 billion people lacked adequate sanitation (UNICEF, 2008). Water has been implicated in 80% of all sickness and disease worldwide through inadequate sanitation, polluted water, or unavailability of water (WHO, 2007). At any given moment it has been estimated that half the world's hospital beds are occupied with patients suffering from water-related diseases (UNDP, 2006).

Africa, despite having much lower population than Asia, accounts for almost one-third of the global population without access to potable water supply, and has the lowest service coverage figures of any continent. Around 6% of the global burden of disease is water-related, and diarrheal and related diseases are responsible for the death of two million people a year, most of them children under five (WHO/UNICEF, 2000). The provision of safe water supply accompanied by adequate sanitation services and hygiene education represents an effective health intervention that significantly reduces morbidity and mortality related to diarrheal disease UNICEF, 2006).

The MDG agreed at the United Nations in 2000 is to halve by 2015 the proportion of people without sustainable access to adequate and affordable safe drinking water (Annan, 2000). This goal will be much harder to achieve in Africa than in the rest of the developing world due to the low levels of existing coverage coupled with high population growth rates in some areas. This is further compounded by the fact that existing services demonstrate limited sustainability throughout the continent

According to the World Health Organization and the United Nations Children's Fund rural water coverage in Africa was 45 % in 2000, compared to 40 % in 1990, still leaving 237 million people un served (WHO/UNICEF, 2000). Meanwhile, urban water coverage in Africa was much higher at 83% in 2000, with only 37 million urban dwellers un served. It is clear rural areas of Africa are lagging significantly behind urban areas in water supply. This fact coupled with high poverty levels in many rural areas and depressed levels of service sustainability, indicates a critical need for focused attention to the provision of potable water to rural communities in Africa.

Access to safe drinking water supplies and sanitation services in Ethiopia are among the lowest in Sub-Saharan Africa. Access to safe potable water for urban areas was 91.5 %, while the access to potable water in rural Ethiopia is about 68.5% (within 1.5 km) in the year 2010.In Ethiopia, investment in rural water supply forms a major plank of the government's poverty reduction efforts. The challenge is huge: Ethiopia's 2008 PASDEP progress report, based on sector data, records rural water coverage at 54% and the country has the highest absolute number of people without access to improved water supply and sanitation in Sub-Saharan Africa.

The sustainability of community-managed rural water supply schemes is a key factor in meeting the MDGs, in terms of ensuring environmental sustainability, improving health and eradicating extreme poverty for the overwhelming rural majority living in the developing world.

In the majority of cases, it is rural poor communities that are socially and economically affected by water inadequacy and subsequent poverty. The quality of potable water and the threat of water borne diseases, such as cholera and typhoid, are critical public health issues in many developing countries (ADB, 2002). Moreover, worldwide, poor sanitation practices and lack of safe and clean water for drinking, cooking and washing are responsible for over 12 million deaths each year (USAID, 1990).For instance, about 2.3 billion people across the world, most of them in developing countries, suffer from disease linked to water unavailability, inadequacy or contamination (POPLINE, 2000; UN, 1997).

Although these problems are diverse and complex, it cannot be denied that one of the most important factors behind them is the non-sustainability of community-managed rural water supply schemes. Governments, nongovernmental organizations and donor agencies are striving to scale up water supply and sanitation coverage in developing countries at the same time as the non-functionality rate of those water supply schemes installed is increasing. It is an alarming fact that, in most developing countries, an estimated 30 to 60% of existing rural water supply schemes are inoperative at any given time (Brikké and Bredero, 2003), with serious impacts on the health and welfare of the people.

Several factors affect the sustainability of water supply schemes in rural areas. A water supply services if sustainable, (Brikké, 2002):

- It is functioning and being used;
- It is able to deliver an appropriate level of benefits in terms of quality, quantity, convenience, continuity and health to all, including the poorest women and men;
- It continues to function over a prolonged period of time (which goes beyond the lifespan of the original equipment);
- Its management is institutionalized;
- The management of the service involves the community (or the community itself manages the system);
- It adopts a perspective that is sensitive to gender issues;
- It establishes partnerships with local authorities;
- Its operation, maintenance, rehabilitation, replacement and administrative costs are covered at local level through user fees or through alternative sustainable financial mechanisms;

Thus, the dimensions of sustainability of water supply scheme and its service delivery are multifaceted. There are social, technical, financial, institutional and environmental issues to be addressed (Brikké and Bredero, 2003). To sustain water supply schemes, it is vital to have the involvement of all segments of the community, in the form of full participation and control over the scheme's (O and M), overall management, strategic decision making, ownership and cost sharing for O and M and construction activities (Lockwood, 2004). Such community management has to be backed by the technical support/assistance of external agents (government or NGO) over a long period of time, relating to O and M, training, monitoring, information collection, coordination and facilitation aspects (Lockwood, 2004; Brikké and Bredero, 2003).

Sustainability issues are also associated with the ability to give backstopping support to the new community indefinitely; to bring legal accountability to financial management by auditing WASHCOS; to facilitate disagreements and resolve conflicts (Schouten and Moriarty, 2003). Moreover, several actors at different levels and degrees of participation have to be involved to sustain community-managed water supply schemes. These include the community in which the service is being delivered, government DWMEOs, NGOs working in the water sector and private service providers (construction and maintenance activities and supply of spare parts) (IRC, 1993).

The sustainability of rural water supplies remains problematic in much of sub-Saharan Africa. Different studies estimate functionality of rural water supply schemes to be between 30 and 40% (Evans, 1992; Lockwood and Smits, 2011; RWSN, 2007). The corresponding level of failure represents a total investment of between $1.2 and $1.5 billion in the last 20 years. That equates to approximately $60 million wasted per year (RWSN, 2009). Appreciating the degree of non-functionality and understanding the underlying reasons will be crucial to defining appropriate actions to improve the situation.

This research therefore assessed technical and management factors that affect the sustainability of rural water supply schemes. Furthermore, it addressed sustainability analysis for the representative sample of rural water supply schemes in Oromia region west Arsi Zone of Shashemanne District. In order to conduct the study, both qualitative and quantitative data were collected besides to these; reviews of archived document were carried out. Different software like, excel spread-sheet, water-cad version6.5, Global Map per and Arc GIS were used in this research

1.2 STATEMENT OF THE PROBLEM

Ethiopia is one of the developing countries suffering from the consequences of poor water supply coverage and especially the rural community had to endure severe problems. The national safe drinking water coverage of the country has not been improved that much, and this holds very true taking in to account the situation of rural areas where 84% of general population lives (ADF, 2005). Approximately 40% of rural Ethiopia (Water Aid, 2010) still lacks access to clean water despite rigorous effort by the Ethiopian government to increase water supply in the country. In addition to the fact that there is an inadequate financial capacity to implement schemes, most studies reveal that, poor sustainability of developed schemes is the core problem challenging the efforts to improve rural water supply coverage. A number of newly constructed schemes fail to function soon after handed over to the community for use and thus, holding back coverage from meeting target plans. The problem is worse in the country, where it is quite a common phenomenon to observe non-functional water sources without adequate protection, such as fencing, in every part of the country. In the Oromia region, for example, about 35% of the rural water systems are not properly functioning (WAE, 2008).

The study area is situated in rural parts of the country, where most of the water supply systems are improper and insufficient service delivery. The problem is continued to be points of discussions in most of the country's rural water supply schemes and the urban water supply services. Most of the water supply schemes were in the deteriorating conditions where above 50% of the systems failed to serve their targets and design lives. A substantial proportion of water supply infrastructure is believed to be either not-functioning or functioning sub-optimally at any given time. So far, operation and maintenance activities executed by regional bureaus, zonal departments and urban water supply services are hardly understood. All activities are breakage oriented and response is given when system failures are reported. In most cases there are no consistent maintenance schedules, no regular supervision and inspection. Monitoring and design standards are also not yet set up.

Not to deter from the enabling facts of autonomous water enterprises, it is also clear that the water bureaus share large responsibilities of studying, designing, financing and Operation and Maintenance management of urban and rural water supply schemes, with little or no responsibilities vested on the communities concerning sustainability of the system, the overall product of the water works implementation

In addition, zonal offices are not adequately developed to provide sufficient and adequate technical and engineering supports for studies, repairs, fulfilling required manpower and their transportation methods in accordance to professional ethics to attend promptly to breakdowns in widely dispersed rural systems with poor road links. As a result the lives of schemes become short and project failures are enormous and clean and adequate water coverage has remained low.

Thus, this research assessed technical and management factors that affect the sustainability of rural water supply schemes and forward remedial solution in the study area.

1.3 OBJECTIVE

1.3.1 GENERAL OBJECTIVE

- To asses technical and management factors that affect the sustainability of rural water supply schemes in West Arsi Zone.

1.3 .2 SPECIFIC OBJECTIVES

- to examine the institutional, financial, technological and technical factors impacting sustainability of the schemes.
- to conduct sustainability analysis for the representative sample of rural water supply systems.
- to identify issues for best practice guidelines for development practitioners to bring about improved sustainability of the scheme.

1.4 RESEARCH QUESTIONS

- What are the main factors that affect sustainability of rural water supply schemes?
- How can we describe the sustainability of rural water supply scheme?
- What is the best practice to bring improved sustainability of schemes in the study area?

1.5 SIGNIFICANCE OF THE STUDY

This research will provide valuable information on the extent of inappropriate selection of technology, poor construction, less community participation in assumptions, and exercised management model affect the sustainability of rural water supply schemes.

Also, it gives an insight for local studies and investigations to understand how the rural water supply schemes in the area perform under the local conditions of operation and management

CHAPTER TWO

2. LITERATURE REVIEW

Water is essential for human life. It plays a vital role not only for the survival of human life, but also for all forms of life. So, every person possesses a subconscious concern to maintain preserve and defend the access to the water which they need for their own survival (Jack, 2009). To supply water for urban and rural community, there are different forms of organization in different countries. Water supply management is pivotal to ensure sufficient amount of good quality water for the community. As a result, water management has emerged as an essential part of the organizational structure of community life. This management starts from the simplest family groups and has gradually become complex and more important in response to the situation caused by water scarcity or increasing population density (Jack, 2009). Roark, Hodgkin and Wyatt (1993), defined management for water supply as the marshalling of resources to plan, direct, monitor and evaluate the O and M of water supply and sanitation (WSS) systems. To manage the services various management models are also working in practice. These are namely, self-management, community management, private and public management. The management type also varies with technical options used and geographical location. Among these models, community water supplies are managed mainly by community itself, private operator or state owned utility. Till date utility services, like, water supply are provided by state owned monopolies all over the world (Wallsten and Clarke, 2002). In public sector management, water supply is managed through municipal utilities or local government providers (Lockwood and Smits, 2011). Until 1980, most of rural water supply were delivered and managed by Government institutions through supply driven approach (Harvey and Reed, 2007). In most of the cases, the efficiency of such management systems was found poor due to inadequacy of government capacity and commitment leading to the level of sustainability at very low ebb. High costs, insufficient supplies and chronic deficits are some of the noticeable weak points of purely public managed water supply (Lewis and Miller, 1987).

2.1 RURAL WATER SUPPLY SITUATION IN DEVELOPING COUNTRIES

A rural water system is a water supply and distribution system that is built for low density, predominantly unincorporated rural areas. Rural water systems primarily serve domestic and livestock needs and usually do not meet firefighting requirements. A common feature of rural water systems is that they predominantly un-looped and have dead ends (Robinson, 1976). Rural water systems are normally operated by rural water associations. A rural water association is a non-profit corporation whose primary function is to finance, construct, operate and maintain a rural water distribution system.

Lack of water supply and sanitation services are alarming globally. More than 884 million people do not have improved drinking water supply; almost all of them are from developing regions and 84% of them live in rural areas (WHO, 2010). Globally around 10% of total burden of diseases are related to unsafe water, sanitation and hygiene and it costs 3.6 million lives annually (Pruss-Ustun et al., 2008). At any moment, half of the developing world's population suffering from diseases associated with inadequate water supply and sanitation services and more than half of hospital beds in the world are filled with people suffering from water related diseases (DFID, 2009). Therefore, access to improved water and sanitation is the cornerstone for healthy communities and plays a significant role for maintaining health, economic and social gains (Bartram et al., 2005; Hutton, Haller, and Bartram, 2007; Montgomery and Elimelech, 2007). World Bank (2009) identified two big challenges for sustainability of rural water supply, one is continue to expand access and another is the high breakdown rate of water supply options. A large percentage of non functional water supply wells and unused latrines are the stark marker of poor operation and maintenance and proof of unsustainable services (Montgomery, Bartram, and Elimelech, 2009). Several global studies have witnessed the unsustainable picture of water supply, especially in developing countries. Briscoe and de Ferranti (1988), mention that one in every four rural water supplies in developing countries does not work and that in some countries the construction of new facilities does not even keep pace with the failure of existing ones. A number of water and sanitation program in developing countries have not "continued to work overtime" (Tyrrel and Howsam 1999).

The tremendous investment in rural water supply during the decade had resulted, inter alia, in a tremendous increase in the number of broken down, poorly functioning, and little used water supply (Kleemeier, 2000). In Africa more or less 250000 hand pumps were installed, out of which only less than one half was operational (HTN, 2003). Water supplies become non-operational within a few years of implementation and the next rehabilitation or development project begins (Harvey and Reed, 2003). A study conducted by Mackintosh and Colvin (2003) in the Eastern Cape found that more or less 70% of the boreholes were not functioning. Another survey conducted on 11 countries in Sub-Saharan Africa showed a range from 35-80% of water supply systems were non functional in rural areas (Sutton, 2004). Haysom (2006) surveyed 7000 wells and boreholes in Tanzania and found only 45% were in operation. DPHE and JICA (2008), studied on 120 village piped water supply schemes in Bangladesh to assess operational status of the systems, which showed only 48% of the schemes were functioning during the survey, whereas, 13 and 39% were partial functional and non-functional respectively. Therefore, irrespective of technical options, non functionality of a huge number of systems fades the sustainability of the rural water supply

2.1.1 DEFINITION OF SUSTAINABILITY AND RURAL WATER SUPPLY

Many researches in water and sanitation sector have tried to define sustainability from different perspectives. In water supply, sustainability has been studied by various researchers lighting shed on its different aspects and recommends for adopting sustainability factors for supplying of safe water in the rural areas.

Sustainability is now a very common word found in almost all the project proposal document as an objective of any water supply and sanitation program (Parry-Jones, Reed, and Skinner, 2001). Literary meaning of sustainability given by Shorter Oxford English Dictionary (1973) is "to keep or maintain at the proper standard". However, sustainability defined by WCED (1987) as "meeting the needs of the present without compromising the ability of future generations to meet their own needs". This definition encompasses both the development and environmental dimension of sustainability. Hodgkin (1994) clarifies sustainability more specifically for water supply and sanitation projects. He defines as: "sustainability is the ability of a WSS development project to maintain or expand a flow of benefits at specified level for long period after project inputs have been ceased".

However, more simple and workable definition of sustainable water system is seemingly given by Sara and Katz (1997) is that the system, which is able to provide an acceptable level of services all through the design period of the water supply system. Abrams, Palmer, and Hart (1998) state sustainability very simply “it is whether or not something continues to work overtime”. They elaborated definition for water service as water continues to be available for the period for that it was designed in the same quantity and at the same quality as it was designed. Webster et al., (1999) define sustainability of rural water and sanitation projects, where the system functions continuously with maintaining physical and nonphysical components of the project active, continues the benefits to the beneficiary level after external support is stopped. Harvey and Reed (2003) defines sustainable rural water supply covering most of the aspects of sustainability. He argues that it is sustainable when “the water sources are not over exploited but naturally replenished, facilities are maintained in a condition which ensures a reliable and adequate water supply, the benefits of the supply continue to be realized by all users over a prolonged period of time, and the service delivery process demonstrates a cost-effective use of resources that can be replicated”.

Even a cursory look over the above-mentioned definitions reveals several key issues of sustainability in water and sanitation sector which are as follows:

- Long term external support should be minimal
- Operation and maintenance costs should be financed by users
- Flow of benefit should be continued over a long period

Sustainability has several dimensions. Sara and Katz (1997) divided sustainability under three components. These are technical aspects, institutional aspects and social aspects. Researchers have identified system design and construction quality as the most influential technical factors for sustainability. As for institutional aspects, water committee, O and M of the system and money collection are the vital institutional determinants for system sustainability. Socio-economic factors like income level, willingness of the users to allocate time, availability of adequate fund and labor too are equally important and vital sustainability issues to maintain the system functioning.

Apart from this, many other researchers have described sustainability of WSS projects taking five dimensions into account, namely institutional, social, technical, environmental and financial or economic (Abrams et al.,1998; WELL, 1998).

Harvey and Reed (2004) have identified eight sustainability factors. These are policy context, institutional arrangements, technology, natural environment, community and social aspects, financing and cost recovery, maintenance, training and capacity building.
Giné and Pérez-Foguet (2008) have added managerial dimension also in the sustainability loop and claimed that institutional, social, technical, environmental, financial and managerial factors are interrelated (Figure 2.1).

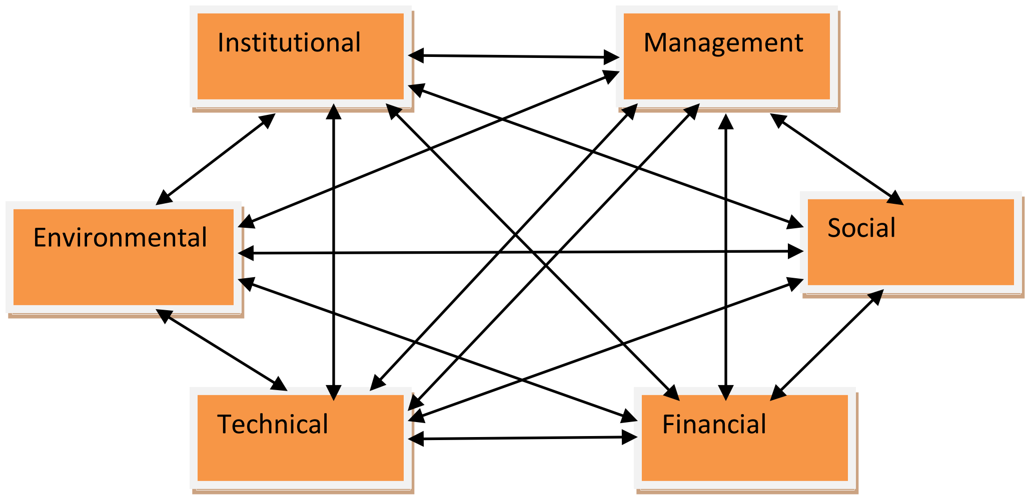

Figure 2.1 Factors affecting sustainability (Gine and Perez- Foguet, 2008)

According to Montgomery et al. (2009), three sustainability components are universal, which lead to long term functioning of water and sanitation supplies. These are effective community demand, local financing and cost recovery, dynamic operation and maintenance. These researchers have also recognized some enabling factors for each of the sustainability components, participatory planning, appropriate technology choice and social marketing influencing effective community demand, local financing and cost recovery influenced by local borrowing and saving schemes, financial planning and community cross-subsidies. Clear management responsibilities, accessible spare parts or technical expertise, monitoring and evaluation, and ongoing outreach and support are the enabling factor for dynamic operation and maintenance.
Several researchers have also depicted sustainability as a dynamic mechanism (Carter et al., 1999; Sugden, 2001) has proposed a sustainability chain consisting of four essential components (Figure 2.2). The missing of any one of these may endanger the sustainability of whole system.

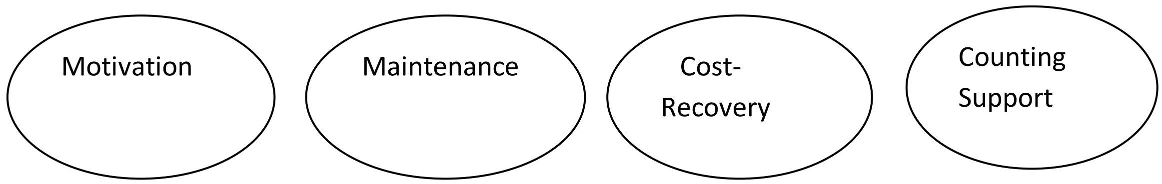

Figure 2.2 the sustainability adopted from Carter et al., 1999

Community motivation encourages community to utilize the new service. Through appropriate motivational activities beneficiary people become aware that the new service source is beneficial by comparison with the previous water service in terms of access, or proximity and safety. Management committee within the community and caretaker, Government organization, Non-government organization, and private sector entity involved in service providing need to perceive participation and the delivery of high quality services.
Maintenance level for water supply system depends on the nature and type of technology. By and large, for all types of technology a clearly structured, resourced and trained maintenance organization is essential. For community management systems, committee appoint caretaker for maintenance. But most of the cases, they need help from backstopping agency like government or NGO. So, communication line between community and backstopping agency is vital for low down maintenance response time.
Cost recovery is vital issue for financial sustainability of any scheme. Cost recovery required for staffing, training, transport, spare parts, materials, tools, and replacement of units. It is necessary to fix up the cost recovery mechanism such as the basis of payment, the means of administering and accounting for water charges by the community. Better cost recovery can ensure sustainability of schemes.
Water supply is a long term function. In developing countries water and sanitation facilities work long time if service is managed jointly by community and external support agencies. So it is essential to deploy government agencies or NGOs for follow-up support. In consideration of this fact, Mazango and Munjeri (2009) have also acknowledged external support as the vital factor which affects sustainability of water supply.
Abrams et al. (1998) also classify the relative importance of sustainability in two phases of service-one is initiation phase and the other one is ongoing phase. Initiation phase is the establishment phase of service. It covers recognition of service need to planning, design and construction of service, the establishment of the institutional framework and initial

commissioning. The ongoing phase is the rest of service life. It deals with operating the services to satisfaction of the consumer, collecting the revenue, maintenance of the infrastructure, administration and all of the day to day activities. Considering sustainability, it is suggested that there are some activities which may promote sustainability with respect to both initiation and continuation phase. For initiation phase sustainability, the points like demand driven development, capacity building, community awareness, project initiation and the development of key performance indictor are worth-mentioning. But by contrast, very little thought has been put in place for continuation phase. However, the continuation phase sustainability is heavily contingent on the institutional arrangement of local government, District councils, Provincial Government and the National Government. It is vital to establish institutional support system which has the capacity to perform their function to survive and deliver real service to consumer.

Table 2.1 Varying definitions and descriptions of sustainability relevant to rural water supply and sanitation

Sustainability Focus	Definitions/Descriptions	Sources/Related Citations
Environmental	Use or degradation of resources at a rate less than or equal to their replenishment or assimilation rates	WURZEL, P. (2001)
Ecological	Ability of an ecosystem to maintain ecological processes, functions, biodiversity, and productivity into the future.	REO (2009)
Institutional or Management	"Prevailing structures and processes have the capacity to continue their functions over the long term."	DFID (2000)
Economic	Within water and sanitation sector: financial aspects of service delivery and self-sufficiency of projects and cost sharing (user fees) even in low-income communities.	Black (1998)
Project	A project is sustainable if 1) sources not over-exploited 2) facilities maintained 3) benefits continue 4) project process cost-effective	Mancinni et al (2004), Harvey et al (2003)
Social	Socio-cultural respect, community participation, political cohesion	McConville et al, (2007)
Pragmatic	"Whether or not something [infrastructure] continues to work over time."	Abrams (1998)
Triple Bottom Line: Ecological, Economic, Social	"Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs."	WCED (1987), Mihelcic et al (2003)
Flow of Benefits	Perceived benefits of projects. An improvement in the health and the subsequent positive impact on the broader welfare of the rural populations."	Lockwood (2003)
	"The resilience to risk of net benefit flows over time."	OED (2003)
Social Equity (gender & economic capacity)	Satisfactory functioning and effective use of services by everyone (men and women, rich and poor) having equal access to benefits	Mukherjee and van Wijk (2003)

2.2 SUSTAINABILITY OF WATER RESOURCE

The following steps can be used by the implementing agency in conjunction with the community to be served to ensure appropriate technology choice to maximize sustainability (Figure. 2.3)

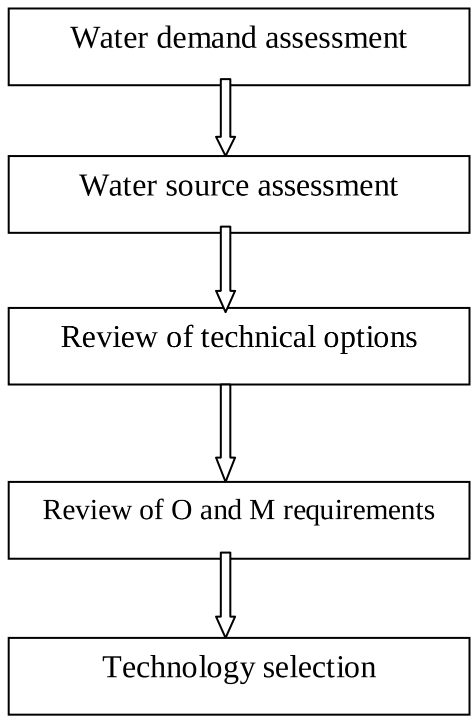

Figure 2.3 Steps to be used to maximize water resource assessment

Step1. Water demand assessment

The first step is to undertake an assessment of the demand for a new water supply among community members. This should measure the:

- Quantity of water required per day or required flow rate;
- Quality of water required (i.e. for drinking, cooking, washing etc.); and
- Acceptable maximum distance from water source required

This will be achieved through consultation with individual community members and focus groups. Random consultation can be carried out by interviewing an individual from every third house in the village and selecting a male then female in turn. This exercise will provide the ideal characteristics required of the water supply.

Step 2. Water source assessment

An assessment should then be conducted of all possible water sources in the vicinity, including existing or traditional sources used by the community and other potential but untapped resources. The characteristics of these water sources should then be matched to the ideal requirements of the community. A range of sources or a single source may be identified which best meets the community demand.

Step 3. Review of technical options

Based on the water source(s) identified, a range of possible technologies should be investigated. For example, if groundwater is identified as the most appropriate water source, options would include open hand-dug wells, hand pump-equipped boreholes, and electrical borehole pumps and distribution systems. All possible options should be listed and presented to the community. Household solutions should be considered as well as community options.

Step 4. Review of O and M requirements

For each technical option identified the O and M requirements must then be assessed. These will include the tools, spare parts, skills, management needs and finances required to sustain operation and maintenance. The requirements should be presented beside the listed options and matched to current capacity to fulfill each of these. A consultative process should be used to establish whether the necessary skills, equipment and finances are available for each option and whether they will continue to be available for the foreseeable future.

Step 5. Technology selection

The final step in the process is to determine which technology option can:

- Deliver the appropriate quantity and quality of water to an acceptable location;
- Be operated and maintained by the community/households at affordable cost; and
- Be replaced or upgraded with relative ease.

The final selection should be made by the community of users and where a number of options remain at this stage consensus should be sought by majority preference.

Even where the most appropriate technology choice is selected this is not a guarantee of sustainability, as social, managerial and financial issues will all have an influence. Technical monitoring also has a crucial role in ensuring technical and environmental sustainability

2.2.1 SUSTAINABILITY OF SURFACE WATER RESOURCE

Water that does not infiltrate the ground is called surface water. Surface water appears either as direct runoff flowing over impermeable or saturated surfaces which then collects in large reservoirs and streams or as water flowing to the ground from surface openings. As water flows across surfaces, it picks up contaminants which may be harmful to humans and carries them into surface water sources. In order to use it for drinking, a surface water source must either be well protected or treated.

Surface water sources such as springs, ponds and lakes can be developed for drinking water but special care must be taken to ensure the quality of the water. Springs generally offer the best alternative in terms of cost, water quality and maintenance. Spring water also is cool and fresh-tasting and very acceptable to the users. Ponds and lakes offer good, accessible quantities of water. Water from ponds and lakes is easily delivered to users by installing intakes. Ponds, lakes, and especially small community ponds are often exposed to contamination. Generally, water from them should not be used unless adequate treatment is available.

Streams and rivers also provide good sources of water if developed properly. Stream and river water that is naturally filtered into wells offers a good, low-cost method for using surface water. Untreated stream water from higher elevations is also available at low cost to the user. Near estuaries and at low elevations, contamination is likely and care must be taken before water is used.

Ground catchments provide a fairly good quantity of water and, with storage; a ground catchment system can meet the needs of a community. Ground catchments are expensive to install and use large areas of land which is scarce in many regions. The choice of a method depends on many factors including the source and resources available and community preferences.

2.2.2 SUSTAINABILITY OF GROUNDWATER RESOURCE

Ground water contributes fresh water of people’s 20%worldwide about. Despite this relatively small proportion its role is important for two reasons: On the one hand, ground water is well suited for the supply of drinking water due to its usually high quality. On the other hand, ground water basins are important long-term storage reservoirs, which in semi-arid and arid countries often constitute the only perennial water resource. The storage capacity is evident if one compares the volumes of surface and ground water resources. Globally the volume of fresh water resources in rivers and lakes is about **100,000 km^3**. With about **10,000,000 km^3**, the volume of ground water is two orders of magnitude larger (Gleick, 1993; Postel et al., 1996). For sustainable water management, however, the renewal rate is more relevant, and for this quantity the situation is reversed. The renewal rate of surface water resources is **30,000 km^3/a**, that of groundwater only about **3,000 km^3/a**. Worldwide, about 800 km^3 of groundwater are utilized by mankind annually. This number still looks considerably smaller than the yearly renewal rate. However, the global comparison does not do justice to the real situation. Average figures hide the fact that of the yearly withdrawal rate about one quarter is supplied by non-renewable fossil ground water reserves (Sahagian et al., 1994).

A ground-water system consists of a mass of water flowing through the pores or cracks below the Earth's surface. This mass of water is in motion. Water is constantly added to the system by recharge from precipitation, and water is constantly leaving the system as discharge to surface water and as evapo-transpiration. The one common factor for all ground-water systems, however, is that the total amount of water entering, leaving, and being stored in the system must be conserved.

Perhaps the most important attribute of the concept of ground-water sustainability is that it fosters a long-term perspective to management of ground-water resources. Several factors reinforce the need for a long-term perspective. First, ground water is not a nonrenewable resource, such as a mineral or petroleum deposit, nor is it completely renewable in the same manner and timeframe as solar energy.

Three terms that have long been associated with ground-water sustainability need special mention; namely, safe yield, ground-water mining, and overdraft. The term "safe yield" commonly is used in efforts to quantify sustainable groundwater development. The term should be used with respect to specific effects of pumping, such as water-level declines, reduced stream flow, and degradation of water quality. Groundwater mining typically refers to a prolonged and progressive decrease in the amount of water stored in a groundwater system; “groundwater mining” typically refers to a prolonged and progressive decrease in the amount of water stored in a ground-water system. Thus, overdraft may refer to groundwater mining that is considered excessive as well as to other undesirable effects of groundwater withdrawals

2.3 POLICIES AND STRATEGIES AFFECTING WATER SUPPLY SUSTAINABILITY

There is a wide range of government policies and strategies that affect rural water supplies, some directly, others indirectly. Many of these have a significant impact on the sustainability of water services, intentionally or otherwise

A number of general national policies influence sustainability. Many African countries have developed similar generic policies due, primarily, to the influence of the IMF and World Bank. The most common of these are policies specific to promote the water sector, such as

- Community management of water systems; and
- Technology standardization

The World Bank (2004) aims to assist policy-makers and sector departments to design PRSP water and sanitation strategies that actively address the needs of the poor. The approach used is to:

- Provide guidance on analysis of the linkages between poverty, water and sanitation;
- Assist in identifying problem areas that require intervention and in defining objectives;
- Provide a menu of possible public interventions, and a framework that assists in their prioritization;
- Assist in defining a monitoring and evaluation framework that allows reevaluation of the linkages, appraisal of poverty outcomes, and assessment of whether the chosen intervention has been effective.

Sustainable rural water supply has a number of positive effects on poverty reduction, such as reducing the burden of disease and money spent on medical treatment; releasing time previously used for collecting water for other activities; and facilitating income generation through productive use of water. Where existing policy and strategy papers fail to emphasize these links, advocacy campaigns may be necessary to highlight the need to incorporate rural water supply strategies into national PRSPs.

2.3.1 RURAL WATER SUPPLY STRATEGIES

Many African governments have ambitious targets for increasing rural water supply coverage in line with international targets such as the Millennium Development Goals. In general, these national targets include time-bound percentage coverage figures and set appropriate service levels in terms of liters per person per day, water quality standards and distance of water points from dwellings. Many African countries have developed rural water supply strategies in order to reach these targets. These strategies may be in the form of 5 or 10 year operational plans, or may cover longer time periods. Current strategies from different African countries are typified by the following:

The setting of minimum quantities of water per person per day;

- Water sector reforms that define water as an economic good and adopt an integrated approach to delivering water and sanitation services;
- A decentralized approach to service delivery in which the role of the public sector at all levels is mainly to monitor, regulate and facilitate the performance of stakeholders in O and M;
- A demand responsive approach to the delivery of community based water supplies, for which users are responsible for managing O and M to ensure sustainability
- Appropriate technology and research activities;
- Cost recovery in order to ensure sustainability;
- Monitoring stakeholder, system and sector performance; and
- IWRM promoting economic use of Water

Many national strategies are influenced by external donors and international organizations, and hence there is a significant degree of uniformity of policy among different countries, at least on paper. As a result, despite local differences in culture, environment and politics, many effects of policy and strategy are region, rather than country, specific

2.3.2 ETHIOPIAN WATER RESOURCE MANAGEMENT POLICY

Water supply and sanitation coverage in Ethiopia is among the lowest of all developing countries and even of most countries in sub-Saharan Africa. The country's water supply sub-sector has encountered a number of challenges throughout its development. Some of the factors that have affected the development process of the water supply sub-sector are as follows (MoWR, 2006):

- Water supply has not been reliable and sustainable;
- Water use has not been efficient;
- Programs and projects have not been objective-oriented;
- Plans have not been certain and clear;
- Water schemes have lacked a focus on good O and M of services;
- Integrated water supply and sanitation services have not been achieved; and
- There has been a lack of understanding that water demand includes livestock

At present, national safe water supply and sanitation coverage have reached 42.2% (41% rural and 78% urban) and 30% (21% rural and 80% urben), respectively (MoWR, 2007). The Ethiopian government (subsequently the regional governments) adopted the National Water Resources Management Policy in 1999 (MoWR, 1999) so as to increase and sustain water supply services in both rural and urban areas. The overall goal of the policy is to enhance and promote 'efficient, equitable and optimum utilization of water resources' for sustainable socioeconomic development.

The policy recognizes that water resources development, utilization, protection and conservation go hand-in-hand and ensures that water supply and sanitation, irrigation and drainage as well as hydraulic structures, watershed management and related activities are integrated and addressed together. Moreover, the policy stresses that water resources management has to integrate the development goals of other sectors, such as health and agriculture. The policy follows the principle that the water supply sector has to ensure that every Ethiopian citizen has access to water of acceptable quality to satisfy their basic human needs.

The government later adopted the UAP to scale up the water supply and sanitation coverage of the country and achieve 100% water supply coverage in most of the rural regions by 2012 (MoWR, 2006). This includes the ONRG. To attain this target, the UAP assumes that, to make water supply schemes sustainable, hand pumps have to be made locally and repaired by local technicians and, generally, pumps and generators have to be standardized in relation to village-level operation and maintenance (VLOM) for sustainable service

It has been estimated that 33% of rural water supply schemes in Ethiopia are non-functional at any time, owing to lack of funds for O and M, inadequate community mobilization and commitment and a lack of spare parts (MoWR, 2007). With regard to this issue, the UAP aims to rehabilitate and maintain existing water supply schemes in the first two years of its seven-year plan, so as to develop a maintenance culture and increase the sustainability of both the newly constructed and the existing water supply schemes (MoWR, 2006).

In the study region, ONRG, overall water supply and sanitation coverage in 2006 were at 42% (35.9% rural and 83.9% urban) and 20%, respectively (BoWR, 2002). There were 2,504 hand dug wells, 1,890 shallow wells, 641 deep wells, 4,386 spring developments with distribution points , 355 springs with network distributions,45 wind driven pumps and 13 solar pumps constructed by the regional government and NGOs in recent years (BoWR, 2006). However, it has been noted that a large number (23.5 to 26.3%) of the water supply schemes are non-functional at any given time, implying negative impacts on coverage and on the attainment of the UAP. To this end, the ONRG, BoWME aimed to increase the sustainability of water supply schemes from the current 81.52 to 100% within five years.

With this in mind, this research undertook a sustainability case study in the ONRG, West Arsi Zone of Shashemenne District to examine functionality levels of existing water supply schemes and to identify factors impacting on sustainability, following a bottom-up approach and offering recommendations for best approaches and practices for the upcoming LAR areas

CHAPTER THREE

3. METHODOLOGY

3.1 DESCRIPTION OF STUDY AREA

The study was conducted in Shashemanne District, West Arsi Zone of Oromia Regional State. Geographically the district extends from 08^0 10' to 08^0 43’N latitude and 40^0 28’E to 40^0 50’E longitude. The total aerial coverage of the study is approximately 665-km^2.

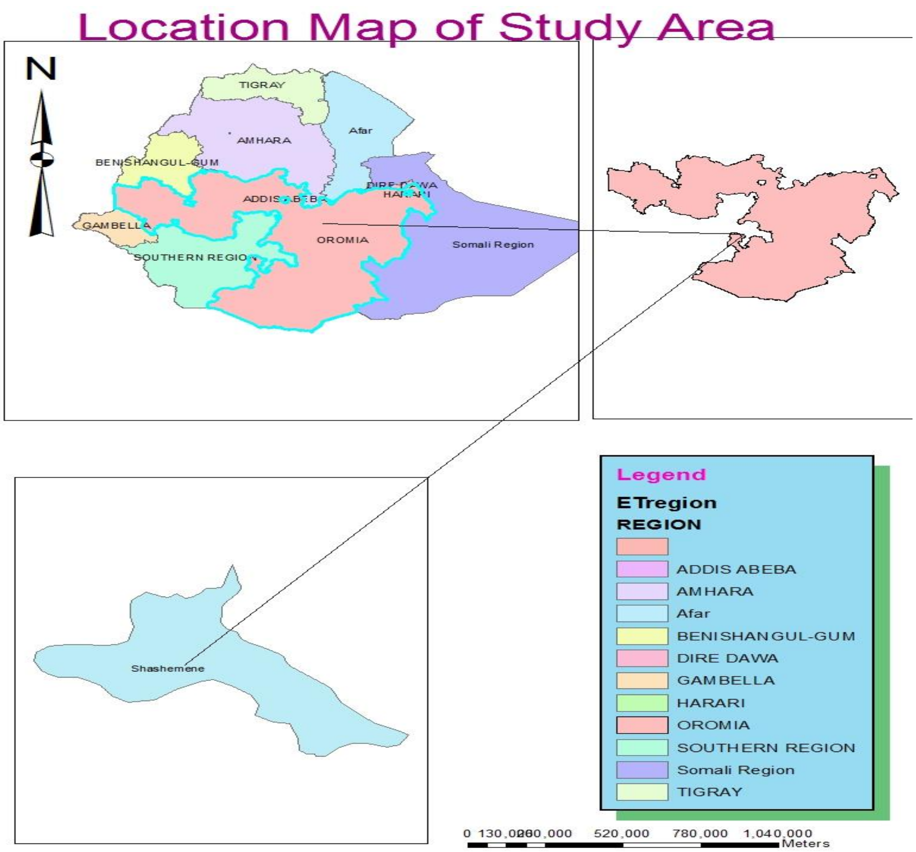

Figure 3.1 Location map of study area

Shashemane District is classified in to three major agro- climatic zones, such as Dega, Weinadega and Kollaa which is mainly due to the difference of altitude. This variation of temperature provides wide opportunities for the production of different types of crops range from warm to cool thermal zones.

The rainfall is weakly bi-modal with spring rainy season during the months of April and May while summer along rainy season during the months of July, August and September. Areas that have over 2722m .a.s.1 access to high and fair distribution of annual rainfall (700-1000mm). But the vast areas of the district (below 2722mm) have erratic and small annual rainfall varies between 550 - 700mm.

3.2 STUDY IMPLEMENTATION

The data collection process began after the checklists were prepared and analyzed (25, June, 2015).The data collection were under taken by a research principal, assistance and assigned District expert. Field activities were carried out in two phases and took a total of four weeks. In the first phase, scheme and water point mapping and FDGs took place in parallel at the community level. The help of DWMEO and assigned expert was indispensable right from the beginning, their role in communicating with the local community and recruiting individuals to help in explaining and coordinating for interviews and FDG was crucial.

In almost all cases, WASHCO and District experts participated fully in executing the FGDs and interviews gathering women from different user communities for the FGDs; giving interviews; participating in the FGDs; and showing the locations of water supply schemes in the different parts of the kebeles.

Water scheme and source mappings were carried out for each and every scheme and water point in a very detailed way. There were long hours of walking, sometimes more than four hours off the road (in some kebeles), and often more than three hours. Some kebeles are very far from the District town (more than 60km). In some schemes, it was difficult to reach WASHCO members.

Second phase activities took place at District level, including institutional stakeholder mapping, interviews, KAP surveys, resource mapping and one FGD.

The FGD at the DWMEO was participatory and welcoming; interviews, surveys and mapping were carried out successfully. Overall, the field activity could be rated as a success.

3.2.1 RESEARCH DESIGN, METHODS AND SAMPLING

In this study both qualitative and quantitative data collection instruments were implemented along with review of documents in archive. A documentation review was carried out for all available documents regarding water scheme plans implementation as well as for monitoring and evaluation at study area, zone and regional levels. Sustainability principles and concepts were also consulted.

For quantitative data collection, physical observation data collection methods were employed to collect water source location and recorded data for borehole as indicted in Annex- 2 and 3. Also random sampling data collection method was employed to collect qualitative data of the water supply schemes. Questionnaire was employed to assess satisfaction of water users at each of the water points. A simplified design of the study is schematically presented in Figure 3.4

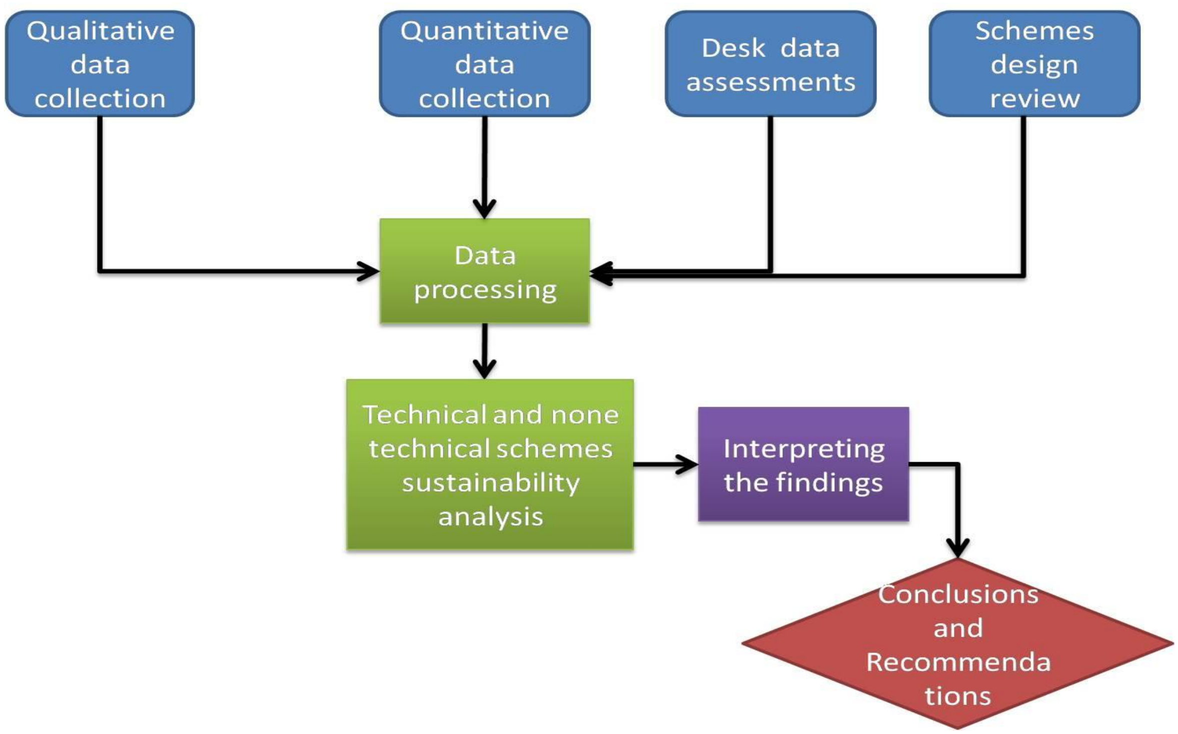

Figure 3.2 Schematic design of the research

Resource mapping provided a detailed overview of the human, physical and information resources available for service provision. This covered all important actors in service provision in the study area. Field visits and observation to places of operations and activities relevant to the sustainability of water schemes were also made to develop a holistic perspective, i.e. an understanding of the context within which the schemes operate at each water point.

Additional information to supplement the documentation review and to obtain a deeper understanding of the issues was collected through interviews and discussions conducted with those considered the main stakeholders. Accordingly, data collection activities were then divided into community (scheme) and District levels. At community level, the following were conducted in the selected water supply schemes: FGDs for WASHCO and residents in each user community; WASHCO resource mapping; and key informant interviews and KAP surveys. At District level, institutional resource mapping; institutional and stakeholder mapping/analysis; and interviews and KAP surveys of the DWMEO were carried out. In addition, a FGD was conducted at the DWMEO.

Pre-tested water source and point checklists were used for water point and source mapping, and all of the water points and water supply schemes sources were visited and mapped during the survey. The checklists included information on grid references; functionality; technology type; financing and installing organizations; source conservation and protection; etc**.** This was supplemented by observation, consultation and questions, as noted above.

To undertake an in-depth study, because of the dependence of different kebeles on a single scheme, scheme-based sampling was adopted. In the selection of the schemes, two major stratifying factors for sampling were employed. These were includes, the electromechanical and the hydro geological parameter. Based on scheme functionality, 30% (eight) of the schemes, including four functional and four non-functional, were randomly selected for detailed analysis. All the selected schemes were motorized and installed submersible pump. Four of the non-functional schemes visited for detailed analysis were Qore Borjota, Faji Goba, Idolaburqa and Obenso Jelo. The functional schemes selected included: Ebicha, Hursa Simbo, Awasho Dhanqu and Hegugetaquni. Moreover two expansion distribution lines were included for detailed analysis since some of the shashamene District kebele's are getting water from Siraro Water Supply Board and Shashemenne Town Water Supply Enterprise from transmission and distribution line by constructing water points through distribution lines. FGDs were conducted in the eight schemes to collect information from

WASHCO and user communities. These used a semi-structured questionnaire guide. In the FGDs conducted at community level, only women participated, owing to their water fetching role and in order to avoid the cultural influence of men during the discussion. Each FGD had 5 to 12 participants of almost the same socioeconomic background. Resource mapping of all the selected schemes investigated their human, financial and material resources. In addition, in all selected schemes, key informant interviews with elderly people and KAP surveys with residents and water users were conducted. Furthermore, interviews were conducted with the eight kebeles chairpersons to understand the role of the kebeles in scheme management.

3.2.2 DATA ANALYSIS

It was well noted that data analysis engages the task to discover models and tendencies in data sets; while data interpretation holds giving details regarding those observed patterns and trends in the data sets (Egger and Capri, 2008). Accordingly, data collected using different techniques were analyzed and interpreted as per the stated study objectives and research questions. Depending on the nature of the data collected, different software, excel, water cad version 6.5, GPS and Global map per were employed to undertake this research. The latest design soft ware required to undertook the methodology of the design process**.**

The Water CAD FOR AutoCAD 2005 Version 6.5, which is powerful water distribution modeling software, has been employed for accuracy and efficiency of design works. This standard computer program has been established taking into account it's significant for future use. In designing the water supply system, the Darcy-Weisbach formula was used.

Additional auxiliary Software which is used for preparation of the model and presentation of design drawings has also been utilized.

Arc-view GIS employed for extracting geographical data such as location map, master plan of each town that shows Road Plans, Residential Quarters, Industrial Areas, Commercial and Public Institution Areas, Green areas, boundaries of Districts and rural kebeles with respective land sizes . Global Map-per has been used for Modeling Digital Elevation of the project area and extraction of contour maps.

3.2.2.1 SYNCHRONIZATION OF DATA BASE

Knowing the locations of possible water supply sources and locations of Demand points, the next question is how to convey the required water from supply sources to demand points. Depending on the topographic conditions, the logical starts at this stage are the selection of best routes, lying out of transmission and distribution mains and definition of data elements required to build the network. The transmission mains are designed for a capacity of maximum daily water demands while distribution networks are for peak hourly demands of the water supply.

Following the establishment of data base for the water supply distribution network, New Project File created for the design software. Then connection of data base with the project file performed to start the hydraulic analysis of the water supply system. The process of describing and interpreting data base of Microsoft Excel to Water-CAD data files is called data base connection. Finally, the synchronization process conducted to match the data bases of software to commence the hydraulic analysis.

3.2.2.2 COMPONENTS OF WATER TRANSMISSION

The detail design of transmission system includes the water system components from spring source to the service reservoir. It is arranged in a logical order of flow process for better understanding. Hydraulic analysis is carried out to evaluate the hydraulic behaviors of the system. This task requires iterative processes of resizing of water supply components and reanalysis of the outputs until the results of hydraulic parameters such as discharge, velocity and pressure values will meet the required criteria.

CHAPTER FOUR

4. RESULTS AND DISCUSSIONS

4.1 SOURCE OF WATER SUPPLY SCHEMES

Borehole locations of the study area were collected using GPS (Annex-1). The spatial distributions of the collected data are indicated in (Figure 4.1). The spatial distribution map of the water source data would help to know the location of the wells based on grid reference.

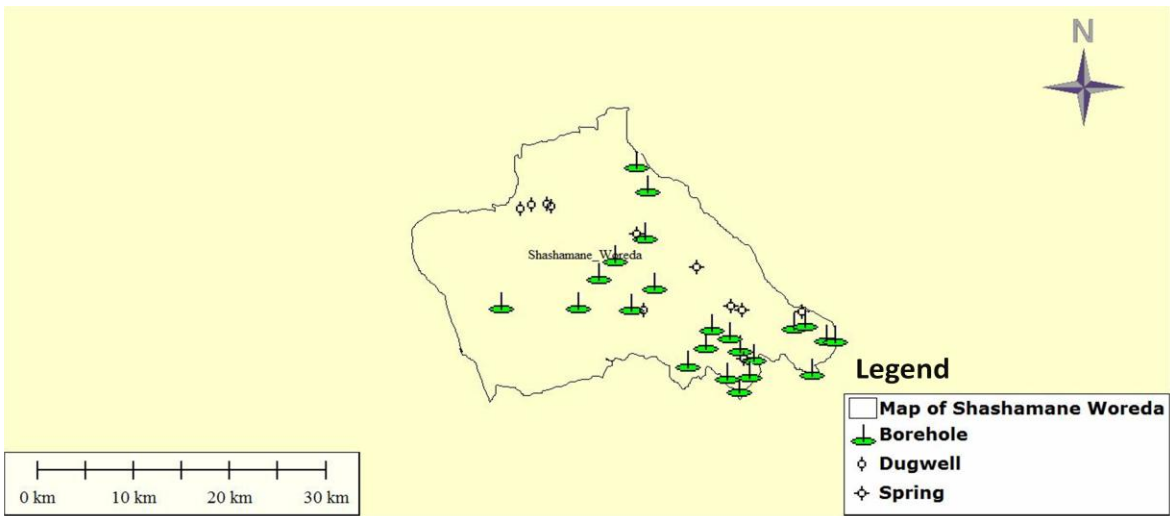

Figure 4.1 Spatial distribution map of the water supply schemes

4.1.1WATER SUPPLY COVERAGE IN THE DISTRICT

Water supply coverage of the district is 68% in the Urban and 32% in the rural areas. There exist 4 deep wells, 10 shallow wells in 2009 these schemes increased to 5deep wells and 12 Shallow wells in 2012GC. The District is currently accessed with 30 deep and shallow wells with distribution, 5 springs with distribution network, 21 springs on spot 20 hand dug wells fitted with hand pump and 120 water points. The District water coverage is found to be 86% at the year of 2015.

4.1.2 PROBLEM RELATED TO THE SCARCITY OF POTABLE WATER IN THE STUDY AREA.

The present environmental stress in the study area affects the availability of drinking water in the District. This was extremely severe in those Rift valley areas of extreme lowlands. People living in this area do not have any alternative source of water for themselves and their livestock. Both people and livestock use to drink water from unsafe run off harvesting ponds traveling more than one hour per round trip. As the soil texture is sandy loam and the rate of evaporation is very high, water harvested in ponds dries up in few months after the rainy season. When the surface water in the pond dries up, people try to get water by digging the sand bed inside the pond and inside the intermittent rivers up to a depth of 10 meters, which the people call it Chirosh during the dry period. To get safe drinking water, people have to travel up to 6 h per single round trip.

Figure 4.2 Women and girls traveling home after fetching water (photo: DWMEO)

4.1.3 SUSTAINABILITY LEVEL OF WATER SUPPLY SCHEMES AND CAPACITY OF INSTITUTION

To achieve sustainability of rural water supply schemes, both internal and external factors must be taken into consideration, as both make important contributions to the success or failure of water supply schemes. Internal factors such as lack of community cohesion, lack of management skills, unrepresentative water commitee, technical issues, strong traditions, misplaced priorities and financial problems must be given priority under a community management model (Schouten and Moriarty, 2003). On the other hand, external factors, such as non-existence of or weak supply chain, lack of standardized technologies, poor design and construction faults, interference from politicians and environmental issues have a big impact on the sustainability of the system and therefore need proper handling

Drinking water sources of the study area are deep, shallow boreholes and spring water with distribution networks to water points. There were also little spring water on spot and hand dug wells fitted with hand pumps. During the survey, 30 motorized schemes of shallow and deep well with 60 water points, 5 spring distributions with 10 water points, 29 constructed water points with distribution line from Siraro Water Supply Board, 7 constructed water points with distribution line from Shashemanne Town Water Supply Enterprise, spring on spot and hand pump were visited. More or less all of the kebeles found to have improved water sources. In addition to the motorized schemes, there were hand dug wells fitted with hand pumps and spring on spots served the community in very small amounts. Spring on spot and hand dug well structures serve the community only during the rainy season and one or two months after the rain passed.

Majority of the schemes was constructed by ZWMEO and some schemes were constructed by international donors, such as UNICEF, USAID, and WORLD Vision and local NGOs like OSHO. Few schemes and expansions works were conducted by religious institution, like Kale-hiwot, catholic, Al-lulker and other NGOs (CDI, later day saint charity).

In the study area, there was high rate of water supply schemes breakdown. As it is demonstrated in the Figure 4.3 out of the total water supply scheme in the District 34% was not in use.

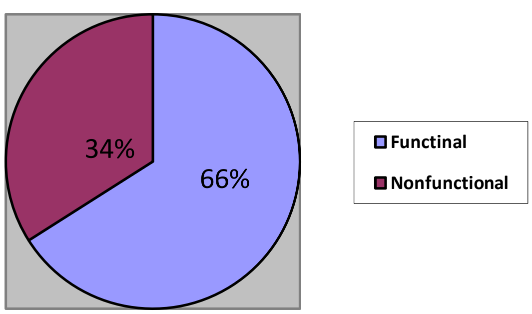

Figure 4.3 Comparison of water supply scheme status

Table 4.1 Nonfunctional schemes

R.No	Site name	GPS Location			Type of water supply facility	Number of beneficiary	Status
		x-coordinate	Y-coordinate	Z (m)			
1	Ovenso Jello	457523	808947	1812	Deep well	3553	Nonfunctional
2	Hagugata Qudi	458419	801069	1887	Deep well	7639	Nonfunctional
3	Qore borjota	443529	793425	1758	Deep well	4405	Nonfunctional
4	Faji Goba	454846	803226	1803	Deep well	8432	Nonfunctional
5	Idola Burqa	457055	793314	2037	Deep well	8737	Nonfunctional
6	Ebicha				Deep well	6243	Nonfunctional
7	Jigesa Qorke	462390	797679	2104	Shallow well	5740	Nonfunctional
8	Danisa	475755	786183	2350	Shallow well	5002	Nonfunctional
9	Aradano shifa	475066	791542	2560	Shallow well	9040	Nonfunctional
10	Gonde Qarso	454020	707524	2663	Shallow well	7986	Nonfunctional
11	Jangela wandare	468820	787306	2469	Shallow well	9780	Nonfunctional
12	Abaro	463442	787816	2345	Shallow well	8605	Nonfunctional
13	Hursa Simbo	469751	787777	2417	Shallow well	7902	Nonfunctional
14	Karara fillicha	461375	801431	1992	Distribution line	14303	Nonfunctional
15	Butte fillicha	457330	799741	1918	Distribution line	8170	Nonfunctional
16	Chabi dida gnata	445743	798596	1768	Distribution line	6062	Nonfunctional
17	Turufe W.Elemo	463019	800873	2140	Distribution line	13,191	Nonfunctional
18	Aleche Harbate	454101	791160	1956	Distribution line	9604	Nonfunctional
19	Dalti calala	442557	790611	1764	Distribution line	3784	Nonfunctional
20	Alelu Ilu	456786	798607		Distribution line	6733	Nonfunctional
21	Jallo Dida	4253750	717561	1816	Deep well	4220	Nonfunctional

Table 4.2 water points from Shashemsnne Town Water Supply Enterprise

R.No	Kebele Name	Type of water supply Facility	Number of Beneficiary	Functionality status
1	Bulchana Deneba	Distribution line with (1wp)	5919	Functional
2	Meja Dema	Distribution line with (1wp)	5928	Functional
3	Qine Chafo umbure	Distribution line with (1wp)	9483	Functional
4	Toga	Distribution line with (1wp)	3383	Functional

Table 4.3 Water points from Siraro Rural Water Supply Board

R.No	Kebele Name	Type of water supply Facility	Number of beneficiary	Functionality status
1	Kore Rogicha	Distribution line with(4 wp)	6416	Functional
2	Bura Borema	Distribution line with (3 wp)	9378	Functional
3	Chaffa Guta	Distribution line with (4 wp)	4324	Functional
4	Faji Gole	Distribution line with (3 wp)	10,730	Functional
5	Ilala Qorke	Distribution line (3 wp)	8664	Functional
6	Kubi Guta	Distribution line with (6 wp)	4076	Functional
7	Chulule Habaraa	Distribution line with (2 wp)	4175	Functional
8	Tatesa Dadesa	Distribution line with(4 wp)	8426	Functional

During field observation, the followings were identified as the underlining causes of non-functionality of scheme:

- Lack of regular follow-up and supervision during the design and construction of schemes i.e. poor construction and design.
- Installation of inappropriate technology - use of star and star-delta connection submersible pumps
- Lack of trained operators and absence of timely servicing of pump and Generators.
- Lack of monitoring, maintenance and rehabilitation of water wells
- Improper recommendation of pump position
- Insufficient source of adequate water
- Distribution line frequently bursting

Despite encouraging efforts to increase the water supply coverage, a high rate of non-functionality of recently constructed schemes has been observed in the study area. Moreover, with regard to technology type, schemes with star-delta submersible pumps were facing recurrent failure more frequently than schemes with submersible pumps of star connection.

Out of a total of 96 water points, 25% were not providing a service to the community. The major reasons for the non-functionality of water points include failing of pumps and generators shared the largest portion, technical problems, such as poor construction and design problems with water wells took the second level and the rest were found to be problems in connection with management .

Figure 4.4 Poor installation of pipe line (Photo by: Researcher 15/ 9/ 2015)

WASHCO in rural water supply is an often voluntary body, selected by the community to represent it in discussions and decision making on all aspects of local water management. In multi-village schemes, Water Boards are established to oversee these tasks. Water Boards comprise representatives from the WASHCOs of individual villages. If a committee is going to function smoothly and meet the needs of the community it represents, it should represent all segments of the community, better off and poor, male and female, groups living in different areas (Bolt and Fonseca, 2001). Most of the users in visited schemes said that the WASHCOS were elected through the active participation of the community. The WASHCOS of these schemes affirmed that there was public participation during their elections.

Every year in the world, many millions of dollars are invested by national governments and international donor agencies alike in project implementation and, despite ever-increasing attempts to tackle the problem, many schemes still fail to maintain the flow of expected benefits over their intended lifetimes of 15 or even 20 years (Lockwood, 2004). In the study area very few of the schemes have served beyond their design period of 15 years, with the replacement of some important parts, such as generators and pumps. Some of these schemes have been serving the community for more than 20 years, with the maximum being 31 years. Despite being in place for the past 15 years, most of them have not been providing a service for about 9 years. Out of all the non-functional schemes, about 90% were constructed in the past 5 to 10 and about 60% were constructed in the past 5 years. This indicates that most of the non-functional schemes have not even served the community for 5 years.

During the survey, it was difficult to find out about the design population of most schemes. Therefore, a uniform percentage growth method has been employed to project the current population, obtained from the Zone Finance Office. In addition, in none of the schemes has a user registration system been adopted. Therefore, to find out the number of people currently using each scheme, estimations was made based on information obtained from WASHCO, users, and the DWMEO. Results show that 92% of the schemes in operation have served far beyond their design population.

When scheme breakdown occurred, the speed of maintenance was slow. Maintenance for minor breakdowns was performed within 2 weeks, whereas major breakdowns took a minimum of 2 months, with an average of 6 months. Despite recurrent efforts by ZWMEO and OWMEB to bring it into operation, Toga Woransa Water Supply Scheme was not repaired for the past 5 years.

In 97.8% of the water points, users consumed water from the main source for all domestic purposes without any complaints about quality. However, in the remaining 2.2% of the water points, users consumed the water for all domestic purposes but have some complaints on quality particularly turbidity of the water from the source. The DWMEO had never carried out any water quality tests or regular monitoring of the source and the water points. However, according to bacteriological and physiochemical water quality tests conducted by OWMEB for selected schemes and water points, the bacteriological quality of the groundwater was found to be good and safe for drinking, but a coli form count higher than the acceptable level set by OWMEB was detected at 20 selected water points among the total water points in the study area.

Despite the excess fluoride content of the groundwater, only 2 schemes with fluoride content higher than the acceptable value 1.5mg/l set by WHO (Water Works Design and Supervision Enterprise Laboratory service) were found to have a fluoride treatment plant.

In 95% of the water points, users reported that supply was predictable and was available both in the morning and in the afternoon (exact time not known). In the remaining 5%, supply was only available in the morning. The water points provided a service for 5 to 10 hours per day, with an average of 7 h. In most of the schemes with more than 1 water point, the points were not placed within a reasonable distance to serve the majority of the community. During FGDs, users said that the tap attendants usually open the water points when queuing was seen around the water point. The time taken to fetch water from the main source ranges from 10 min to 5h (roundtrip), with an average of 2h and 15 min. The round trip water fetching time exceeded WHO recommendations (WHO, 2006a), which is set at 30 min of walking time for a roundtrip, equivalent to a distance of about 1km. The fetching time also exceeded the recommendations of the UAP, which plans to provide improved water to every rural dweller within a 1.5km radius by the year 2012 (MoWR, 2006).

Queuing time varies from season to season. During the dry season the queuing time increased from 15min to 9h, with an average of 5h (Figure 4.5). In the wet season, the queuing time decreased from 10min to 4h, with an average of 2h. Therefore, the average roundtrip including waiting time was found to be 5h in the dry season and 2h in the wet season. In almost all of the schemes, women and girls were responsible for the collection of water. Hence, women and girls were expected to walk for a long time in search of water for household use. The number of individuals in a household for the users involved in discussions for all schemes ranges from 3 to 9, with an average of 6 individuals. It is therefore easy to imagine the workload women face to ensure the availability of water for 6 individuals in a household. Women and girls were expected to spend more than 5h during the dry season to collect water from the main source, time which could otherwise be used for other productive activities. In addition, owing to the long time spent queuing up, sometimes people return home without fetching water at all.

Figure 4.5 Queuing up waiting for the opening of the water point (Photo: DWMEO)

The average quantity of water used from protected sources per household per day was found to be 63l, indicating that on average 10l of water is used per person per day. This finding indicates that per capita consumption of water in rural parts of study area was by 5l/c/d lower than the 15l/c/d standard set in the UAP (MoWR, 2006). The findings were also lower than those of Carter and Howsam (1999) and the WHO (2006a), which indicate that access to 20l/c/d of water per person per day is a minimum requirement in respecting the human right to water and minimum hygiene standards. During the wet season, the majority of the study area population, residing far from the improved sources, used unprotected sources like ponds, rivers and unprotected springs for all domestic purposes, including drinking. In most of the schemes, watering cattle during the dry season also took place at the water points.

The interrelated issues of groundwater quality and quantity can best be addressed by management approaches encompassing the entire groundwater recharge areas or groundwater catchments (WHO, 2006b). The Ethiopian Water Resource Development Policy and the ORNG strategic plan clearly indicate that conserving, protecting and enhancing water resources are central to using the resource on a sustainable basis (MoWR, 1999; BoWR, 2007). Schemes around which watershed management is being undertaken represent 20.5%, whereas no effort has been made at 79.4% of schemes. During the field investigation, no deliberate effort to conserve the groundwater resource and enhance its productivity was observed. However, in some places, it has been seen that rehabilitating degraded lands through the government program of natural resource conservation (water shade).

The majority of WASHCO were not properly recording and saving the revenue collected from water sales. In those schemes with good financial management, like Toga and Jello Dida a strong committee, monthly income was found to be higher than expenditure. The best schemes show income sufficient to cover even major repairs. In contrast to this there are some weak committee with poor financial management like Jigeessa and Hegugata Dhenqu running without deposit even if their income is higher than their expenditure. However, in all schemes, tariff setting did not involve the community and did not take into consideration poor and marginalized people. Banking details of the visited WASHCO are given in Table 4.4

Table 4.4 Annual incomes and expenditure of some visited WASCHOS

R.No	WASHCO Name	Year	Annual Income	Annual Expenditure	Difference	Remark
1	JelloDida	2013	32134.00	20642.32	11493.16	
		2014	55726.65	41511.51	14215.14	
2	Toga	2013	50787.00	50774.55	12.45	
		2014	97256.47	68624.95	28631.47	
3	Jigessa	2013	35952.00	20014.20	15937.90	Only 1053.7 at bank
		2014	117270.70	114051.24	3219.49	No deposit
4	HegugetaQuni	2013	24310.00	17459.14	6850.85	No deposit
5	AwashoDhenqu	2014	51663.75	39520.30	12143.45	Only 1,000 at bank

4.1.4 RESOURCE AVAILABLE AT WASHCO AND DISTRICT LEVEL

During field survey it observed that most WASHCO did not have the necessary human, financial and material resources to undertake even minor maintenance. Moreover, most WASHCO members tap attendants and operators report feeling that they have not received enough theoretical or practical training to undertake their work effectively and efficiently

Table 4.5 Financial and material resources of some visited WASHCOS

		Physical resources			Financial resource (S/A)
No	**WASHCO**	**Equipment**	**Type**	**Quantity**	**Amount in Birr**
1	Jigessa	Hand tool kit Pipe wrench	Set 12'' ,24''	1 2	1053.7
2	Toga	Pipe wrench, open end-wrench, screwdriver	24'' 17X19, flat & Philips	2,1,2	28631.47
3	Jelo Dida	Spinner, screw-driver, combination wrench, pipe wrench	24mm, flat,19mm,12'',24''	1,2,1,2	14215.14
4	Hegugeta Quni	Hand tool kit Pipe wrench, screw-driver	Set, 18''philips	1,1,2	No deposit
5	Awash Dhenqu	Screw-driver, combination wrench	Flat & Philips, 14mm,17mm	1,2	11,000
6	Idola Burqa	Screw-driver, pliers	Flat & Philips, 14mm	1,1	No deposit

The DWMEO was under-resourced and received insufficient annual budget for office administration costs and other activities (Table 4.6). Adequate budget was not allocated for the other activities, the office was expected to undertake, and it had been depending on the unreliable assistance of donors for expansion, spare parts purchase and per diem to undertake maintenance work.

Table 4.6 Budget allocated and utilized by DWMEO, 2011-2015 GC

Eth. Fiscal year	Budget requested(ETB)	Budget released (ETB)	Budget utilized
2011	-	37,000	100%
2012	-	56,000	100%
2013	-	75,000	100%
2014	-	82,000	100%
2015	-	71,000	100%

The water sector problem was well known by the District Administration. They believed that the sector's problems needs more than efforts that could not solve by the water sector alone. Despite budget deficit of the District, the Administration had been trying its best to play its part in solving the human and financial problems of the DWMEO. The annual budget allocated to the water sector is gradual improving from year to year. The budget allocated was not still enough to solve the sector's problem

The DWMEO also has limited human and logistical resources to undertake its activities. The resource mapping showed that the number of positions in the office and the number of human resources present are not comparable. Currently, only about 50% of positions important for the sustainability of rural water supply schemes occupied. The DWMEO does not have the qualified technician, sufficient finance and logistical resources to undertake major maintenance

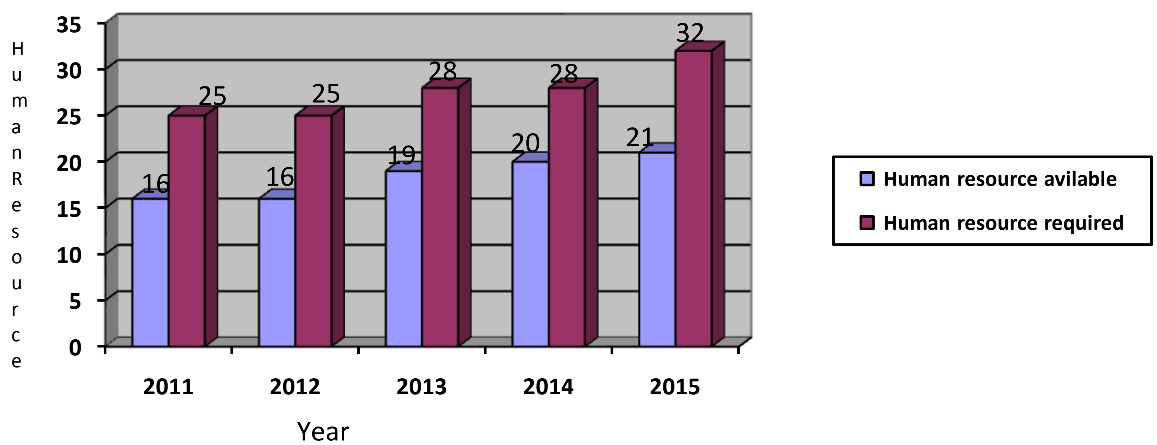

Figure 4.6 Human Resource of the DWMEO, 2011-2015

There was miss allocation of human resource in the office. The water supply facility management division responsible for scheme sustainability is leading by non-professional expert whereas an electro-mechanical expert assigned to another division. Some of the positions are still vacant (Table 4.7). In addition, most of the occupied positions are held by individuals without the appropriate qualifications or experience. Most of the present technical staffs in DWMEO have either a diploma from technical and vocational schools (10+3) or (10+3) diploma from Woliso and Asela College of Water Technology in electro-mechanical, rural water supply and small scale Irrigation development. Few of them were BA degree in social science studies with different qualification. In the office the important positions such as engineer, geologist, electrician and plumber crucial for water supply sustainability are unoccupied.

Table 4.7 Available and occupied positions of DWMEO

No	Occupation	Sex	Qualification	Edu.leve	Service year
I	Administration staff				
1	Office head	M	DEVT	BA	25
2	Secretary	F	-	-	-
3	Plan & Budget expert	-	-	-	-
4	Supervision &Evaluation of plan accomplishment expert	M	LAW	Diploma	11
5	Gender issue expert	-	-	-	-
II	Water supply construction department				
6	D/Office head & water supply construction department coordinator	M	SURV	Diploma	15
7	Water resource Engineer	M	RWSS	Diploma	7 &8/12
8	Geologist	F	RWSS	Diploma	8 &8/12
9	Sociologist	-	-	-	-
10	Community participation expert	F	SSID	Diploma	5 & 8/12
11	Community Auditor	F	ACC	BA	8 &8/12
12	Water supply & sanitation technician	F	RWSS	Diploma	6&7/12
13	Electro-mechanical expert	M	EMT	Diploma	6 & 9/12
III	Water supply facility management Department				
14	Department head	M	COMD	BA	10 & 7/12
15	Mechanic(Electro-mechanical)	M	EMT	Diploma	6 & 9/12
16	Plumber	-	-	-	-
17	Water supply & sanitation technician	F	RWSS	Diploma	8 & 8/12
18	Electrician	-	-	-	-
IV	Water resource management				
	Department head	-	-	-	-
19	Water resource engineer	-	-	-	-
20	Water quality & sanitation technician	M	RWSS	Diploma	5 & 8/12
21	Geologist	-	-	-	-
22	Water supply & sanitation technician	F	RWSS	Diploma	4 &7/12
V	Minerals & Energy Department				
23	Department head	M	PHY.	Diploma	19 & 9/12
24	secretary	-	-	-	-
25	Expert for mineral activities & control	F	COM	CERT	16 & 2/12
26	License provider & mineral information expert	F	-	Diploma	7 & 2/12
27	Expert for control of revenue from mineral development	M	EMT	Diploma	8& 8/12
28	Electrification & renewable energy source expert	M	EMT	Diploma	6 & 7/12
29	Biomass technology expansion expert	F	RWSS	Diploma	1 & 12

4.1.5 FINANCIAL FACTOR

4.1.5.1 WATER TARIFFS AND TARIFF SETTING

According to the information gathered, there is no standard water tariff structure in place in the study area. During the field investigation, it was observed that the cost of a 25 and 20 l jerry can of water varied from scheme to scheme. The cost for 20 l jerry can was US$ 0.0075 -0.01 and for 25 l US$ 0.0125 -0.015. Most of the users in all schemes said that, the above cost paid for 20 l and 25 l respectively is too high to afford for everyday activities.

According to the WASHCOS of some schemes, the high cost of water owes to the high cost of O and M of the schemes. Chairperson of Hursa Faji said that the tariff for a 25 l jerry can was US$ 0.0075 at the beginning, but this was increased to US$ 0.0125 owing to the high operational cost of the scheme. The other scheme's WASHCO said that the tariff was amended from US$ 0.0075 to US$ 0.01for the same reason.

Users of some schemes complain that the community didn't participate when the tariff was set. Users at other scheme said that they had participated in tariff setting. They added that the tariff setting had been organized by the implementing organization. Users of very few schemes said that they had no information about the body responsible for tariff setting. Users at Edola Burqa scheme said that only male members of the community took part in tariff setting. Users in the other schemes said that the WASHCO and the Kebele Administration set up the water tariff.

In the schemes constructed by NGOs, the tariff is set by the implementer together with the community and the kebele Administration. The implementing organization, after fixing a reasonable cost and considering the O and M, consults the community about the tariff to be implemented. Generally, in other schemes, only the WASHCO and the DWMEO were found to have set tariffs without consultation with the community. Management committees in all the schemes and the DWMEO said that O and M is the main factor taken into consideration when setting water terrify. In no schemes does tariff setting take into consideration poor and marginalized people.

4.1.5.2 FINANCIAL MANAGEMENT SYSTEM

Financial management and transparency are among the more problematic aspects of community management. Continuing transparency on income and expenditure, bookkeeping and accounting are essential (Bolt and Fonseca, 2001).

During the field investigation, some WASHCOS were found to have a financial manual, which they received while they were attending trainings. However, none of them use the manual for day- to- day activities. Most of the WASHCOS had legal revenue collection receipts. However, few of them sometimes use ordinary receipts from shops for revenue collection. It was also observed that no schemes have a relatively good bookkeeping system and well organized financial documents showing income and expenditure. Only few of them had financial documents showing mainly the income of the scheme.

The WAHSCO Organizational Manual says the committee should collect revenue every day from the tap attendant through the cashier and save the money collected, leaving not more than 500 Birr as petty cash in the hands of the cashier (OWRB, 2002). However, no scheme was observed to be applying this rule. All the committees collect money from the tap attendants at different times and some save this in the bank and others keep it themselves. The WAHSCO of some scheme said that money is collected from the tap attendants every 15 days and, if there is more than 500 Birr, the cashier deposits this in the bank. The WAHSCO of other scheme said that the money is collected from the tap attendants every week through the cashier and deposited in the bank.

According to the DWMEO experts, all WAHSCOS in the District have problems in reporting financial and physical activities to the office and to the community. The committees also have serious problems in financial management and saving. The office experts added that, of all the WAHSCO in the District, some WAHSCOS are relatively good as they have saved money in the bank within few years. Those committees also meet regularly with the DWMEO for technical support.

According to the OWMEB strategic plan, full cost recovery of O and M costs are required to ensure the sustainability of rural water supply schemes (OWRB, 2007). Owing to the absence of properly handled and documented financial reports, it was difficult to view the financial flow of most of the institutions. During the field investigation, however, WAHSCOS established recently were found to have relatively good bookkeeping and financial documents, showing scheme income and expenditure.

WAHSCOS of all schemes said that there is no serious audit of their financial and material resources. In the WAHSCOS Organizational Manual, it is clearly written that the WAHSCO has to cooperate with experts from the DWMEO who come to audit and monitor the financial and physical resources of the committees (OWRB 2010).

Generally, no regular auditing by the DWMEO has taken place. The DWMEO community promoter said that the lack of consistency and, in some cases, absence of auditing owes to a lack of the human, financial and logistical resources to undertake such activities. Absence of commitment among existing experts and the recurrent turnover of office head to supervise the different activities being undertaken in the office also contribute to the absence of audits and monitoring of WAHSCOS financial and material resources

4.1.6 KNOWLEDGE, ATTITUDE AND PRACTICE OF SERVICE PROVIDERS AND USERS

4.1.6.1 USER COMMUNITY

In most of the schemes, owing to the centralized approach followed by the implementers, participation of the community in different phases of scheme development was very poor. In addition, except with regard to fetching water when the scheme is in operation, the community does not actively participate when there is a breakdown. Even if the community is interested in participating in O and M and believes that involvement is important for scheme sustainability, little effort has been made by WASHCOS and the DWMEO to involve the community. Generally, the community does not know clearly its role and responsibilities in water service delivery and management and considers the WASHCOS and the DWMEO to be responsible bodies in scheme O and M. During the field investigation it was observed that most of the non-functional schemes and water points were not fenced: fences had been removed as a result of poor attention paid by the community. With regard to water resource management, the awareness of the community was poor. In most of the schemes, the community believes the source is a ‘hidden sea underneath’ which cannot be depleted and can be used forever. No deliberate effort to conserve the groundwater resource and enhance its productivity has been observed

4.1.6.2 WASHCOS

Most of the WASHCOS reported that they are working hard to satisfy the increasing water demand of the community. However, it was observed that the WASHCOS do not clearly know their roles and the roles of others in water service delivery and management. Most of the WASHCOS have not received enough theoretical or practical training to undertake their work effectively and efficiently. In most of the schemes, the WASHCOS depend on the DWMEO for scheme maintenance and spare parts provision. Many WASHCOS members reported feeling discouraged owing to the absence of incentives.

There is no clear understanding among users, WASHCOS and the DWMEO regarding WASHCOS accountability. No committee has regularly reported on finance or other activities, either to the community or to the DWMEO. Most of the WASHCOS have poor financial management systems and no financial documents

4.1.6 .3 DISTRICT LEVEL

In the District there are serious problems owing to the high investment cost of source development and the un-sustainability of constructed schemes. Even though the District Administration knows of these problems, it has still been allocating a very limited budget to the sector. According to the office head, the initiative of the communities and District Administration are the major motivating factors, whereas the major factors hindering day-to-day activities are: the absence of sufficient and practically trained human power; the lack of a budget to the sector; the lack of the necessary logistics to support the WASHCOS; and the absence of time to deal with office activities, owing to additional workloads and to the lack of commitment of some office experts. The office does not coordinate with other actors and sector offices to help the WASHCOS and everyone is busy with their daily work. Generally, the DWMEO does not provide the necessary support to the WASHCOS owing to a lack of the necessary human, finance and logistical resources in the office.

4.2 TECHNICAL FACTOR

During field assessment it was seen that schemes with the problems of poor quality construction and design. Anbo scheme was the one with the above mentioned problems.

The proposed Anbo spring was planned to supply clean potable water for Shashemanne District of surrounding rural Kebeles and Bishan Guracha Town. The location of the spring eye is be represented by the grid co-ordinate of 07^{0}06.336N and 038^{0}34.548 at an altitude of 1688 m a.s l. Anbo spring development was proposed to be constructed to supply potable water for 25,062 people living in the above mentioned rural kebele's and Bishan Guracha Town.

During field surveying it was observed that the constructed water supply scheme could not be able to give intended service. It identified that the constructed water supply scheme has pressure line problem. The distance from reservoir site to spring eye is 7.65 km, which constitutes a pressure line of the Ambo Spring Water supply system. The pressure line pipe is GSI of 4"; the area on the pipe laid is almost located at lowland with high temperature. The pipe laid is not buried, because it was hard to excavate trench on the hard rock along the root, thus it suspended in open air under this high temperature.

At the location where the slope of the pressure line abruptly increasing UTM, X-448181 and Y-789141 usually high leakage was common problem at the time when the scheme was operating. This indicates that high back pressure is created from the top direction where reservoir side and the pipe and the fittings couldn't be able to resist the pressure. Almost all pipes are not firmly joined by couplings and unions, to reinforce the joints on some joints flanges were welded to the pipes. In addition to this poor workmanship is also observed, along the line where pipes can be buried in the trench was not done; also some gully crossing structures are not serving their purpose. As it was demonstrated in the photos of Figure 4.7 and 4.8, pipes are suspended over the structures, unnecessary bending are created, this situation in turn created head loss in the pressure line.

In general the major problems observed on pressure line can be summarized as follows

- Lack of appropriate design of pressure line, climate factor was not considered
- The topography and soil characteristics of the area was not considered
- The selected pipe type GSI cannot resist the temperature of the area on the open air.

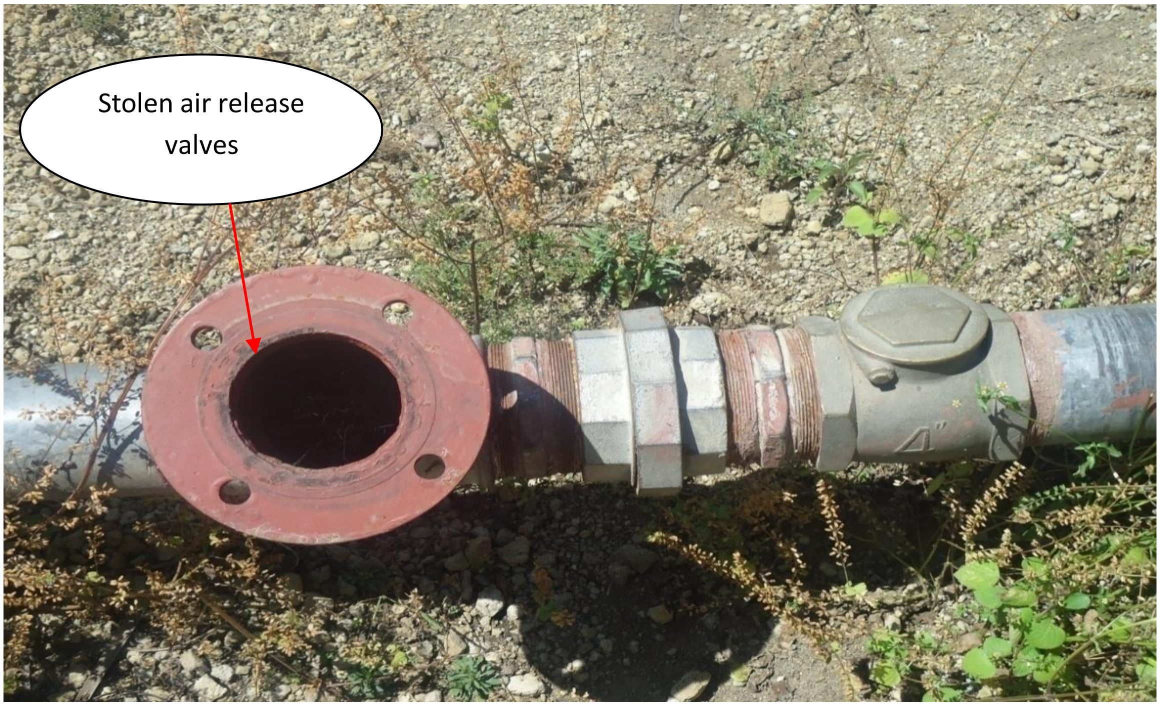

Figure 4.7 Improper pipe installations (Photo by: Researcher 20/ 8/ 2015)

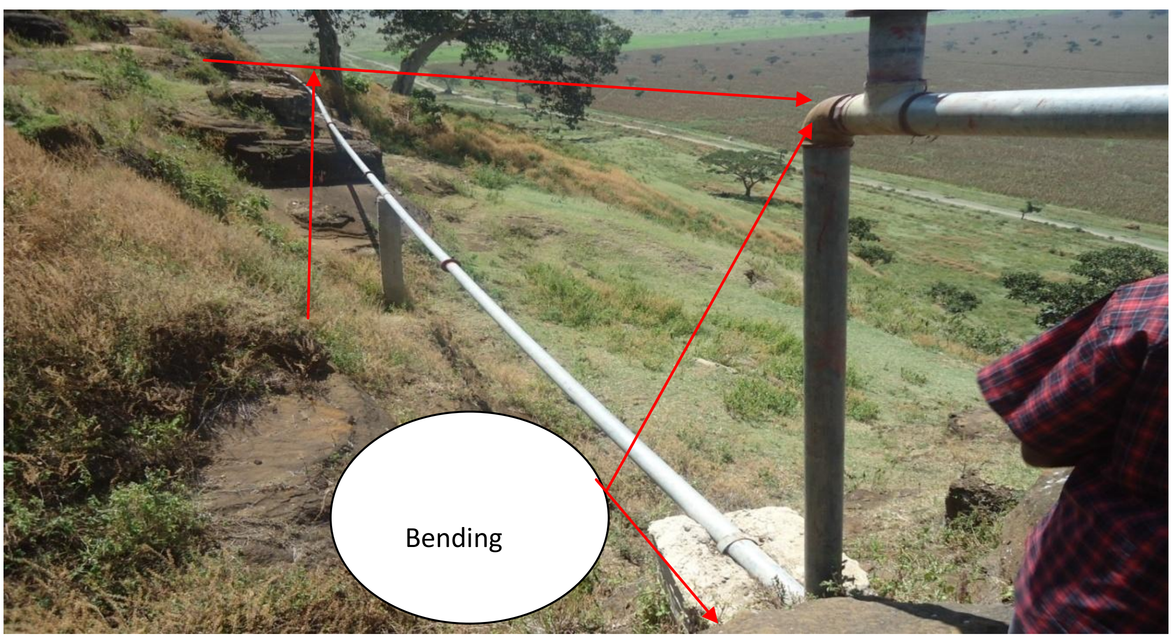

Figure 4.8 unnecessary bending in the transmission main (Photo by: Researcher 10/8/ 2015)

It was understood that, the activities performed for the maintenance of the pressure line could bring about immediate solution with very intensive care and heavy day to day operation and maintenance activities. To solve the problem fundamentally, the pressure line shall be redesigned and the hydraulic pressure need to be analyzed.

4.2. 1 DESIGN REVIEW OF THE SCHEMES

In the previous design, it was observed that the flow velocities in the transmission mains were not considered. Experience shows that in many cases pipes designed to flow velocities of, 0.8 to 1.2 m/sec are quite at optimum conditions for long lines.

The diameter of pipe and amount of flow through it determined the velocity of flow and energy lost. The greater flow and the faster velocity were the greater frictional losses. So, the pipe line was designed to reduce the frictional energy lose on one hand to make the pipe size economical as much as possible.

The design review of this water supply has been employed using computer Software. Computer modeling of water distribution systems has been prepared to all identified system components.

4.2.1.1BUILDING DATA BASE FOR MODELING WATER SUPPLY SYSTEMS

The purpose of creating data base for a water supply system is to exporte and import data elements between the Water cad model and date base files so as efficiently perform the analysis of the system and produce the required out puts.

There are four ways to input the data required to build network which mainly depends on the format in which the data being stored, the complexity of the project and personal experience of designers. In case of this project Microsoft Excel Spread Sheets are used for establishing the data bases of the network as a starting point and other methods will be employed as required. The arrangement of basic project data and corresponding modeling elements have been outlined as follows

4.2.1.2 WATER DEMAND DATA

The total water demand for the Bishan-Gguracha town and surrounding rural kebeles after summarizing all water demand requirements are presented in the table below.

Table 4.8 Total required water demand

S. No	Item	Unit	Projected Demand			
			2015	**2017**	**2027**	**2037**
	Average Day Demand (ADD)	m^3/d	1,521	2,259	3,252	3,995
		l/s	17.61	26.14	37.64	46.24
	Max Day Demand (MDD)	m^3/d	1,978	2,936	3,902	4,794
		l/s	22.89	33.98	45.17	55.48
	Peak Hour Demand (PHD)	m^3/day	3,043	4,517	5,854	7,191
		l/s	35.22	52.28	67.75	83.23
	Population		44,166	47,326	58,739	71,953

The water demand data and respective supply points are represented as nodes junction in Water-CAD. The water demands data and their respective points of locations have been spatially distributed in accordance with the master plan of the town and density of population or other water user customers. Either the average or maximum day demand of those areas could be used when modeling demand points.

4.2.1.3 HYDRAULIC ANALYSIS AND PRESENTATION OF RESULTS

Hydraulic analysis was carried out to evaluate the hydraulic behaviors of the system. This task required iterative processes of resizing of water supply components and reanalysis of the outputs until the results of hydraulic parameters such as discharge, velocity and pressure values were meet the required criteria.

In hydraulic analysis works, rather than repeatedly calculate the water pressures, it is an easier practice to simply report as the head. The properly designed system able to determine the energy that was lost to friction by the time that flow reaches various critical points in the system. According to the hydraulic analysis,(Annex -4 and -5) the summary of results showed that , the minimum node pressures of 4 to 6m H_2O are occurred around the out let of the reservoir. Nevertheless, the rest node pressures were meeting the requirements. In the other hand, maximum node pressures of 229-230m H_2O were occurred where the pipeline start of the pump station. Acceptable limit of 1.13m/s velocities noted in all the system of pipes.

4.2.2 GROUND WATER DEPLETION

Throughout field assessment it was identified which water schemes had problems with the mechanical pumping equipment and distribution system and which had problems with the drinking ground water well itself. On the mechanical side most of the motorized pump installation and some hand pumps in the District were found to require some rehabilitation involving maintenance, and replacement.

Problems within the drinking ground water well became evident when the project pumping test and maintenance report showed that 3 of 8 tasted produced significant quantities of silt in the water, even when the pumping was at rests considerably lower than the maximum yield of the ground water well. In addition when removing motorized pumps from existing drinking ground water well for the borehole service, 5 pumps were found to be blocked by silt.

During the assessment of existing drinking ground water well data in the District, very limited amount of ground water well data can be seen. The available data showed that static water level, water strike depth, yield and pumping test data recorded annually between 1999 and 2011. Prior to 1996, pumping tests had been carried in only 7 of the total drilled drinking ground water well in the district. In addition, where borehole yields are recorded there is no indication as to whether these are the maximum yield of the drinking ground water well or the pump used for the test. The drinking ground water well data showed the change in parameter data recorded through time.

Table 4.9 Sample data collected for Eddola Burka drinking water well

S.N	Description	Units	Recorded data during well construction	After four years	After eight years	After twelve years of well service	Remarks
1	Water quality result						
a	Ammonia	mg/lt	0.89				
b	Sodium		21				
c	Potassium		18.5				
d	Fluoride		0.1			0.8	
2	Effective well depth (Cased depth)		256	256	256	256	
3	Water strike depth	m	110				
4	Static water level	m	79.7	84	92	96	
6	Water column of the wells	m	176.3	172	164	160	

	Discharge (Safe Yield)	lt/se	5	5	5	5	
	Pump position	m	182	182	182	182	
	Dynamic water level	m	120	142	153	161	
	Total drawdown	m	40.3	58	61	65	
7	Annual rainfall of the area	mm	850	730	604	480	
8	Estimated evapotranspiration	mm	200	290	345	450	
10	Safe yield per the pumping test result (Constant test)	l/sec	5	4.9	4.82	4.75	

These basic parameters change through time may indicate sustainability of the water supply schemes influenced by ground water depletion.

Due to long time service per day, the degree of ground water discharge is too high; which has severely affected ground water concentration and lead to over pumping. Moreover, below average rainfall, recur drought; poor natural resource management and increasing evapo-transpiration were the cause for the ground water depletion in the study area. As it is demonstrated in the fig.4.10 the ground water parameters changed through time clearly indicate ground water depletion.

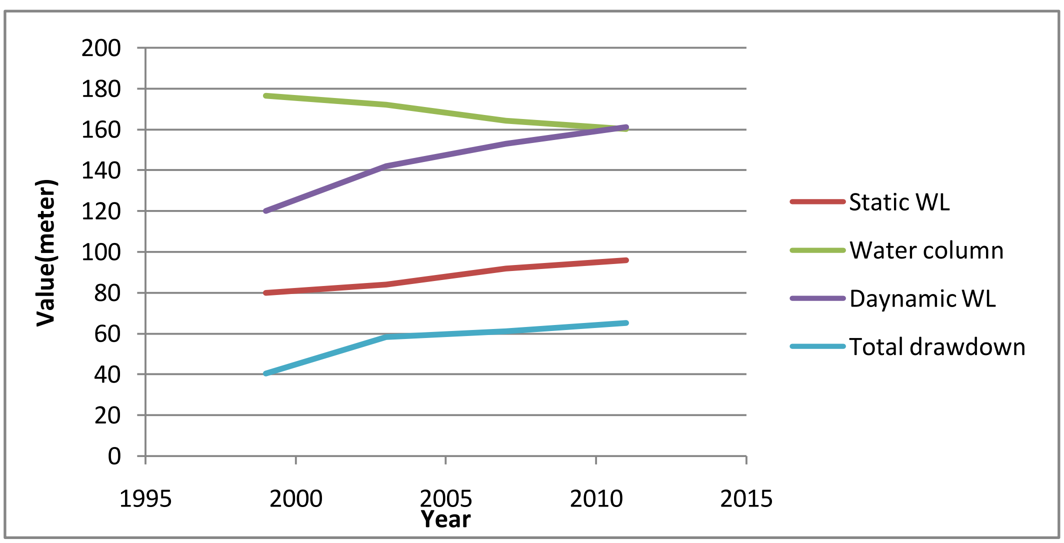

Figure 4.9 Groundwater parameters varying through time

CHAPTER FIVE

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

This study was initiated with objective of investigating the sustainability issue of rural water supply schemes in Shashemannee district. The findings on sustainability and service levels in Shashemane district reflect a critical situation. Currently the community of the district is accessed to safe drinking water sourced from deep and shallow well ground water. Generally, 30 deep well with distribution, 20 hand dug wells fitted with hand pump, 5spring with distribution network and 21 springs constructed on spot are delivering a service for the beneficiaries. However, 34% of the water supply schemes and 25% of the water points are not providing a service to the community. Most of the rural kebeles are therefore currently dependent on the operational 66% and 75% of the schemes and water points, respectively. Unless the non-functional schemes are maintained immediately, over pumping and intense exploitation on the functional schemes would leads to shortening the life span of the functional schemes

In the district, Due to long time service per day, the degree of scheme malfunction is too high, which has severely affected on water service deliver. Electro mechanical problem, over pumping, poor scheme management, annual rainfall drop and recurrence drought were the major cause of schemes malfunction. As observed during field survey, the non-functional schemes were not timely maintained.

The DWMEO had never carried out any water quality tests or regular monitoring of the source. However, according to bacteriological and physiochemical water quality tests conducted by OWMEB on the selected schemes, the laboratory test result showed that the ground water was recommended for drinking according to the WHO standard. However, based on the test conducted on some schemes, the concentration of fluoride was higher than the acceptable level set by Despite the excess fluoride content of the groundwater, only 2 schemes with fluoride content higher than the acceptable value set by WHO (1.5mg/l) were found to have a fluoride treatment plant.

The water points provided a service for 5 to 10 h per day, with an average of 7 h. During FGDs, users said that the tap attendants usually open the water points when queuing was seen around the water point. The time taken to fetch water from the main source ranges from 10 min to 5h (roundtrip), with an average of 2h and 15 min. The round trip water fetching time exceeded WHO recommendations (WHO, 2006a), which is set at 30 min of walking time for a roundtrip, equivalent to a distance of about 1km. The fetching time also exceeded the recommendations of the UAP, which plans to provide improved water to every rural dweller within a 1.5km radius by the year 2012 contribute

In general, the schemes do not provide sufficient water to meet the UAP. Per capita water consumption in the District is at only 10 l, 10 l less than the 20 l recommended by the WHO as a minimum requirement for respecting the human right to water and minimum hygiene standards. It is also lower than the 15 liter standard set in the UAP to 15 liters of water per capita within a 1.5km radius.

A number of factors have attributed to poor sustainability and service levels of the schemes in the district.

In most schemes, the community participated in the WASHCO elections. Except in few WASHCO, women are highly marginalized owing to the cultural influence of male members over females. During the WASHCO elections, no consideration was made of incorporating different socioeconomic groups into the committee. In addition, there is no term and duration of membership unless an individual acts unlawfully. Most of the WASHCO members reported feeling discouraged owing to the absence of incentives in return for their efforts to serve the community. Most importantly, there is no systematic follow-up and supervision by the DWMEO to evaluate the effective functioning of the committee

Generally, some schemes have good financial management and strong committees that generate reasonable monthly income more than their expenditure. Such schemes with best income are capable to cover major maintenance cost. This offers a clear opportunity. However, in most schemes, tariff setting did not involve the community and did not take into consideration poor and marginalized people. Poor management means that no scheme has been carrying out saving systematically. The investment costs of the schemes installed in the District were very high; most were covered by the government and donors. The cost of minor maintenance is covered by the WASHCO that were strong in finance and by the DWMEO. The cost of major maintenance is covered by ZWMWO and OWMEB including major spare parts.

The scheme maintenance required by a water supply system was determined by the quality of design and construction during project implementation. As the program develops the maintenance load will progressively reduce due to closer attention to details during design, and improved the standard of construction. Appropriate supervision and use of good quality materials at the construction stage of the scheme are therefore prerequisite. Therefore, for long term life span and smooth operation system of any newly constructed schemes, an initial design and material to be used is the measuring factor. No matter how good the management of a water supply facility is, if it is not well designed technically, it will not operate efficiently

5.2 RECOMMENDATIONS

The following recommendations have been drawn based on the findings of the study, in order to ensure sustainability and increase service level of rural water supply schemes.

1. Rehabilitation and maintenance of non-functional schemes; replacement of schemes that are beyond their design period and are not currently providing a service; construction of new schemes in areas where there is high demand for improved water and increasing the number of water points in schemes where there is high water demand but limited numbers of water points.
2. Implementation of integrated watershed management activities to conserve and enhance the groundwater resource and creation of awareness in the community on the nature of the groundwater resource and the importance of source conservation, enhancement and protection.
3. Involvement of the community throughout project development phases to create a sense of ownership.
4. Strict follow-up and supervision during the design and implementation of newly constructed schemes to avoid leading to recurrent scheme failure.
5. Capacitating of the WASHCO through the provision of trainings and maintenance kits.

6. Regular follow-up and supervision of the WASHCO and schemes to prevent mismanagement and to check on scheme status.
7. Capacity building of the DWMEO, through the provision of logistics, maintenance kits, sufficient budget and human resources, and assignation of professional office head that is fully engaged and performs only office work.
8. Providing training for capacity building and refresher training are important in order to scale up the capacity of the water committees to manage the schemes properly. However, the possibility for refresher training is unthinkable in most cases due to the budget constraint at the district level. Therefore, financial and technical support is required not only at community level but at district levels
9. Completed projects then, shall be handed over to the community with sufficient budget, spare parts and toolkits that helps run the system for about three years (probation period) as should be designed at the beginning.
10. The choice of technology influences the Operation and Maintenance of the system and thus its sustainability. It should then be noted that in the design and study periods, spare parts and all necessary items must be included in order to facilitate for post construction operation and maintenance activities that would be carried out by the community.
11. Operation and Maintenance experts should be participate in study, design and construction supervision stages of new projects.
12. Spare parts supply shops that operate on a revolving fund should be established at zonal levels and this will facilitate availability of spare parts and required components at localities of the scheme.

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ANNEXE-1: Questionnaires

Water Use and Accessibility

1. What is your main source of water supply?
   - Is the water point functional?
   - For how low long has it been in operation?
   - For how long is the water point open every day?
   - How much is the volume of water a household is allowed to take? Do you have a restriction on water use?
   - What can you say about the quality and quantity of the water from this source?
   - Is the water sufficient for your daily activities?
   - Where do you get water from when the scheme fails to work and there is a shortage of tap water? Does everyone have access to the water point?
2. How far is the main source from your residence?
   - How much time do you spend collecting water per day? (time spent at water point + time to travel – roundtrip)
   - How many times do you fetch water per day?
   - Which members of the family are actively involved in fetching water?
3. Do you access an alternative source? Why do access the alternative source?
   - How far is the alternative source from your residence? (in time and distance)
   - When do you use the alternative source? (dry time, wet time, throughout the year)
   - Is there any mechanism you use to filter it?
4. What are the criteria to get water service from the water point? Who set up the criteria, what was your role in decision making?
5. For what purposes do you use the water?
6. What can you say concerning water charges you are paying?
   - Do you know why you pay?
   - How much do you pay?
   - Is the tariff affordable?

SCHEME FUNCTIONALITY

1. How is the functionality of the scheme?
   - How frequently do systems fail to work throughout the year?
   - How soon are they maintained?
   - How soon do systems fail after construction? What are the reasons?
2. What do you think are the main reasons for failure? long time operating without break ?

COMMUNITY PARTICIPATION

1. Did you remember how the scheme was installed here?
   - What was the role of the community in problem identification, prioritization, site selection, project design selection, and technology and service level selection?
   - Do you think that your views and comments were respected and taken into account while the project was being developed?
2. Explain how you participated in the construction of the scheme. What was your contribution during the scheme construction?
3. What influenced you to participate in project activities?
4. What contribution do you make to the following activities?
   - Operation and maintenance of the scheme? (cash, kind, labor, involvement)
   - Rehabilitation of the scheme and expansion of service?

MANAGEMENT OF WATER SUPPLY SCHEMES

1. Who is responsible for the day-to-day management activities of the water in the scheme?
2. Can you tell me how and when the WASHCO came into being?
   - What are the criteria to select the members? Who set these?

- What is the composition (gender, age, religion, poor and marginalized people) of the WASHCO? Is there an incentive for being member?
- What is the duration and term of operation for the WASHCO ?

3. What can you say about the management capacity of water service delivery by WASHCO and tap attendants?
   - Do you feel satisfied with the management operation of the water service? If yes, what are the positive sides? If no, explain why not.
   - What do you think should be done to help them?
   - Are there any managerial problems? What are they?
4. Explain how transparent the committee is with regard to income accrued and expenditure? Does the committee call for formal meetings to report the financial status of the institution?
5. Who is responsible for setting the water charge? How are decisions reached to set the tariff? What was your role in setting the water tariff? Did the tariff setting take into account the different socioeconomic conditions of the community? (Willingness and capacity to pay, poor, middle income, better off, marginalized, women, etc)
6. How do you pay for the water service? (On-the-spot payment for the service, monthly payment for a definite volume of water etc)

INSTITUTIONAL FACTORS

1. Can you tell me how and when the WASHCO came into being?
   - What were the criteria of selection?
   - How was the participation of women, poor, youth, elderly, Kebele Admin., NGOs?
   - Who organized the selection process? Kebele/NGOs/District/BoWR?
   - How many times can a committee be selected?
   - What is the duration of service for WASHCO in one election?
2. What are the roles and responsibilities of WASHCO? What is the composition of WASHCO in terms of gender, religion, economic status, location in the kebele?
   - Men to women ratio
   - Religious composition
   - Poor vs rich
   - Distant users vs users near by
3. Do you report to the community about your activities? (Y/N)………….. (if, no, why not?)
   - About what kinds of activities do you report to them? (Revenues and expenses?)
   - How frequently do you report? (once in…………….)
   - How is the response of the community regarding your reporting?
4. How do you manage your financial activities?
   - Have a bank account?
   - Have financial manual?
   - Have legal revenue collection receipts?
   - Have justifying documents (receipts, payroll, etc) for your expenses?
   - Properly handle financial documents?
   - Have a trained bookkeeper?
   - Financial reports?
5. Do you audit your financial and capital resources?
   - Who does the auditing?
   - How frequently? (once in a …………..)
6. Do you have a bookkeeping system for your incomes and expenses? Do you show it to relevant people or organizations as the need arise?

TECHNICAL FACTORS

1. How is the functionality of the scheme?
   - How frequently does the system fail (per year)?
   - How soon is it maintained after breakdown?
2. What do you think are the major reasons for the breakdown/non-functionality?
   - Are there design problems?

- Are there construction problems?
- Is it technology selection?
- Water quality problems?
- Cultural matters?

3. Who selected the technology installed?
   - Community participated?
4. How do you explain the situation in relation to maintenance?
   - Which parts fail more recurrently?
   - Where do you get your spare parts for minor and major maintenance?
   - How is the price of spare parts?
   - How do you cover the price of spare parts?
   - Are there local private spare parts suppliers?
   - Do you get spare parts in a timely manner?
   - Do you do minor maintenance?
   - How many are locally maintained? (by whom?)

FGD for DWMEO

FUNCTIONALITY AND SERVICE LEVEL

1. How do you explain the functionality of the schemes developed in the District?
   - How long do they perform after construction? (give special examples of difference)
   - How soon are they maintained?
   - Which schemes fail more recurrently and why?
   - Which schemes perform for a longer period of time without failure? Why?
   - Is it serving beyond its design population?
   - For what purposes are they used? (domestic, irrigation, cattle watering)
   - Are there schemes which the people are not using although they are technically functional? If yes, why?
2. How do you see the schemes' capacity/ability to meet the water demand of user communities?
   - High population pressure on the schemes beyond the designed population?
   - What quality problems are there? Where? How do you understand the problem?
   - How is scheme location in relation to user communities? (near, average, far)
3. Are there any basic functionality differences in schemes developed by the government (District/zone/region/fund) and NGOs? If, yes, why?
4. Is there a regular monitoring system for the water quality of schemes? If yes……………
   - Who does the monitoring?
   - How soon?
   - Is the water quality analysis data in line with regional/WHO water quality criteria?
5. Are there any complaints by the user community on the quality of the water delivered?
   - What kinds of complaints are they? (taste, odur, color)
   - Are there observed waterborne disease cases because of the use of the scheme?

General Details

1.District				
2. Kebele				
3.Specific Location				
4.Coordinates	E		N	
5.Date of Interview				
6.Name of Investigator				
7.Water Source used				
8.Interview background information				
Name				
sex	Age	Educational qualification		
Water point				
Position held in community/Institution				

ANNEXE-2: GPS Location of Water supply Sources

R.No	Water Facility Name	Year of construction Before 1995	Functionality status	X-Coordinate	Y-Coordinate	Z(m)
		1=yes 2=No	1=Function 2=Non Function			
1	Jello Dida water point	2	2	4658692	806265	1816
2	Jello Dida water point	2	2	459071	807150	1811
3	Jello Dida water point	2	2	458365	806703	1813
4	Jello Dida water point	2	2	457772	807661	1810
5	Ovenso Jello water point	2	1	457523	808947	1812
6	Ovenso Jello water point	2	1	455914	812934	1801
7	Kubi Guta water point	2	1	452888	810942	1788
8	Kubi Guta water point	2	1	453762	810435	1761
9	Kubi Guta water point	2	2	453111	810067	1762
10	Oine Umbure chafo w.point	1	1	448982	797689	1799
11	Qore Borojota water point	2	2	442240	791929	1760
12	Qore Borojota Deep well	1	2	443529	793425	1758
13	Qore Borojota water point	2	2	444240	794075	1761
14	Qore Borojota water point	2	2	444393	795395	1755
15	Meja Dema water point	1	2	453651	796669	1886
16	Meja Dema water point	1	1	453409	797470	1844
17	Meja Dema water point	2	1	451092	795824	1885
18	Danisa water well	1	1	476209	785790	2532
19	Danisa water well	1	1	476168	785767	2534
20	Danisa water well	1	1	475805	786076	2530
21	Danisa water well	1	1	475755	786183	2350
22	Danisa water well	1	1	475108	787161	2452
23	Danisa water well	1	2	474083	787271	2354
24	Danisa water well	2	1	474837	786632	2330
25	Danisa water well	2	1	474887	786632	2624
26	Danisa water well	1	1	475302	786685	2352
27	Danisa water well	1	1	475645	786270	2464
28	Hursa Simbo water point	2	2	470147	786785	2417
29	Hursa Simbo water point	2	2	469266	787638	2404
30	Hursa Simbo water tanker	2	1	468869	788093	2486
31	Hursa Simbo water point	2	1	468684	788273	2447
32	Hursa Simbo water point	2	1	469751	787777	2454
33	Hursa Simbo water point	2	1	468258	788715	2435
34	Hursa Simbo Hand dug	2	1	468210	788772	2453
35	Hursa Simbo Hand dug	2	1	468160	788853	2445
36	Hursa Simbo hand dug	1	1	467270	790149	2432
37	Bulchana Deneba water point	1	1	451525	793495	1871
38	Bulchana Deneba water point	1	1	451525	793495	1845
39	Bulchana Deneba water point	2	1	450553	794069	1843
40	Bulchana Deneba water point	2	1	450515	794109	1887
41	Bulchana Deneba water point	1	1	450465	793982	1842
42	Bulchana Deneba water point	2	2	449938	792768	1844
43	Faji Sole water pump	2	1	465397	791024	2323
44	Ilala Qorke water point	1	1	469787	804475	1944
45	Ilala Qorke water point	2	1	461127	804719	1945

46	Ilala Qorke water point	2	1	461398	804844	1995
47	Ilala Qorke water point	1	1	461171	806584	1988
48	Ilala Qorke water point	1	1	461420	806344	1970
49	Turufe water point	1	1	463019	800873	2140
50	Turufe water point	1	1	462751	801457	2146
51	Turufe water point	1	1	462624	801713	2150
52	Abiyu water point	2	1	464239	797312	2099
53	Abiyu water point	1	1	464320	797211	2135
54	Abiyu water point	2	1	464187	797479	2239
55	Abiyu water point	2	2	464186	797472	2202
56	Turufe watera elemo spring	2	1	463910	797391	2155
57	Abiyu water point	2	1	463864	797805	2093
58	Turufe water point	1	1	462522	801981	2032
59	Wandera hand pump	2	1	464752	789133	1992
60	Shasha hand pump	2	1	466996	785749	2226
61	Suke hand pump	2	1	468182	784300	2258
62	Shagule Hand pump	2	1	469264	785933	2228
63	Jengela wandera shallow well	2	1	468820	787306	2469
64	Kerera-Fillicha water point	2	2	461375	801431	1992
65	Kerera-Fillicha water point	2	2	461480	800892	1996
66	Lafto water point	2	2	460266	800494	1834
67	Sostegna zone water point	2	2	461590	800066	1842
68	Kerera-Fillicha water point	2	2	462485	799457	1987
69	Filicha water point	2	2	460139	799976	1989
70	Alleche water point	1	1	454101	791160	1956
71	Alleche herabate water point	1	1	454143	791162	1953
72	Alelu Ilu water point	2	1	455355	798617	1775
73	Alelu Ilu water point	2	1	456786	798607	1772
74	Chabididegnate water point	2	2	445743	798596	1768
75	Faji Goba water point	1	1	454844	803232	1831
76	Faji Goba Deepwell	1	1	454846	803226	1803
77	Abaro Shifene Borehole	2	2	463442	787816	2345
78	Kore rogicha hand dug well	2	1	448445	804288	1768
79	Kore rogicha hand dug well	2	1	448862	803990	1761
80	Kore rogicha hand dug well	2	1	446816	804214	1752
81	Kore rogicha hand dug well	2	1	445650	803779	1763
82	Hegugeta Quni water point	2	1	458738	803297	1891
83	Hegugeta Quni water point	2	1	458275	803481	1893
84	Hegugeta Quni water point	2	1	458159	801896	1890
85	Hegugeta Quni water point	2	1	458589	801610	1892
86	Hegugeta Quni water point	2	1	458686	801499	1889
87	Hegugeta Quni Deep well	2	1	458419	801069	1887
88	Awasho Denqu water point	2	1	458575	793942	2225
89	Awasho Denqu water point	2	1	461567	795070	2221
90	Awasho Denqu water point	2	1	460201	795579	2219
91	Awasho Denqu water point	2	1	459393	795560	2220
92	Bura Borema water point	1	1	443414	802232	1686
93	Bura Borema water point	1	1	443295	802451	1688
94	Bura Borema water point	1	1	443570	802335	1690
95	Bura Borema water point	1	1	443745	802245	1694
96	Toga water point	2	2	444672	792666	1704
97	Toga water point	1	1	447114	791469	1724
98	Jigesa Qorke water point	2	2	463289	796433	1910
99	Jigesa Qorke water point	2	2	463579	797016	1913

100	Jigesa Qorke shallow well	1	2	462390	797679	2104
101	Jigesa Qorke water point	2	2	463889	796998	1912
102	Ardano Shifa spring	2	1	474825	792444	2322
103	Ardano Shifa spring	2	1	473911	791274	2409
104	Ardano Shifa water point	2	2	477307	789947	2486
105	Ardano Shifa water point	2	2	478124	789814	2538
106	Ardano Shifa shallow well	2	2	475066	791542	2560
107	Ardano Shifa water point	2	2	472565	794097	2640
108	Bute Fillicha water point	2	2	462858	795589	1914
109	Bute Fillicha water point	2	2	461835	797201	1915
110	Bute Fillicha water point	2	2	461333	796539	1910
111	Bute Fillicha water point	2	2	459255	797537	1912
112	Bute Fillicha water point	2	2	456569	802445	1923
113	Bute Fillicha water point	1	2	457458	800456	1916
114	Bute Fillicha water point	1	2	457330	799741	1918
15	Chulule Hebera water point	2	1	448574	807653	1755
116	Chulule Hebera water point	2	1	448095	807959	1758
117	Chulule Hebera water point	2	1	451686	805596	1763
118	Chulule Hebera water point	1	1	450929	806160	1761
119	Chulule Hebera water point	2	2	450250	807054	1759
120	Chulule Hebera water point	1	1	451414	804251	1760
121	Feji Gole water point	2	1	454230	805355	1831
122	Feji Gole water point	2	1	454083	805496	1803
123	Feji Gole water point	2	2	453603	807213	1820
124	Idola Burka water point	2	2	458461	792628	2030
125	Idola Burka water point	2	2	459261	791540	2031
126	Idola Burka water point	2	2	460059	790955	2033
127	Idola Burka water point	2	2	460676	790620	2032
128	Idola Burka water tanker	2	2	460747	790769	2055
129	Idola Burka Bore hole	2	1	457055	793314	2037
130	Idola Burka water point	1	1	456670	482220	2035
131	Watera shegule water point	2	2	469858	796316	2226
132	Watera shegule water point	2	2	469641	797305	2258

ANNEXE-3: Ground Water Parameters

SAMPLE DATA FOR HURSA-FAGI BOREHOLE

	Quantitative data of the boreholes				
No	Description	Recorded data during well construction	Recorded data after two year	Recorded data after four year	Recorded data after six year
1	Drilled depth	287.72	287.72	287.72	287.72
2	Effective well depth (Cased depth)(m)	286	286	286	286
3	Water strike depth(m)	153			
4	Static water level(m)	148.20	150	151.5	151.95
5	Dynamic water level (m)				
6	Water column of the wells(m)	137.8	136	134.5	134.05
7	Annual rainfall of the area(mm)	750	680	604	
8	Estimated evapo transpiration(mm)	235	315	430	
9	Estimated potential yield (l/sec)	5			
10	Safe yield per the pumping test result (Constant test)(l/sec)	4.5	4.35	4.25	4.15
11	water quality				
	a. Turbidity	-	20	12	
	b.PH	6.06			
	c. Sodium	35.5			
	d. Fluoride	0.89	0.91	0.95	
	e. calcium	21.88			

SAMPLE DATA FOR HAGUGETA-FAGI BOREHOLE

	Quantitative data of the boreholes			
No	Description	Recorded data during well construction	Recorded data after a year	Recorded data afterfour year
1	Drilled depth	258.5	256.7	256.7
2	Effective well depth (Cased depth)(m)	256	256	256
3	Water strike depth(m)	152		
4	Static water level(m)	149	151	151.5
5	Dynamic water level (m)	209		
6	Water column of the wells(m)	107	105	104.5
7	Annual rainfall of the area(mm)	750	680	604
8	Estimated evapo transpiration(mm)	235	315	430
9	Estimated potential yield (l/sec)	3	2.95	2.75
10	Safe yield per the pumping test result (Constant test)(l/sec)	2.5	2.35	2.25
11	water quality			
	a. Turbidity	-	21	22
	b.PH	7.06		

	c. Sodium	37.5		
	d. Fluoride	0.91	0.93	0.98
	e. calcium	28.88		

SAMPLE DETA FOR EBICHA BOREHOLE

	Quantitative data of the boreholes				
No	Description	Recorded data during well construction	Recorded data after three year	Recorded data after six year	Recorded data after nine year
1	Drilled depth	316	316	316	316
2	Effective well depth (Cased depth)(m)	312	312	312	312
3	Water strike depth(m)	97			
4	Static water level(m)	94.5	95	96.25	95.95
5	Dynamic water level (m)	111.59			
6	Water column of the wells(m)	217.5	217	215.75	216.05
7	Annual rainfall of the area(mm)	881	802	750	604
8	Estimated vapor transpiration(mm)	155.5	210.75	312	425.5
9	Estimated potential yield (l/sec)	6.5	5.75	5.25	4.85
10	Safe yield per the pumping test result (Constant test)(l/sec)	5	4.95	4.75	4.65
11	water quality				
	a. Turbidity	18.25	21	22	23
	b.PH	6.05			
	c. Sodium	19			
	d. Fluoride	0.60	0.93	0.98	1
	e. calcium	16.0			

ANNEXE-4: hydraulic analysis results of transmission main joints MMD

Label	X (m)	Y (m)	Elevation (m)	Demand (l/s)	Pressure (m H2O)	Calculated Hydraulic Grade (m)
JT-1	453,138.00	785,234.00	1,703.25	0	229	1,933.05
JT-2	452,988.07	785,238.67	1,701.65	0	230	1,931.97
JT-3	452,842.64	785,219.14	1,705.11	0	225	1,930.91
JT-4	452,718.74	785,189.13	1,697.61	0	232	1,930.00
JT-5	452,655.58	785,215.23	1,698.19	0	231	1,929.51
JT-6	452,585.73	785,295.39	1,697.66	0	231	1,928.74
JT-7	452,522.44	785,372.39	1,696.46	0	231	1,928.03
JT-8	452,480.17	785,400.62	1,696.03	0	231	1,927.66
JT-9	452,339.82	785,494.33	1,697.93	0	228	1,926.45
JT-10	452,210.66	785,517.57	1,694.48	0	231	1,925.50
JT-11	452,112.26	785,535.28	1,691.75	0	233	1,924.78
JT-12	451,902.62	785,603.12	1,691.69	0	231	1,923.20
JT-13	451,774.51	785,623.25	1,690.78	0	231	1,922.27
JT-14	451,626.33	785,646.54	1,688.84	0	232	1,921.19
JT-15	451,521.94	785,662.94	1,689.17	0	231	1,920.43
JT-16	451,340.34	785,732.11	1,689.50	0	229	1,919.04
JT-17	451,200.16	785,785.49	1,690.62	0	227	1,917.96
JT-18	451,106.71	785,821.08	1,692.48	0	224	1,917.24
JT-19	450,919.51	785,891.48	1,691.43	0	224	1,915.81
JT-20	450,826.84	785,926.33	1,692.49	0	222	1,915.09
JT-21	450,680.26	786,063.86	1,695.61	0	218	1,913.65
JT-22	450,570.87	786,166.50	1,695.37	0	217	1,912.57
JT-23	450,505.24	786,228.07	1,696.05	0	215	1,911.93
JT-24	450,433.28	786,425.37	1,702.69	0	207	1,910.42
JT-25	450,381.89	786,566.28	1,702.88	0	206	1,909.34
JT-26	450,341.85	786,676.05	1,706.52	0	202	1,908.50
JT-27	450,235.33	786,825.05	1,707.06	0	200	1,907.19
JT-28	450,182.67	786,898.71	1,711.37	0	195	1,906.54
JT-29	450,031.16	787,043.34	1,715.46	0	189	1,905.03
JT-30	449,891.67	787,176.49	1,714.56	0	189	1,903.65
JT-31	449,800.23	787,232.36	1,712.84	0	190	1,902.88
JT-32	449,672.24	787,310.58	1,711.49	0	190	1,901.80
JT-33	449,548.17	787,386.39	1,715.36	0	185	1,900.75
JT-34	449,415.51	787,465.79	1,721.90	0	177	1,899.64
JT-35	449,326.07	787,519.32	1,721.72	0	177	1,898.89
JT-36	449,239.75	787,613.86	1,719.49	0	178	1,897.98
JT-37	449,152.82	787,813.49	1,725.11	0	171	1,896.41
JT-38	449,101.48	787,931.37	1,727.24	0	168	1,895.49
JT-39	448,992.96	788,124.16	1,722.76	0	171	1,893.90
JT-40	448,930.23	788,202.29	1,720.98	0	172	1,893.18
JT-41	448,852.55	788,299.03	1,725.35	0	167	1,892.29
JT-42	448,739.27	788,433.63	1,724.78	0	166	1,891.02
JT-43	448,619.98	788,575.36	1,725.64	0	164	1,889.69
JT-44	448,545.73	788,662.86	1,728.19	0	160	1,888.87
JT-45	448,436.54	788,791.51	1,732.25	0	155	1,887.65
JT-46	448,332.39	788,916.45	1,732.87	0	153	1,886.48
JT-47	448,217.84	789,091.02	1,743.82	0	141	1,884.98
JT-48	448,128.04	789,284.87	1,770.30	0	113	1,883.45
JT-49	448,024.59	789,473.04	1,803.34	0	78	1,881.91
JT-50	447,930.46	789,680.44	1,849.62	0	31	1,880.27
JT-51	447,828.61	789,805.44	1,873.25	0	6	1,879.11

ANNEXE-5: hydraulic analysis results of transmission main MMD

Label	Length (m)	Diameter (mm)	Material	Hazen-Williams C	Velocity (m/s)	Discharge (l/s)	Pressure Pipe Head loss (m)	U/S Hydraulic Grade (m)
P-1	150	250	DCI	110	1.13	55.63	1.08	1,933.04
P-2	148	250	DCI	110	1.13	55.63	1.06	1,931.97
P-3	127	250	DCI	110	1.13	55.63	0.92	1,930.91
P-4	68	250	DCI	110	1.13	55.63	0.49	1,929.99
P-5	106	250	DCI	110	1.13	55.63	0.76	1,929.50
P-6	100	250	DCI	110	1.13	55.63	0.72	1,928.74
P-7	51	250	DCI	110	1.13	55.63	0.37	1,928.02
P-8	169	250	DCI	110	1.13	55.63	1.21	1,927.66
P-9	131	250	DCI	110	1.13	55.63	0.94	1,926.44
P-10	100	250	DCI	110	1.13	55.63	0.72	1,925.50
P-11	220	250	DCI	110	1.13	55.63	1.58	1,924.78
P-12	130	250	DCI	110	1.13	55.63	0.93	1,923.20
P-13	150	250	DCI	110	1.13	55.63	1.08	1,922.27
P-14	106	250	DCI	110	1.13	55.63	0.76	1,921.19
P-15	194	250	DCI	110	1.13	55.63	1.4	1,920.43
P-16	150	250	DCI	110	1.13	55.63	1.08	1,919.03
P-17	100	250	DCI	110	1.13	55.63	0.72	1,917.96
P-18	200	250	DCI	110	1.13	55.63	1.44	1,917.24
P-19	99	250	DCI	110	1.13	55.63	0.71	1,915.80
P-20	201	250	DCI	110	1.13	55.63	1.44	1,915.09
P-21	150	250	DCI	110	1.13	55.63	1.08	1,913.65
P-22	90	250	DCI	110	1.13	55.63	0.65	1,912.57
P-23	210	250	DCI	110	1.13	55.63	1.51	1,911.92
P-24	150	250	DCI	110	1.13	55.63	1.08	1,910.42
P-25	117	250	DCI	110	1.13	55.63	0.84	1,909.34
P-26	183	250	DCI	110	1.13	55.63	1.32	1,908.50
P-27	91	250	DCI	110	1.13	55.63	0.65	1,907.18
P-28	209	250	DCI	110	1.13	55.63	1.5	1,906.53
P-29	193	250	DCI	110	1.13	55.63	1.39	1,905.03
P-30	107	250	DCI	110	1.13	55.63	0.77	1,903.64
P-31	150	250	DCI	110	1.13	55.63	1.08	1,902.87
P-32	145	250	DCI	110	1.13	55.63	1.04	1,901.80
P-33	155	250	DCI	110	1.13	55.63	1.11	1,900.75
P-34	104	250	DCI	110	1.13	55.63	0.75	1,899.64
P-35	128	250	DCI	110	1.13	55.63	0.92	1,898.89
P-36	218	250	DCI	110	1.13	55.63	1.56	1,897.97
P-37	129	250	DCI	110	1.13	55.63	0.92	1,896.41
P-38	221	250	DCI	110	1.13	55.63	1.59	1,895.49
P-39	100	250	DCI	110	1.13	55.63	0.72	1,893.90
P-40	124	250	DCI	110	1.13	55.63	0.89	1,893.18
P-41	176	250	DCI	110	1.13	55.63	1.26	1,892.29
P-42	185	250	DCI	110	1.13	55.63	1.33	1,891.02
P-43	115	250	DCI	110	1.13	55.63	0.83	1,889.69
P-44	169	250	DCI	110	1.13	55.63	1.21	1,888.87
P-45	163	250	DCI	110	1.13	55.63	1.17	1,887.65
P-46	209	250	DCI	110	1.13	55.63	1.5	1,886.48
P-47	214	250	DCI	110	1.13	55.63	1.53	1,884.98
P-48	215	250	DCI	110	1.13	55.63	1.54	1,883.45
P-49	228	250	DCI	110	1.13	55.63	1.64	1,881.91
P-50	161	250	DCI	110	1.13	55.63	1.16	1,880.27
P-51	128	250	DCI	110	1.13	55.63	0.92	1,879.11