SUSTAINABILITY ASSESSMENT OF DONI SIFA SMALL-SCALE IRRIGATION SCHEME IN UPPER AWASH RIVER BASIN

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Approval of Board of Examiners

We, the undersigned, members of the board of examiners of the final open defense by Fitsum Mulugeta Getaneh have read and evaluated his thesis entitled "Sustainability Assessment of Doni Sifa Small-scale Irrigation Scheme in Upper Awash River Basin" and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirement of the degree of Master of Science in Irrigation Engineering.

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Declaration

I hereby declare that this MSc Thesis is my original work and has not been presented for a degree in any other university, and all sources of information used in this thesis have been duly acknowledged.

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This is to certify that the thesis entitled “Sustainability Assessment of Doni Sifa Small-scale Irrigation Scheme in Upper Awash Basin” submitted in Partial Fulfillment of the requirement for the degree of Master of Science in Irrigation Engineering, the Graduate program of the department of Water Resource and Irrigation Engineering and has been carried out by Fitsum Mulugeta Getaneh Id. No GSR_1502/08, under our supervision. Therefore we recommend that the student has fulfilled the requirements and hence hereby he can submit the thesis to the department.

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ACRONYMS AND ABBREVIATION

AIA	Actual Irrigation Area
AEZ	Agro-Ecology Zone
ABA	Awash Basin Authority
CD	Compatibles Disk
CGIAR	Consultive Group on International Agricultural Research
CSA	Central Statistical Agency
E	East
EC	Electric Conductivity
EIA	Environmental Impact Assessment
FAO	Food and Agriculture Organization of United Nation
FDRE	Federal Democratic Republic of Ethiopia
FESLM	Framework for Evaluation of Sustainable Land Management
FGD	Focus Group Discussion
FI	Farm Income
GC	Gregorian calendar
GDP	Gross Domestic Product
GIS	Global Information System
GPS	Global Positioning System
Ha	Hectare
HH	Household
IFAD	International Fund for Agricultural Development
IFI	Impact of O&M Cost in Farmer Income
ISI	Irrigation Sustainability Index
IRR	Internal Rate of Return
KM	Kilo Meter
LQIs	Land Quality Index
M^3	Cubic Meter
MCDA	Multi-Criteria Decision Analysis
MOA	Ministry of Agriculture

MOWIE	Ministry of Water Irrigation and Energy
MOWR	Ministry of Water Resource
N	North
NGO	Non-Governmental Organization
NPV	Net Present Value
ODA	Official Development Assistance
OM	Operation and Maintenance
PASDEP	Plan for Accelerated and Sustainable Development to End Poverty
PCA	Principal Component Analysis
PH	Power of Hydrogen
SCP	Special country Program
SLM	Sustainable Land Management
SNNP	Southern Nation, Nationality and People
SSI	Small-Scale Irrigation
SRL	Sustainable Rural Livelihoods
TAC	Technical Advisory Committee
TC	Total annual Cost
UK	United Kingdom
USA	United State of America

ABSTRACT

This study was conducted with a general aim of assessing the sustainability of Doni Sifa Small-scale Irrigation Scheme in Upper Awash River Basin. The specific objectives of the study were to determine the current status of the irrigation scheme, analyze the technical, environmental, socio-economic and institutional sustainability of the system, determine the problems associated with sustainability, and propose/recommend possible measures to enhance the sustainability of the system. Primary and secondary data were gathered to achieve the objectives of this study. The primary data were collected using: survey questionnaires, interviewing the beneficiaries, focus group discussion and field observations. In addition to primary data, secondary data were collected from several sources, which include meteorological data, maps and soils data of the study area. A descriptive analysis was used to analyzed qualitative data; the Microsoft Excel was used for the analysis of quantitative data. The result of 40 years Awash River stream flow analysis indicated that 2,959,000m^3 water is available on the month of Oct11-March and the required amount of water for the scheme was 468,000$m^{3;}$ it clearly shows the scheme is free from water availability problem. However, it was found that there was a shortage of irrigation water in the study area which caused conflicts among farmers. It was also found that most of the system's structures were in very poor conditions. Moreover, the area has 125% cropping intensity which is very low and diversity, flooded once or more a year but there was no severe fertility problem. Environmental sustainability indicators showed that some portions of the study area were severely degraded, and the fields were highly exposed to wind and water erosion as evidenced by the formation of gullies. The farmers do not practice any conservation measures and poorly managed the irrigation water indicating a need for capacity building. The economic analysis also found that the scheme IRR, gross B/C and net B/C ratio was -1%, 0.66 and 0.27 respectively which is unsustainable from the economic point of view. The overall condition of the scheme from technical, environmental, socio- economic and institutional point of view was unsustainable. To address this problem, a set of possible measures were recommended for the scheme.

Key words: Small-scale irrigation, Sustainability, Upper Awash, Doni-Sifa, Ethiopia

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1. INTRODUCTION

1.1. Background of the Study

Studies show that Ethiopia has rich and vast water and land resources. The estimated annual surface flow of the rivers is about 123 billion m^3. However, these rich water resources have not been exploited. This situation is even further aggravated by technical, financial, social and environmental related prob1ems. Also, the ill effects of drought and unreliability of rainfall have seriously hindered the agricultural development. It is therefore necessary that the available water and land resources of the country have to be tapped in order to combat the persistent drought and the scanty and unreliable precipitation (MoWIE, 2014).

Ethiopia comprises 112 million hectares (Mha) of land. Cultivable land area estimates vary between 30 to 70 Mha. Currently, high estimates show that only 15 Mha of land is under cultivation. For the existing cultivated area, our estimate is that only about 4 to 5 present is irrigated; with existing equipped irrigation schemes covering about 640,000 hectares. This means that a significant portion of cultivated land in Ethiopia is currently not irrigated. This section examines Ethiopia’s Water sources for irrigation, current irrigation schemes, and potential to increase irrigated lands (Seleshi, 2010).

The International Fund for Agricultural Development (IFAD) has been supporting the construction of many small-scale irrigation schemes under the Special Country Programs, SCP-I and SCP-II, and most of these schemes are currently in operation. However, some of these schemes are not operating with full capacity due to various reasons. Such reasons, among others, include frequent reorganization and rapid staff turnover, limited staff capacity and technical know-how, problems associated with the legal empowerment of water users associations (WUAs) and the lack of community participation in the development process (Awulachew et al., 2008).

1.2. Statement of the Problem

Ethiopia has been highly affected by drought and climate-related hazards, and millions of people have been left without sustenance every year. To increase productivity and diversify the livelihood scenarios as an option, small-scale irrigation (SSI) schemes have been introduced (Dereje and Desale, 2016).

Small-scale irrigation is playing an important role in adapting to climate change, achieving food security, and improving household incomes. The Ethiopian Government considers irrigated agriculture as a primary engine of economic growth and plans to increase the current level of irrigation infrastructure three-fold by the end of 2015. However, there has been concern regarding the performance and management of existing small-scale irrigation. Based on the assessment of 52 small-scale irrigation schemes, and three case study sites, we describe the challenges and interventions required to improve irrigation water management in Ethiopia. Though most schemes are operational, many do not operate at full capacity, due to design failures, excessive siltation, poor agronomic and water management practices, and weak local institutions. In addition to low returns, there is competition for irrigation water between upstream and downstream users, vegetable growers and cereal growers, and between farmers with large irrigable plots and those with small plots. Despite these challenges, our field assessment revealed that small scale irrigation increases crop yields, improves crop diversification, and reduces the risk of crop failure (Tilahun, 2014).

The community in/around existing Doni Sifa small scale irrigation is affected by severe drought and his brother famine from year to year even during good year because of late coming, failure in the middle of cropping season or early stopping of rainfall. Near the study area, Awash River is very much full and even over flooding endangers life and properties. This calls for a need to conduct detailed to semi-detailed study on potential irrigable land, river stream and water management system studies (Gemechis, 2014).

Hence, it is obvious that there is a lot to be done in seeking for some set of technical, institutional, agronomical, environmental, socio-cultural and economical practice under which we feel confident that the system will continue to existing and function. Therefore, this specific research is designed to generate location specific data on sustainability of irrigation scheme in the study area.

1.3. Significance of the study

In the development of policy and strategies of the country starting PASDEP, GTP I and GTP II, sustainability is a burning issue. In any context sustainability implies an option about what is going on the future. Result of this are expected to be useful for:

- Policy makers or managers may get early warning of changes that may indicate weakness of sustainability,
- Showing the existing knowledge and percentage of sustainability of Doni Sifa irrigation scheme ,
- Local government, NGO and private investors involved in the promotion of SSI development in the study area will gain some valuable information for future use,

1.3. Objectives of the Study

1.3.1 General objective

The general objective of this research was to assess the sustainability of Doni Sifen irrigation scheme in upper Awash.

1.3.2. Specific objectives:

i. To state current status of Doni Sifa small-scale irrigation scheme;

ii. To analyse the technical, environmental, socio-economic and financial sustainability of the scheme; and

iii. To identify the problems associated with the sustainability of the scheme.

1.4. Research questions

This research attempted to answer the following questions:

i. What is the current status of the irrigation scheme?

ii. Is the irrigation scheme sustainable from the technical, socio-economic, institutional and environmental point of view?

iii. What are the main problems/gaps associated with sustainability in the study area?

iv. What measures can be adopted to make the scheme more sustainable?

2. LITERATURE REVIEW

In this chapter, theoretical, conceptual, review of previous work and also analytical framework related to sustainability assessment of irrigation scheme was organized as follows.

2.1. The concept of sustainability and sustainable development

According to Craig Hanson (2013) Sustainability is defined as Global goals, targets, and indicators for poverty eradication and improved well-being must integrate economic, social, and environmental dimensions of sustainability and their inter-linkages, with equity and resilience as cross-cutting priorities.

A broadly acceptable definition of sustainable agriculture, from a biophysical perspective, has been proposed by the Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research (CGIAR): "Sustainable agriculture involves the successful management of resources for agriculture to satisfy changing human needs, while maintaining or enhancing the quality of the environment and conserving natural resources" This is a practical approach to sustainability since it recognizes the legitimate use of natural and man-made resources for satisfaction of human needs, but it cautions against the exploitation of these resources in a manner which would degrade the quality and potential of the resources on which production depends. It also recognizes that human needs change and therefore the systems of production must also change (Julian Dumanski *et al*., 1998).

According to Timing *.et.al*,(2001) In the context of arid or semi-arid basins where irrigation is the dominant water use, sustainability in irrigation water management can be indicated by water supply system reliability, reversibility, and vulnerability, environmental system integrity, equity in water sharing, and economic acceptability.

The term 'Sustainable Development' can be defined as the "Environmental, economic and social well-being for today and tomorrow". This definition covers a vast range of fields including economy, technology, politics, environment, etc. Thus, it is quite difficult to narrow down the scope only to "Sustainable Development and Environment Protection", as needs of human beings escalate on a daily basis, the consumption of resources increases. This trend is universally accepted and cannot be changed within a month, year or even in a decade. The more the consumption of resources increases the more it becomes a barrier to the sustainable development of the world (Syndictate 06).

Sustainability of an irrigation scheme refers to the long-term abilities of all parties to the contract (i.e., the public authority which has granted the PPP, the private firm(s) that provides the services, and the beneficiaries of the services) to benefit in a sustained way from the project. For the private sector in particular this implies being able to operate and maintain the scheme profitability. Revenue from water user fees (both connection fees and consumption fees) is sufficient to enable the recovery of operations and maintenance (O&M) and any capital investment. Sustainability is thus linked to a viable agricultural value chain, as the level of fees that farmers will be able to pay will ultimately is dependent on the increased income that they will achieve as a result of the irrigation services (Cledan Mandri-Perrott and J. Bisbey, 2016).

The concept of agricultural sustainability is relative and case dependent (Pretty, (2008); cited by Paula Antunes *et al*., 2017). It depends on the particular environmental, cultural and social context of each case/area. Furthermore, sustainability is not an absolute condition of an agricultural system, but more seen as an evolving concept. What is considered “sustainable” or “unsustainable” depends very much on local conditions and recent trends (Zhen & Routray, 2003 cited by Paula Antunes *et al*., 2017).

Following the concept of Ximing. Cai *et al*. (2001) a set of manageable indicators of sustainability are necessary to detect problem as they arise and to provide an early warning system for decision makers. The indicator should be monitored and measured on the basis of the performance of natural systems. In particular the indicators should be helpful in tracing long term cumulative environmental changes due to irrigation practices, which can potentially create irreversible problems. Sustainability in irrigation water management can be indicated by:

Water supply system reliability, reversibility, and vulnerability

Reliability comprises three terms: occurrence reliability (the ratio of the number of periods of system success to the number of periods of operation), temporal reliability (the ratio of time of the system is in the success state to the total time of operation), and volumetric reliability (the ratio of the volume of water supplied to the total volume demand).

Reversibility is the probability of the system can recover from failure to some acceptable state within a specified time interval. Vulnerability represents the severity or magnitude of a system failure.

Environmental system integrity

Indicators for environmental system integrity fall into three categories:

1) Health of aquatic and floodplain ecosystems. Extensive irrigation can affect drinking water health as indicated by bacteria, nutrients, and toxic contaminants and soil health as indicated by soil's water holding capacity, total organic Nitrogen and Carbon, PH value and the condition of surface aggregates.

2) Water quality; Irrigated agriculture affects water quality in several ways, including higher chemical-use rates associated with irrigated crop production, increased field salinity resulting from applied water, accelerated pollutant transport with drainage flows, groundwater degradation due to increased deep percolation to saline formation, and greater in stream pollutant concentration due to flow depletion.

3) Soil degradation; Irrigation responsible for soil water logging and salinization in many regions where drainage systems are poor, irrigation with traditional furrow systems also causes soil erosion that can be measured by the extent of topsoil losses.

Equity in water sharing
Equity involves complex natural, political, and socio-economic factor such as, conflict between upstream and downstream and various water users.

Economic acceptability
Economically acceptable irrigation systems provide lifestyle and social option for farmers and also contribute to the wider economy and community.

Sustainability cannot be objectively quantified as it requires value judgments to actually apply the concept to specific projects and to come to conclusions as to whether or not the projects will supply sustainable benefits. Two fundamental problems arise:

(1) The measure of benefit is often imprecise-the benefit intent of a project may cover multiple goals. Though a level of service may be maintained, that service itself has several dimensions of benefit: such as quantity, access, reliability, quality, and cost (QARQC).

(2) The adjective "sustainable has strong normative connotations. Different participants in the projects (donors, host government, beneficiaries) will have different evaluations of sustainability based on the relative value of achieving the various goals.

Benefit levels may be expressed in many ways. One frequently used measure is improved health, as indicated by a reduction in child mortality and morbidity from diarrheal diseases. Or it may simply be stated as the number of people who have improved access to potable water and sanitation systems. In any case, benefit level implies a threshold value whereby goals are said to be achieved and consequently a project is pronounced sustainable. However, if one accepts that there are degrees of sustainability, and then one must abandon the distinction of "have them/"have "they not achieved all goals, and allow for tradeoffs among different goals. One would need an explicit preference function for the decision-maker to use. This implies a welfare function which would aggregate the different benefits by assigning relative value to the achievement of different goals. Even then, the concept of sustainability would require a time dimension (WASH, 1994).

2.2. A Framework for Sustainable Irrigation System

2.2.1. Agricultural sustainability assessment tools/approaches

Sustainability in agriculture is a complex concept and there is no common viewpoint among scholars about its dimensions. Nonetheless various parameters for measuring agricultural sustainability have been proposed (Dariush Hayati et al. (2010). Some of agricultural sustainability assessment tools are discussed below.

2.2.2. Elimination Method of Multi-Criteria Decision Analysis (MCDA)

A wide variety of methods have been developed to assess the sustainability of agriculture at the international, national, regional, farm, and product level. While this is an important step, there are drawbacks for many of these methods. In some methods, only one aspect of sustainability is assessed, such as cost-benefit analysis, or the carbon or ecological footprint. Other methods assess the three pillars of sustainability: environmental, economic, and social. Some methods are expert-driven (top-down), while some are expert- and stakeholder-driven (top-down and bottom-up), and some are only stakeholder-driven (bottom-up). Some assessments are based on indicators and some are based on indexes. Most of the initiatives for agricultural assessment have been undertaken by individual scholars or groups. The approaches for the assessment of agricultural sustainability are continuously evolving, because sustainability assessment frameworks are influenced by local agricultural priorities and practices. There are more than 100 assessment tools used around the world (FAO, 2015; cited by Byomkesh Talukder et al., (2016).

The application of Monitoring and Evaluation systems to assess water facility projects has provided decision makers to plan for the sustainability of the future projects based on the performance of the existing projects. There are many subjective and objective opinions while determining the effectiveness of these projects. For the community–based projects, sustainability is a major cause of concern to all the stakeholders. In order to monitor and evaluate the sustainability of these projects, different indicators are identified for measuring their effectiveness. A framework for an integrated evaluation system is developed in this study using analytical hierarchy process for multiple-criteria decision making. There is much subjective information that needs to be quantified in order to remove any bias in evaluator's assessment of qualitative measures. A framework developed in this study in this study is then applied to assess the sustainability of the sixteen chosen water facility projects in Nepal. The results have shown that there is significant value of such framework in providing information and input for different decision-making levels (Kamalesh Panthi and Shashi Bhattarai, 2008). Detail of the Framework discussed below:

The Analytical Hierarchy Process (AHP) based multiple criteria analysis deals with the relative priority of importance of each factor by pairwise comparison of all factors with respect to a certain criteria. A hierarchical structure of these factors is formed by grouping them into different levels. The application of the hierarchical structure allows the factors to be broken down in to details. AHP based multiple criteria analysis starts from building tree like structure with criteria at higher level and factors and sub-factors are at the lower level. Objective of evaluation lies at the top and the options or alternatives to be evaluated are placed at the lowest level of the hierarchy. The AHP simplifies the process of identification and assessment of criteria, factors and sub-factors related to a problem. The importance or weight of the factors can either be directly applied or could be generated by making pair-wise judgment between the various factors. Performance of project is applied at the lowest level of the hierarchy. Criteria are the highest level of sustainability monitoring indicators, whereas sub-factors are at the lower level.

2.2.3. Framework for Evaluation of Sustainable Land Management (FESLM)

Any measure of physical and biological sustainability must combine measures of productivity enhancement, measures of natural resource protection, and measures of social acceptability. Thus we advocate some combination of the ideas of those who focus on indicators of resource quality and those who emphasize economic productivity measures. Such an integrated approach is being developed as a FESLM. The FESLM was developed through collaboration among international and national institutions as a practical approach to assessing whether farming systems are trending towards or away from sustainability Smyth and Dumanski (1993); cited in Dumanski *et al*. (1998).

2.2.4. Sustainable Rural Livelihoods (SRL) framework

The Sustainable Rural Livelihoods (SRL) framework is the most recent development of an approach to the analysis of links between livelihoods and natural resource use which has been widely discussed in recent years Scoones (1998), Carney (1998), Ellis forthcoming stated in Woodhouse *et al*., (2000). Its central idea is that sustainability of livelihood strategies of individuals or households depends on access, use, and development of different types of assets. The framework further considers that the kinds of strategies which may be available, the choices made, and the outcomes achieved are influenced by two sets of factors which establish a context. The framework has been developed primarily to address the needs of policies and project interventions to reduce rural and urban poverty (Woodhouse et al., 2000). According to Woodhouse *et al*., (2000) elements of SRL framework are defined in detail.

Assets

Assets are considered to be stocks of different types of 'capital' that can be used directly or indirectly to generate livelihoods. They can give rise to a flow of output, possibly becoming depleted as a consequence, or may be accumulated as a surplus to be invested in future productive activities. The SRL framework identifies five basic types of capital that comprise assets for livelihoods: natural, physical, financial, human, and social.

Natural capital consists of land, water, and biological resources such as trees, pasture, and wildlife. The productivity of these resources may be degraded or improved by human management.

Physical capital is that created by economic production. It includes infrastructure, such as roads, irrigation works, electricity supply, and reticulated water, and also producer goods such as machinery.

Human capital is constituted by the quantity and quality of labor available. At household level, therefore it is determined by household size, but also by the education, skills, and health of household members.

Financial capital consists of stocks of money or other savings in liquid form. In this sense it not only includes financial assets such as pension rights, but should also include easily-disposed assets such as livestock, which in other senses may be considered as natural capital.

Social capital includes any assets such as rights or claims which are derived from membership of a group. This includes the ability to call on friends or kin for help in times of need, support from trade or professional associations (e.g. farmers' associations), and political claims on chiefs or politicians to provide assistance. These latter are sometimes discriminated as 'vertical' claims on structures of authority, contrasted with 'horizontal' claims among group members of similar status. The ability to make such claims may be considered as a mark of social inclusion or exclusion of particular individuals or groups.

2.3. Indicators of sustainable irrigation systems

2.3.1. Indicators framework

Indicators are a way of measuring progress towards the achievement of the goal, i.e. the targets or standards to be met at each stage. They provide an objective basis for monitoring progress and evaluation of final achievements. A good indicator should define the level of achievement, specifically: how much? (Quantity), how well? (Quality), by when? (Time) (Andreas P. *et al*, 2002).

Several sets of methodological frameworks or guidelines have been identified for the measurement of sustainability indicators at the farm or community to district levels. These have all tended to come from an approach focused on sustainable agriculture and/or sustainable land management – often directly related to the FESLM. These have included: the guidelines for conducting case studies under the FESLM (Dumanski, 1995; as stated in Phil Woodhouse *et al*., 2000).

Gomez *et al.* (1996) construct farm-level indicators using the FESLM approach. The indicators are applied to 10 farms in Geba, Cebu, Philippines. Six indicators are used; five are concerned with biophysical factors with profit as the final indicator: yield, profit, frequency of crop failure, soil depth, organic and permanent ground cover (Woodhouse *et al*., 2000).

According Andreas P. Savva and Karen Frenken (2002), to be able carry out sustainability, indicators have to be developed for each of the above areas. Indicators are variable that help to measure changes in a given situation. They are defined as specific (explicitly) and objectively verifiable measure of charges or results brought by any activity. In other words, indicators are defined to provide standards against which to measure, asset or show the progress of any activity against any targets. The performance should be linked to pre-project condition in order to assess the changes obtained because of the project. Questions to be asked can be, for example what where the yield maize before the project what are they now? What were the living conditions of the farmers before the project and what are they now? What was incidence of the malaria in the past and what is it now. For this, baseline information is required to establish benchmarks with which the changes can be compared. As guidance, some of the sustainability indicators related the areas above showed. Ideally, the indicators are established and selected together with all stakeholders. To measure sustainability of small-scale irrigation scheme, many researcher first collect data of individual indicators and then category indicators are judged from the former and then sustainability index of single value are calculated from the categorical indicators, similarly Tiewtoy et al.,(2010) used 19 indicators under four categories.

Table 2.1. Matrix for sustainability indicators (Woodhouse et al., 2000)

Dimensions (FESLM)	**Assets (SRL)**				
	Natural	Physical	Financial	Human	Social
Productivity	Levels and trends for Productivity		Levels and trends for Rates of return	Total earned income	Active cooperative associations,
Economic viability		Return on fixed capital assets	Farm gross margins	Affordability of health,	Contributions on social welfare
Production risk / security	Pest/ disease risks	flood control and irrigation infrastructure	Output and input price variability	Health status Educational attainment	Security of crop, livestock
Protection from degradation	Soil 'quality' Soil erosion Pesticide use				Environmental organizations, campaigns
Social Acceptabilit y	Conflicts over access	Distribution of access to infrastructure	Income distribution	Inequality in access to health	Accountability of elected leadership

2.4. Definition and Concept Related to Irrigation Technology

2.5. Irrigation Status in Ethiopia

There is no documented history of water management for agriculture. Remnants of millennium old water storage structures for non-agricultural use around Axum in Tigray show the oldest usage of water in a controlled manner. Certain, non-irrigation related technologies to conserve water and soil have been practiced by Konso people in the South, at least for the last four hundred years. However, there is no well-documented resource material on water use for irrigation in Ethiopia. Modern irrigation development in Ethiopia is not having centuries old history. There is no written history on how Ethiopia has used irrigation technologies to secure agricultural production, as the vast country with small population had adequate natural resources base and rainfall to produce the food requirements without the need to develop irrigation (Seleshi Bekele *et al*. 2007).

Private concessionaires who operated farms for growing commercial crops such as cotton, sugarcane and horticultural crops started the first formal irrigation schemes in the 1950s in the upper and lower Awash Valley. In the 1960s irrigated agriculture was expanded in all parts of the Awash Valley and in the Lower Rift Valley. The Awash valley saw the biggest expansion in view of the water regulation afforded by the construction of the Koka dam and reservoir that regulated flows with benefits of flood control, hydropower and assured irrigation water supply. In addition, the construction of the tarmac Addis-Assab road opened the Awash Valley to ready markets in the hinterland as well as for export (Metaferia, 2004, cited in Seleshi Bekele *et al*. 2007).

Although certain aspects of the development during the pre-Derge era have wrong doings in terms of property and land rights, there has been remarkable emergence of irrigation development and establishment of agro industrial centers. Teshome (2003), cited by Seleshi Bekele, *et al*. (2007), has reviewed and discussed the land tenure system in the various regimes in Ethiopia. These establishments were highly motivated private sectors, which are both export and domestic market oriented.

Traditional irrigation in Ethiopia dates back several centuries, especially in the highlands for subsistence food crops, while "modern" irrigation was started by the commercial irrigated sugar estate established in the early 1950s by the Imperial Government of Ethiopia and the Dutch company known as HVA-Ethiopia in the upper awash basin for industrial crops such as sugarcane and cotton. In the 1960s, large-scale irrigation was developed by private companies in the whole awash basin, thanks to the Koka dam, as well as in the Lower Rift Valley. Modern small-scale irrigation through communal schemes started only in the 1970s to fight major droughts and famines, especially the 1973 one. In the mid-1970s, state farms were created through the nationalization of private property. Modern private irrigation re-emerged with the liberalization of the economy in the 1990s (FAO, 2016).

During the Derge era, all private farms were nationalized to establish the so-called state farms, thereby ending the embryonic private sector. The government pursued the development of medium and large-scale irrigation schemes in a number of river basins in addition to expansion in the Awash Valley. The Amibara Irrigation Project in the Middle Awash, Alwero Irrigation Project in Gambella, Gode-West Irrigation near Gode town, the Omorrate Irrigation scheme in Southern Omo, the Tana Beles, the Fincha Suger State, etc are some of the expansions, most of which are suspended currently.

Following the downfall of the Derge, the current government withdrew from the expansion of State Farms and further construction of medium and large-scale irrigation (Metaferia, 2004). This has been the trend until the aftermath of the 2002/3 severe drought that has caused about 15 Million populations under extreme food shortage. Not only the government hesitated to expand medium and large scale irrigation but also it has interrupted finalization of the above 5 major irrigation projects started in the former regime. On the other hand, the government indeed provided certain attention on small scale irrigation mostly in the food insecure areas. Nevertheless, in the water sector development program (WSDP) it was identified to expand large and medium scale irrigation by about 147,000 ha and small scale irrigation by about 127,000 ha. As strategy of developing irrigation sector, the plan of the government targets to develop a total of additional 274,612 ha of land which brings the total irrigated area of about 478,000 ha by 2015. Despite ignoring the medium and large-scale sector for a decade long, recently after the development of the water sector development program, there is a growing attention to the irrigated agricultural sector. The revised strategy even plans to put more irrigated land in short period of time (Seleshi et al. 2007).

2.5.1. Irrigation Potential and Development in Ethiopia

River basin master plan studies and related surveys indicate a maximum irrigation potential of about 5.7 million ha, but about 3.7 million ha is commonly quoted. The irrigation potential of Ethiopia is at present estimated at about 2.7 million ha, considering the availability of water and land resources, technology and finance (FAO, 2016).

Ethiopia has vast cultivable land (30 to 70 Mha), but only about a third of that is currently cultivated (approximately 15 Mha), with current irrigation schemes covering about 640,000 ha across the country. However, the study estimates that total irrigable land potential in Ethiopia is 5.3 Mha assuming use of existing technologies, including 1.6 Mha through RWH and ground water.

2.5.2. Irrigation Development in Oromia Region

Oromia has 63 river systems and 688 tributary streams which annually generate 58 billion cubic meters of surface water, the equivalent of half the nation’s surface water resources. Despite the large water resources potential, Oromia’s agricultural sector is almost entirely dependent on rained farming. Irrigated agriculture constitutes just fewer than 5 percent of the potential and about 2.14 percent of the total cultivated land. The implication of these figures is that irrigated agriculture has to go a long way before it can make a significant contribution towards regional food security.

In Oromia Region, it is said that out of the estimated 1.7 million ha of potential irrigable land, only 85,400 ha has been developed so far, which about 5 % of the potential is. The modern irrigation practice in many places has been introduced as late as mid 1980’s when there was a country-wide drought affecting huge number of population. In 1998, about 92,617 ha of land were under traditional and modern irrigation, while 2,426 ha were under construction. Feasibility studies on about 53,762 ha have been carried out, while about 299,820 ha have been identified for possible development.

Traditional irrigation schemes which are estimated to cover 48,816 ha constitute the major portion, followed by large-scale state farms consisting of 26,506 ha. All in all, the total developed and planned area, for the development of irrigated agriculture is estimated at 583,998 ha.

Small-scale irrigation has the potential to contribute to improved food security and higher rural incomes in sub-Saharan Africa. However, a combination of factors has hampered its development. These include pressure on agricultural water due to increased climate variability and perceived institutional weaknesses (School of Global Studies Research Briefing, 2016).

Investment in irrigation development is an important strategy in reducing risks associated with rainfall variability and achieving food security (Sisay Belay and Fekadu Beyene, 2013).

The development of irrigation and agricultural water management holds significant potential to improve productivity and reduce vulnerability to climactic volatility in any country. Although Ethiopia has abundant rainfall and water resources, its agricultural system does not yet fully benefit from the technologies of water management and irrigation. The majority of rural dwellers in Ethiopia are among the poorest in the country, with limited access to agricultural technology, limited possibilities to diversify agricultural production given underdeveloped rural infrastructure, and little to no access to agricultural markets and to technological innovations. These issues, combined with increasing degradation of the natural resource base, especially in the highlands, aggravate the incidence of poverty and food insecurity in rural areas. Improved water management for agriculture has many potential benefits in efforts to reduce vulnerability and improve productivity (Seleshi Bekele Awulachew, 2010).

2.5.3. Socio- economic impact of small-scale irrigation

Land use was based on traditional ownership, although all land officially belonged to the governments. The social organization in the Afar region is governed by a customary law and social structure that unites several tribes. Land use is specifically adapted to the size and kind of livestock such as cattle, goats, sheep, and camels; the delineation and non-utilization of lands, usually reserved for livestock grazing, for regeneration purposes. Conflict is ongoing in the Awash River Basin, much of which is inter -ethnic and inter-clan in nature. Changes to land use had many unwanted impacts, and most of the pastoralists were evicted from the wet grazing lands for dam construction and irrigation development for sugar cane, horticultural crops and cotton (Fiona Flintan and Imeru Tamrat 2002; François Piguet, 2001).

In the Awash Valley, Schistosoma mansoniis found at the higher altitudes (the upper valley) where the intermediate host, Biomphalaria pfeifferi profusely breeds in tertiary and drainage canals of the sugar estates. Schistosoma haematobium, causing urinary schistosomiasis, occurs in the middle and lower valley (where average temperatures are higher) where the intermediate snail host Bulinus abyssinicus breeds in the clear marshy waters of swamps in undeveloped flood plains. Health records show that before the development of sugar estates, prevalence was limited to the provinces of Harar, Tigray and the Lake Tana Basins of Gojam and Gondar. Agricultural development attracted people from these areas, including people infected with the parasite. Malaria is a serious problem within the Awash basin, the disease being present in all areas below 2000, frequent epidemics having been reported from areas within the basin (WHO, 2004; Abeku *et al*., 2003; Abeku *et al*., 2002) (see Fig 8, some areas showing no incidence of Malaria in the South Western parts of the basin, between Nazreth and the outskirts of Addis Ababa up to 2000 m).

According to Ximing Cai et al. (2001) indicators of environmental system integrity fall into three categories such as health of aquatic and floodplain ecosystems, water quality and soil degradation.

1) Health of aquatic and floodplain ecosystems. Extensive irrigation can affect drinking water health as indicated by bacteria, nutrients, and toxic contaminants and soil health as indicated by soil's water holding capacity, total organic Nitrogen and Carbon, pH value and the condition of surface aggregates.

2) Water quality. Irrigated agriculture affects water quality in several ways, including higher chemical-use rates associated with irrigated crop production, increased field salinity resulting from applied water, accelerated pollutant transport with drainage flows, groundwater degradation due to increased deep percolation to saline formation, and greater in stream pollutant concentration due to flow depletion.

3) Soil degradation. Irrigation responsible for soil water logging and salinization in many regions where drainage systems are poor, irrigation with traditional furrow systems also causes soil erosion that can be measured by the extent of topsoil losses.

2.6. Related studies on irrigation sustainability

Recently, smallholder farmer irrigated agricultural practice is one of the development issues in developing countries. This is due to its roll to increase food production and agricultural yields, income, living standard and food security. Thus, in line with this research some empirical studies on irrigation are reviewed below.

A study conducted by Tiewtoy et al. (2010) on irrigation sustainability assessment of selected projects in Tha Chin basin, Thailand, The study assesses the sustainability of the Kamphaengsaen (KPP) and Phophraya (PPP) projects located in the Tha Chin Basin, Thailand. The assessment is based on the investigation of sustainability indicators using principal component analysis. The dominant indicators affecting sustainability are identified. The key indicators are weighted and computed to obtain the irrigation sustainability index (ISI) used to classify the sustainability into five levels. The results for KPP show net farm income, awareness on irrigation water use, matching of water delivery schedule and agricultural operation, and field application ratio being the major sustainability indicators. For KPP, six zones show a very low sustainability level; five zones are low; 11 zones are medium; four zones are high and one zone very high. Four key indicators are found in PPP, including perception of drained water quality, satisfaction on adequacy of water distribution, field application ratio, and net farm income. For PPP, one zone shows a very low sustainability level; three zones are low; five zones are medium; one zone is high and one very high. The ISI developed may also help stakeholders and policy makers to understand the roles, influences and implications of the key indicators towards sustainable management of the irrigation sector in the country.

A study conducted by Waiter. Ochs (2003) on water quality management for sustainable irrigated agriculture conclude as, Water quality management is a critical element in the maintenance of sustainable irrigated agriculture systems in the Mediterranean Region as well as throughout the World. The management of water quality requires thorough attention to all aspects of the water regimen from the water source until disposal. Many aspects such as water quality assessment, water source protection, irrigation water management, salinity management, water table management, management and disposal of drainage water, as well as the monitoring and evaluation system require consideration and controls to protect the water quality for an irrigated area and for downstream users.

Water quality control within the scheme requires good field and scheme level management, proper agronomic practices to control salinity and pollution, sound salinity management practices to permit reuse of water when appropriate and water table control where conditions permit. The management and disposal of drainage water that is to leave a scheme, should involve consideration of using saline drain water for salt tolerant plants, biological and chemical treatments, constructed wetlands, stabilization ponds, evaporation ponds, dilution of disposed drain water and final discharges that consider downstream users.

Assessment of the existing situation conducted by Awlachew *et al.*, on the role, constraints and opportunities of small-scale irrigation and water harvesting in Ethiopian agricultural development conclude that, There is a general perception in all regions of Ethiopia that the current trend of low performance of some of the small-scale irrigation schemes is related to flawed project design and lack of adequate community consultation during project planning. Since small proportion of the potential is used and most of the

SSI programs are currently in the planning stages, and are yet to be implemented, these conclusions should be seen as providing a unique opportunity to learn from these drawbacks. If ignored, well-intended efforts of governments and NGOs are likely to continue falling short of their intended impacts.

A study conducted by Tizeta (2017) on the effect of small scale irrigation on household food Security: the case of bona-zuria woreda, sidama zone, southern Ethiopia The study concluded that small-scale irrigation is one of the viable solutions to secure household food needs and diversify their diet composition in the study area. Finally, it is recommended that governmental and non-governmental organization should expand access of small scale irrigation by farm households to improve their food security.

Wagnew (2004) conducted a case study on socio-economic and environmental impact assessment of four community based small-scale irrigation in upper Awash basin of Ethiopia, conclude that Small-scale irrigation plays a role in meeting the growing demand for food and to achieve long-term food security. The high yields obtained in irrigation and other benefits such as increased incomes, employment creation, food security, are an indication that irrigation can bring sustainable agriculture and economic development without sever effect on the environment. It has come out clearly that irrigation can be comparatively well designed and in a sound technical state but other issues related to land allocation, population pressure, input supply, market situation, and health situation can affect the sustainability of irrigation schemes.

Tsehoyou.G and Krish. H (2013) conducted a case study on Challenges in farmer-managed small-scale irrigation schemes in south achefer woreda of Amara region, Ethiopian; conclude that, the performance of the irrigation users' cooperative in managing the scheme found at low levels show a wide gap between the objective and actual implementation. Among the factors that were found to be significant are poor enforcement of rules and regulations, non-existence of water rights, limited membership which makes the implementation of collective action difficult, poor external support from the respective stakeholders, and the multifunctional nature of the organization which causes leaders not to focus on the core objectives of water management activities. Designing an appropriate local institutional arrangement according to the demand and priority of each scheme which fits the specific contextual situation and minimizing the causes for institutional failure are indispensable to create a sustainable local institution for irrigation management. Therefore, policies in favor of promoting the development of small-scale irrigation have to take the above factors into consideration for successful implementation.

A study conducted by Aweke *et al*., (2015) Soil Quality Indices for Evaluating Smallholder Agricultural Land Uses in Northern Ethiopia revealed and degrading agricultural landscapes. Most Ethiopian soils are already exhausted by several decades of over exploitation and mismanagement. Since many agricultural sustainability issues are related to soil quality, its assessment is very important. We determined integrated soil quality indices (SQI) within the surface 0–15 cm depth increment for three agricultural land uses: rain fed cultivation (RF); agroforestry (AF) and irrigated crop production (IR). Each land use was replicated five times within a semi-arid watershed in eastern Tigray, Northern Ethiopia. Using the framework suggested by Karlen and Stott (1994); four soil functions regarding soil's ability to: (1) accommodate water entry (WE); (2) facilitate water movement and availability (WMA); (3) resist degradation (RD); and (4) supply nutrients for plant growth (PNS) were estimated for each land use. The result revealed that AF affected all soil quality functions positively more than the other land uses. Furthermore, the four soil quality functions were integrated into an overall SQI; and the values for the three land uses were in the order: 0.58 (AF) > 0.51 (IR) > 0.47 (RF). The dominant soil properties influencing the integrated SQI values were soil organic carbon (26.4%); water stable aggregation (20.0%); total porosity (16.0%); total nitrogen (11.2%); microbial biomass carbon (6.4%); and cation exchange capacity (6.4%). Collectively, those six indicators accounted for more than 80% of the overall SQI values.

3. MATERIALS AND METHODS

3.1. The study site

3.1.1. Description of the study site

The study area is located in Boset woreda of Oromia Regional State. Doni-Sifa is bounded by the geographic coordinates 8°25'00''- 8°50'00''N latitude and 39°15', 39°50'E longitude and shares borderlines with Fentale, Adama and Lume districts, Amhara Regional State and Arsi zone. Wolenchiti town is the administrative center of the district. Qombe Gugsa, Sifa Bate and Nura Hasse rural kebeles the specific study area is located in the upper valley of Awash river basin and 33 km North of Sodore town, 52km from Adama, and 152km from the capital city of Ethiopia. The project area lies on the left side of the rural road, which runs from Awash Melkassa to Nura (Figure 3.1).

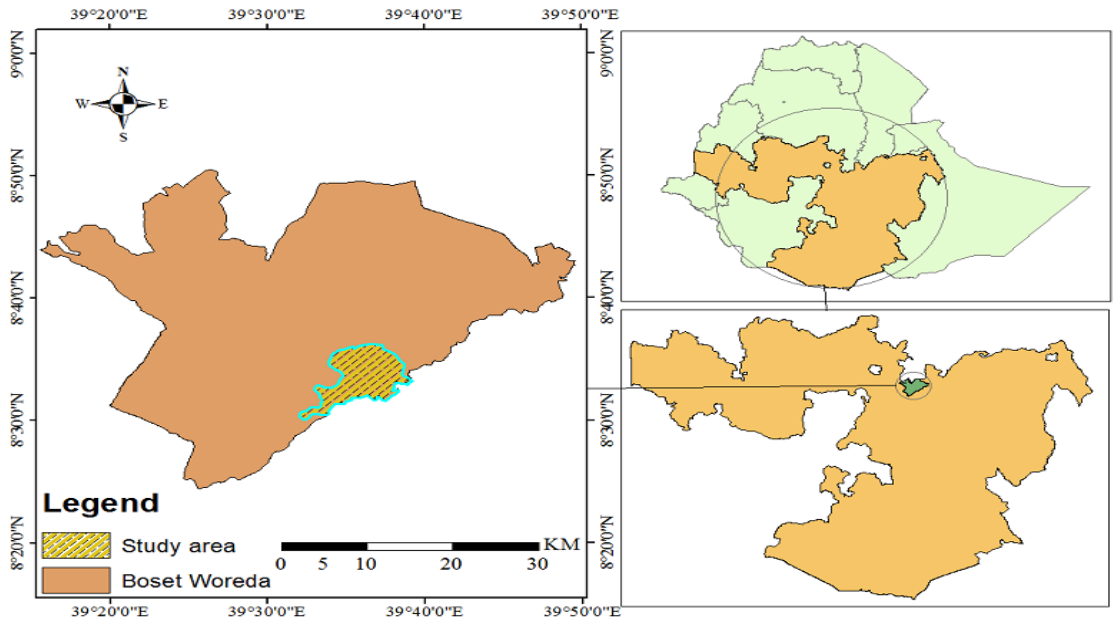

Figure 3.1. Location map of the study area (source: Gemechis, 2014).

3.2. Research Methodological Framework

According to the stated objectives the researcher formulates a methodology based on a Framework for Evaluation of Sustainable Land Management (FESLM) and Sustainable Rural Livelihood (SRL) methodological framework to develop a set of indicators which were used to monitor the system and also develop a methodology to guide the identification of meaningful and measurable internal and external indicators.

Methodology Framework

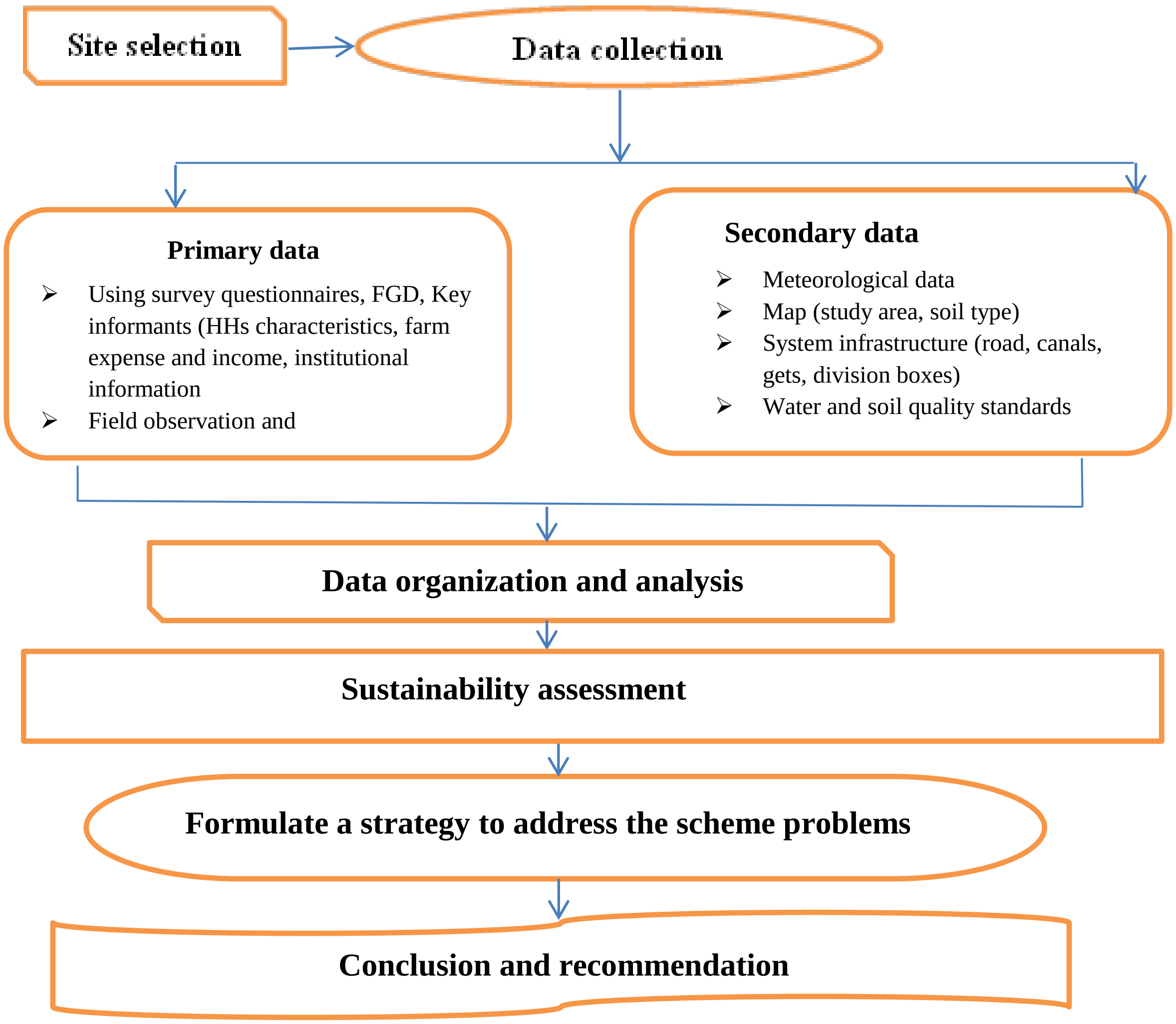

Figure 3.2. Methodological framework used in the study (adopted from Sanidda Tiewtoy et al., 2010)

According to Kamalesh Panthi and Shashi Bhattarai (2008), the determinant factors affecting irrigation system sustainability are grouped into four categories namely: Technical, Environmental, and Socio- economic and Institutional**.** These factors were selected since they were easy to collect, measure, document, cost effective and also represent the scheme situation of the study area.

To assess the sustainability of the study area, the researcher used a Framework for Evaluation of Sustainable Land Management and Sustainable Rural Livelihood methodological framework. In order to justify the sustainability of Doni Sifa Small- scale irrigation system, the following activities were undertaken.

1st. Review and select indicators based on FESLM and SRL assets which are easy to collect measure, cost effective and relevant with the situation.

2nd. Grouping the selected indicators under four categories (i.e. Technical/physical, Environmental, Socio-economic and Institutional). Table 3.1 shows the indicators used in assessing the sustainability of Doni Sifa irrigation scheme.

Table 3.1. Selected sustainability indicators used in assessing the sustainability of Doni Sifa SSI scheme (Sanidda Tiewtoy et al., 2010 and Kamalesh Panthi & Shashi Bhattarai, 2008)

Categories	Indicators	Source of data
Physical/Technical	Availability of water and quality at source Physical condition of the system structures Soil properties (nutrients balance, fertility) Land use intensity and diversity Frequency of flooding hazard	Field measurement, literatures Field observation Laboratorial result survey questionnaires
Environmental	Irrigation water quality (PH, EC, DO and TDS) Soil quality (PH, EC Existence of toxic nutrients Extent of land degradation (soil erosion, deforestation, Any ill effect due to irrigation system	Field measurement Field observation Literatures
Socio-economic	Community participation (design, O&M, monitoring & evaluation) Social inclusion and equity (ethnic, gender etc.) Water user conflict Awareness of irrigation water management Crop yield Farm income Benefit cost ratio	Survey questionnaires FGD Informal interview Literatures
Institution	Financial institution (existence, availability of fund, transparency Water user committee (existence, functionality, Existence of other governmental or NGO institution to facilitate different technical assistance, giving training, farm input etc.	Survey questionnaires FGD Informal interview Literatures

3.2. 1. Method of data collection

Primary and secondary data were collected for this study. To achieve the research objectives, qualitative and quantitative data were gathered. The primary data was collected through scheduled household interview, focus group discussions, and direct observation of the irrigation scheme and field measurements.

3.2.1.1. Primary data collection

Household survey

To collect primary data both open and close ended questionnaires on the condition of physical structure, socio-economic factors, organizational and institutional condition of the beneficiary, on household assets, cropping pattern, field input, water management practice, income, expenditure, demographic information and any problem related to the scheme was collected from sample households using structured interview questionnaires. The interview questionnaires were pre-tested and some modifications were made based on suggestion received. The interview was conducted by five enumerators who have enough background information about the area and well acquainted with language and culture was assigned and oriented before starting the work of filling questionnaires.

Focus Group Discussion

The Primary data collected from house survey need to be further enriched by additional information collected through focus group discussion. FGD was conducted with five participants using semi-structure questionnaires. The participants were selected purposively to include one traditional water leader and two water users committee, one female and a youth in the beneficiary society.

Field Observation

Field observations to assess the actual situations of the scheme and to identify its problems/gaps, associated with sustainability were conducted. The existence of the following potential problems were verified during the actual field observation/visit: overall functionality of irrigation scheme, defect on design irrigation structures, canal carrying capacity, the conditions of water distribution structures, canal siltation, weed growth in canal and on the farm, erosion hazard, water logging, irrigation practice and water application method, land use intensity, land use diversity (agro-diversity), type of crop grown and other relevant information. Photographs were taken to document the field problems noted during the field visit.

3.2.1.2. Secondary data collection

Secondary data including site description, map of the study area, soil map, land use pattern, climatic data, and others were gathered from various sources to include: zonal and district bureau of agriculture and rural development, regional water bureau, finance and economic development, research articles from published Ethiopian and international journals, relevant books, reports from MoWR, MoA, publications and Internet sources.

3.3. Data Analysis and classification

Data analyses were done after data collection. A descriptive analysis was used to analyze qualitative data. The Microsoft Excel software was used for the analysis of quantitative data. Descriptive statistics were used to analyze quantitative data.

3.3.1. Physical Data

3.3.1.1. Biophysical feature of the scheme

Indicators of land quality (LQI) are a key requirement for sustainable land management, and the World Bank is leading an international coalition to develop these indicators. The LQI program addresses the dual objectives of environmental monitoring and sector performance monitoring for managed ecosystems (agriculture, forestry, conservation, and environmental management). Core LQIs being developed for immediate application: Nutrient balance, Yield gap, Land use intensity and Land use diversity (agro diversity). For this specific research to assess the current status of biophysical feature of the scheme Core LQIs were used.

3.3.1.2. Status of soil fertility

Soil fertility is the characteristic of soil. It defines the ability of soil to support abundant nutrients as plant requires. It can be assessed from soil chemical properties i.e. organic matter (OM), cation exchange capacity (CEC), percent base saturation (% BS), available Phosphorus (P) and available Potassium (K). These properties can be attributed to soil fertility by total mark of each soil chemical property as shown in Table 3.3 to get the score and then compare the level of soil fertility. Based on the Land Development Department of Thailand LDD (2000); cited in Sanidda Tiewtoy, et al. (2010) soil fertility was divided into three classes i.e. 1=low, 2=medium and 3=high. Table 3.3 shows level of soil fertility applied to three ranks namely low, medium and high. For this specific study the level of soil fertility was determined by using LDD standard.

Table 3.2. Soil fertility standard (adopted LDD (2000) cited in Sanidda Tiewtoy et al., 2010)

Fertility level	OM (%)	BS (%)	CEC(cmol/kg)	P(mg/kg)	K(mg/kg
Low Mark*	<1.5	<35	<10	<10	<60
	(1)	(1)	(1)	(1)	(1)
Medium Mark*	1.5-3.5	35-75	10-20	10-25	60-90
	(2)	(2)	(2)	(2)	(2)
High Mark*	>3.5	>75	>20	>25	>90
	(3)	(3)	(3)	(3)	(3)

Note: Mark* (5-7) = Soil fertility is low (Score =1)
Mark* (8-12) = Soil fertility is medium (Score =2)
Mark* (13-15) = Soil fertility is high (Score =3)

3.3.1.3. Frequency of flooding hazard

It means how often flooding hazard happen on beneficiary fields and the surrounding. To get information about it, this specific research was used questionnaires for farmers about their experience on flooding hazard and key informant interview for worda DA expert. It dived in to four class (i.e. A. no flood within 2-3 years, B. occasional, C. flooding hazard every year D. more than one time within a year).

3.3.1.4. Cropping intensity and crop yield

Cropping intensity was used to evaluate to what extent second and third crops take place within a year. The indicator (CI) is defined below. For this case crop yield was groped in to five and the information was collected from sampled HHS by using questionnaires (i.e. very high, high medium, low and very low)

$$\mathrm{CI} = \frac{A(C1) + B(C2) + C(C3)}{CA}$$

Where:

CI = cropping intensity

A (C_1) = total area harvested in first season

B (C_2) = total area harvested in second season

C (C_3) = total area harvested in third season

CA = cultivable area

3.3.2. Environmental Data

While some one taking about sustainability of irrigation scheme environmental condition of the area is a leading factor. To assess the status of environmental condition of the scheme the following parameters are involved such as water quality, soil quality, land degradation flooding hazard, disease.

3.3.2.1. Water quality

Irrigation water quality is one of important factor for assessing environmental sustainability. To measure the quality of irrigation water in this research the following factors were considered: PH and electrical conductivity (EC).

A. PH value

The values of PH in irrigation water determine whether it is acidic or basic. It's scale range from 1-14, if PH value is 1-7 is acidic, if PH value is 7-14 is basic and if PH value is 7 neutral. The normal value of PH which is plenty environment for plant growth is range from 6.5 to 8.

3.3.2.2. Soil health of the study area

One of the most used definitions of soil quality is the capacity of a soil to function within ecosystem boundaries to sustain biological productivity, maintain environmental quality, and promote plant and animal health. Land use and management can have a profound impact on many soil properties, thus indirectly affecting soil quality which can result in improvements or constraints for productivity of agricultural lands and for agricultural sustainability in the long term (Antonio Delgado and Jose´A. Go´mez, 2016).

To assess the status of soil quality the following parameters were involved such as soil PH, soil electrical conductivity (EC).

A. Soil PH

Based on PH value of a given soil we can classify as acidic, basic or neutral. If the PH value is less than 7 it is acidic, if the PH value is greater than 7 it is basic and if the PH value is equal to 7 it is neutral.

3.3.3. Socio-economic Data

3.3.3.1. Socio-economic condition of the scheme

To determine socio-economic status of the scheme the following data were collected: household size, age structure, educational status, land tenure, experience of farmer, cropping intensity and crop yield, cost of production, farm income. The economic viability of the scheme was determined using the Net Present Value (NPV) method.

A. Households size

Household survey was conducted by using questionnaires to determine the size of HHs family members.

B. Age structure

For this specific research the sample HHs age structure group in to four classes (i.e. age < 12 years, 13-17 year, 18-65 years and age > 65 years).

C. Educational status

Educational status of the HHs for this purpose group in to five (i.e. higher education completed / university or college, high school completed, elementary, write and read without school and illiterate).

D. Land tenure

Land tenure represents farmer's land ownership.

E. Farmers experience in agriculture

The experience of farmers for this research divided in to five (i.e. < 5 years, 5- 10 years, 10-20 years, >20 years).

G. Cost of production

Cost of production include a) farm input cost (i.e. land renting seed, fertilizer, herbicide and pesticide, pumping and other); b) labor cost (i.e. land preparation, broadcasting/seeding, planting and harvesting cost); c) transportation cost before and after harvesting; d) water fee.

H. Growth farm revenue/income

Farm revenue means the selling price of project product. It was estimated by the product of unit price and total production.

I. Net farm revenue

The net farm revenue was calculated by subtracting total farm cost from growth farm revenue.

Net farm revenue = Growth farm revenue - Total farm cost

J. Net Present Value of the Scheme

The NPV method of economic analysis was used to determine the economic viability of the scheme. This was done using the Microsoft Excel software.

3.3.3.2. Awareness of farmers on irrigation water management

Awareness on irrigation water management means knowledge of farmer how to use water wisely and increase water use efficiency at the same time the environment from degrading. For this case it divided in to five (i.e. A. Know nothing, B. Bad, C. Good, D. Excellent and E. Not sure).

3.3.3.3. Occurrences of conflict between irrigation water users

In 21th century water is the main source of conflict throughout the world not only between upstream and downstream water users but also between water user for agriculture and water users for non-agricultural purpose. I fear third world war will begin between different water user sectors. For this specific research only considered conflict occurrences between upstream and downstream water users. The information was collected from sampled farmers by using survey questionnaires and it divided in to four classes (i.e. A. Frequently, B. Sometimes, C. Occasionally and D. Never).

3.3.3.4. Community Participation

Community participation in planning, designing, operation and maintenance and evaluation and monitoring steep plays a great role for sustainability of small-scale irrigation scheme.

3.3.4. Institutional Data

Institutions include the national and regional small- scale irrigation development agencies, community organizations, and private-sector entities. These institutions, acting in various combinations, are the primary influences affecting sustainability. WASH technical report 94. (1994), proposed a lot of key questions that used for assess the sustainability of water supply and sanitation projects. Here, the researcher used it as base line information with some modifications for assessing institutional sustainability and some physical feature of the scheme. The factors and some of the questions are the following:

3.3.4.1. People benefited from the project

A usage level of at least 50 percent is considered acceptable. The use of water supply facilities will vary during the year, depending on the availability of alternative sources of supply. The 50 percent level is defined as the average for the year.

3.3.4.2. Condition of the project

At least 75 percent of the irrigation systems should be in operational order at any given time. The acceptable operational level is higher than the usage level because maintenance and repair depend upon standards that can be readily defined, whereas consumer behavior is less predictable. All mechanical systems will need occasional repairs and be out of commission for some period of time. To be operational, a system requires the support of a qualified repair person, a supplier of spare parts, and adequate funds. The extent to which the facilities are used will influence the willingness to provide the funds. However, even enthusiastic demand and a readiness to pay cannot offset costs beyond the users' means or compensate for a lack of spare parts because of import restrictions.

3.3.4.3. Management committees

At least 75 percent of management committees should be meeting periodically and carrying out agreed upon tasks. The management committees should be carrying out their duties regarding O&M, accounting, monitoring, and evaluation. Their most important task is to provide overall leadership to maintain community support of the system and to ensure that funds for O&M are adequate.

3.3.4.4. Relationship between extension agents / development agent (DA) and the committees

Extension agents should meet with each committee at least twice a year to provide support for ongoing activities, to assist in solving community problems, and to provide information on new developments related to the sector.

3.3.4.5. Is a specific government agency effectively managing the SSI sector?

A government agency must be unambiguously in charge of managing the sector and providing oversight of the project area. If several ministries are involved, coordination between them is essential. One agency and its staff should be recognized as having clear responsibility and be given an adequate budget.

3.3.4.6. Does each institution (community, regional agency, national agency) have adequate financial resources?

Communities should have an established fund to cover O&M costs. Some communities may prefer to raise funds only when a breakdown occurs. This is acceptable if the community is certain it can get the money fairly quickly, but this practice is not recommended. Regional and national agencies should have adequate funds to employ the requisite number of extension agents and to equip them with the transportation and materials to carry out their work. In fad, if the responses to the first five questions above are positive, then that is a sufficient indicator that adequate financial resources exist.

3.4. Characteristics of the Study Area

3.4.1. Climate

According to Bost woreda agricultural office data, the Woreda covers a total area of 151,406.6 km^2 with 40% is plate, alluvial and the rest 25% is covered by mountain. The area is classified into three agro-climate zone 79%, 20% and 1% is kola, Weynadega and Dega, respectively. Doni Sifa irrigation system lies in agro-climatic zone classified as drought prone area of the region. In the study area rainfall is erratic and there are two rainy seasons. The long rainy season begins from Jun and ends in September. The short rainy season is from February to April.

3.4.2. Topography and soils

The area is situated on an undulating alluvial plain with open vegetation. The area surrounding the project site is affected by gully formation up to 10m deep was observed. It was observed that at some depths the soil profile was sandy that makes it prone to soil erosion. The irrigable area lies between a hill to the north and Awash River to the south and southeast. More than 85% of the command area has slope less than 5%. The soil is mostly medium textured ranging from silt loam to sandy loam. The depth of the soils in the area varies from 30 to 160cm. Soil type of the area is classified as 13%, 25%, 30%, 25%, 5% and 2% black sand, loam, gravel volcanic and other type,2 respectively (Bost Woreda Agricultural Office, 2017).

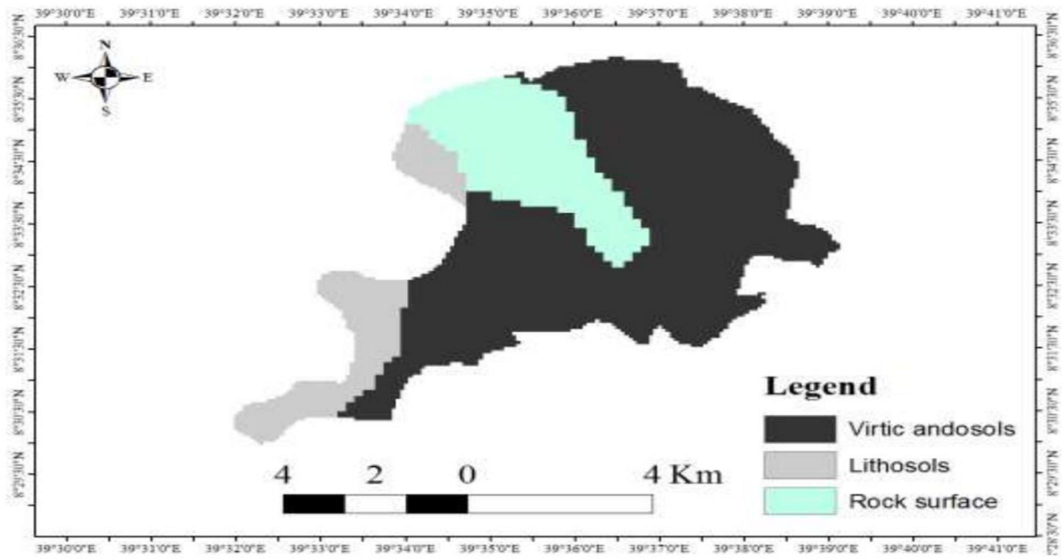

Figure 3.3. Soil map of the study area (source: Gemechis, 2014)

About 80.9% (5402.5ha) of the study area is productive soil of Vitric andosols and Lithosols whereas 19.1% (1275.5ha) of the land is of rocky surface or shallow soils (Fig. 3.3).

3.4.3. Slope and Land suitability

Gemechis Tesema (2014) reported that 6,678 ha of the area has a slope range of 0-8% and rest has slope range of 0-5%, which makes 83% of the total area. An estimated 6,516 ha of the land could be brought under irrigation agriculture excluding areas that is already under irrigation. Land suitability of the area with slopes of 0-2% which is highly suitable covers 42.7% (2903.28ha) of the total area; areas with slopes of 2-5% rated as moderately suitable covers 40.4% (2743.32 ha), and those with slopes of 5-8% that was rated as moderately unsuitable covers 15.2% (1031.52ha) of the total area. These figures indicate that the study area has a large suitable land for irrigation.

Soil physical properties of the study area

Average moisture contents (v/v) at field capacity (FC) and permanent wilting points (PWP) were observed 24.6, 22.5 and 25.51% and 16.8, 17.2 and19.6% respectively for the three location of the field. The average moisture content at FC and PWP were 20.7 and 14.25% (w/w). The pH was found in the range of 6.7 to 7.4. The pH value of the soil in the experimental site was almost in suitable range for crop production particularly for common crops production. The optimum soil pH for crop production was considered to be 6.5 to 7.0 (Gemechis T. 2014). This number is indicating that soil of the study area is in suitable range for crop production that means there was no serious salinity or alkalinity problem. But salinity is the main threat in the area since farmers' irrigation water management is very poor. Improper fertilizer application also exposes the soil and water to salinity problem.

3.4.4. Main Crops and Planting Calendar

Cropping intensity in the study area is low, with only limited areas for double cropping. In the Upper valley, a high proportion of irrigated land is under perennial crops dominated by sugarcane. Cotton dominates the cropping pattern in the middle Valley of the irrigated land followed by perennial crops like bananas, orange and papaya. Small amounts of vegetables, maize and tobacco are produced. In the lower Valley, cotton is again the dominant crop in the State farm area being as a mono-crop and a rotation crop. On the non-state farmland, maize is the dominant crop followed by the cotton land.

In the study area onion is the most dominant crop according to information gathered from Bost woreda agricultural office in 2016/17 cropping season. About 84% of irrigated land was covered by onions; 11% and 5% of land were covered by tomato, and maize, respectively.

4. RESULTS AND DISCUSSION

4.1. Status of irrigation structures

Doni Sifa small-scale irrigation scheme was upgraded in 1998 with a collaboration of the government and World Vision and constructed a 7.5km main canal. From this, 5.5km is lined and the 2 km is earthen canal before the head structure and end users. The main canal includes diversion head, collection chamber, spillway, 5 flumes, 2 culverts, 3 drop structures and 10 division boxes. The upgraded system was designed to irrigate 220ha but recently 180ha is irrigated. Irrigation water for the scheme comes from Awash River through a simple diversion structure. The water flow through some distance with unlined canal at some distance there is a structure used to trap unwanted materials and then join to lined canal, and then goes through some distance with lined canal up to water head structure. The purpose of this structure is to raise the water head and it has three manually operated gates. The first gate is used to control flow of water through main canal and the rest two are used to raise water head and also used as spillway.

Currently, the scheme suffers from structural failure (demolish head work gates, sedimentation of head work and canals, division boxes were without gates and sealed by debris and weeds, etc.), poor operation and maintenance, and shortage of water. Most of the system's structures are non-functional and only the main canal gate is functioning partially and the other two control gates were out of service. The main canal gate also faces the same feat unless some corrective measures are undertaken. During field visit and measurements, it was found that the capacity of main canal was reduced to more than half. Irrigation water from the main canal is conveyed 7.5 km before reaching the farmers' field. Shortage of water in the service area can be attributed to poor maintenance of main canal, control gates, and other distribution structures. The design capacity of main canal is 360 lit/sec, the maximum carrying of it is 400 lit/sec and recently the average discharge this canal is 180 lit/sec. The extent of these problems is depicted in Figure 4.1.

(a) (b)

(c) (d)

Figure 4.1. Current status of Head control gets

(e) **(f)**

Figure 4.2. Current status of Division box (November 12/2017)

The above picture on (a) represent main control gate used to allow water to main canal and the rest (b, c & d) represent regulators used to raise water head and also serve as spillway. Picture (e & f) represent division box used for control flow of water from main canal to secondary canals. Currently most of those structures were not functioning. The FGD revealed that the main cause of failure of the head control gates were the contractor’s used of poor quality materials. In addition, there was no follow up, maintenance and repair made on these structures at early stage. It appeared that the farmers do not feel the ownership of the scheme. They thought that the project does not belong to them. Also, the government and NGO left it as soon as the construction ended indicating the absence of proper monitoring of the system from the very start. In the case of division boxes’ gates, some of gates were stolen making them non-operational. All system control gates are mechanical, thus they need lubrication and repair periodically in order to function properly.

To remedy the above problems, the researcher recommends that the concerned government agency or NGO should undertake capacity building of farmers and officers of the scheme concerning the proper operation and maintenance of the system.

4.1.2. Current status of main and secondary Canals condition

The main canal length is 7.5km with this 5.5km is lined and the rest 2.2km is earthen and secondary and tertiary canals were constructed by farmers. The design capacity of main canal is 360 lit/sec, the maximum carrying of it is 400 lit/sec and recently the average discharge this canal is 180 lit/sec. Currently carrying capacity of this canal highly reduced due to sedimentation, covered with weed and lack of cleaning activities etc… The situation is presented in figure below.


(a)

(c)

(b)

(d)

(e)

(f)

Figure 4.3. Current status of main, secondary and tertiary canals (November 12/2017)

Figure a and b represent the current status of main unlined canal condition. (a) Represent condition of unlined main canal before head work structure and (b) represent the condition of main unlined canal at end users field. Fig. c and d represent the condition of secondary and tertiary canals and Fig. e. represent the condition of lined main canal.

4.1.2. Socio-Economic Conditions of the Farmers

Results also revealed that the socio-economic conditions of the farmers did not improved inspite of ample source of water and fertile land in the service area. According to the survey results, most farmers' land is highly productive. Some problems/constraints to the improvements of socio economic conditions of the beneficiaries include: lack of farm inputs such as improved seeds, high cost fertilizers and pesticides, and other farm inputs.

Water shortage at the farmers' fields is due to poor functionality of most the system's structures and often delayed repair and maintenance. This often leads to crop failure and yield reduction. Another problem in the area is the lack of adequate market outlets and price fluctuation. The farmers claim that they are lucky if they could gain a good market price for their produce but lost most of the time. Moreover, the farmers also claimed the lack or absence of technical support from development agent (DA) or concerned agency in the service area. Lack of financing resource was also another that contributes to poor socio-economic conditions of the farmers in the area. This is also responsible for the low cropping intensity and diversity in the scheme.

4.1.2. Institutional Support

Institutional support is a determinant factor for the success or failure of small-scale irrigation scheme. Currently, participation of concerned governmental or NGO in supporting the scheme is very limited if not absent. In addition their roles in providing farm inputs such as improved seeds, fertilizers and pesticides at reasonable price, facilitating technical training for the scheme beneficiaries and providing loans with low interest rates to farmers is very rare.

4.2. Sustainability of Doni Sifa SSI scheme

4.2.1. Technical sustainability

4.2.1.1. Water supply and abstraction in the study area

Awash River is a source of irrigation water for Sifa Bate small-scale irrigation project. The Awash basin covers a total area of 110,000 km^2 and comprises three regions Oromia, Afar, Amhara, Addis Ababa city Administration and Dire Dawa council. Awash basin is intensively utilized river basin in Ethiopia due to its strategic location, access roads, available land and water resources. Currently 21,865ha traditional and 4,932ha modern small-scale irrigation schemes have been developed in the basin. Irrigation potential in Awash Basin is estimated to be 206,000ha. However, the basin suffers from severe environmental degradation, annual flooding improper utilization of land and water resources, socio-economic constraints, poor agricultural practices, low yielding and community health problems (Gemechis, 2014).

The results of field observation/visit and surveys show that scarcity of water at the farm level was the main cause of conflict among farmers. This also results to low cropping intensity, yield reduction and crop failure.

Climatic data was analyzed by using 39 years series data from 1977 to 2016 from Awash Melkasa meteorological station. The result of 39 years rainfall data analysis indicates that the study area mean annual rainfall is 823.98mm and the maximum and minimum annual rainfall was 1,310.4mm and 477.1mm, respectively. Average monthly minimum temperature and average monthly maximum temperature was 13.82^{o}C and 29.71^{o}C, respectively. The minimum, maximum and mean relative humidity of the study area was 41.22, 72.03 and 56.3%, respectively. The minimum, maximum and mean wind speeds of the study area were 4.17, 8.07 and 6.93 km/day, respectively. Also, the minimum, maximum and mean sunshine duration in the study area was 6.72, 10.32 and 8.65hrs, respectively (Table 4.1).

Table 4.1. Average monthly rainfall, temperature, RH, windspeed, sunshine duration, and reference ET in the area.

Month	Rainfall (mm)	Min. Temp. (°C)	Max. Temp (°C)	RH (%)	Wind sp. (km/day)	Sun shine duration (hr)	ET_o
January	16.40	11.69	28.92	41.22	7.76	10.32	9.78
February	23.36	13.41	30.14	55.6	8.03	9.42	7.5
March	53.64	15.08	31.46	46.12	7.56	9.74	5.59
April	54.72	15.46	31.48	46.16	6.92	7.08	9.76
May	59.29	15.51	32.10	64.16	6.63	8.37	8.53
Jun	74.67	16.32	31.11	60.46	8.07	7.93	9.37
July	202.71	15.64	27.87	72.03	7.80	6.72	9.66
August	181.85	15.33	27.32	69.87	6.06	6.96	9.46
September	96.99	14.42	28.61	66.60	4.17	7.30	9.58
October	39.50	11.63	29.74	51.32	5.49	9.82	9.84
November	11.03	10.75	29.31	49.66	7.03	10.32	9.58
December	9.77	10.55	28.56	52.45	7.67	9.77	9.76
Annual	823.98						
Mean	126.77	13.82	29.71	56.30	6.93	8.65	9.36
Max.	202.71	16.32	32.1	72.03	8.07	10.32	9.84
Min.	9.77	10.55	27.32	41.22	4.17	6.72	5.99
Std.	69.93	2.02	1.49	9.72	1.13	1.33	1.22

Dependable rainfall and stream flow

Dependable rainfall and stream flow of Awash River was analyzed by using the *Cumfreq* software. This software fits the dataset to 20 different cumulative distribution functions and automatically chooses the best cumulative frequency distribution function for the given dataset. The 90, 70, and 50% dependable rainfall and stream flow were then calculated using the built-in calculated of this software after the best distribution that fits the given rainfall/stream flow dataset was found. The analyses were made for rainfall data from (1977-2016) and annual and monthly stream flow of Awash River from (1969-2008).

The results revealed that annual rainfall is best described by a Log-normal distribution. The 90, 70 and 50% dependable rainfalls and the best probability distribution that fits the rainfall dataset for each month of the year are shown in Table 4.6.

The result of 40 years Awash River stream flow analysis indicated that 2,959,000m^3 water is available on the month of Oct11-March and the required amount of water for the scheme was 468,000m$^{3;}$ it clearly shows the scheme is free from water availability problem.

Table 4.2. Annual and monthly dependable rainfall (1977-2016 Awash Melkasa meteorological station)

	Month (mm)												Annual
	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	
90%	5.8	7.5	48	45	47.7	70.1	188.2	171.4	94.1	14.8	1.6	32.5	1047.3
70%	17.9	25.9	75.6	68	81.4	96.7	234.7	207.1	115.5	38.6	9.1	9.2	918.7
50%	53.7	77.0	116.7	117.7	145.1	143.3	324	271.7	150.6	122.9	53.1	2.7	918.7
Cum frequency distribution	Poisson type	Gumbel mirrorel type	Gumbel mirrorel type	Fisher-Tippett 2	Root-normal	logistic	Fisher-Tippett 2	Fisher-Tippett III	Root-normal	Gumbel	Poisson type	Poisson type	Log-normal

The annual stream flow data of Awash River was best described by the Gumbel type distribution. The 90, 70 and 50% monthly dependable flows in Awash River and the best probability distributions that fit the dataset are shown in Table 4.3.

Table 4.3. Annual and monthly dependable stream flow of Awash River (1969-2008)

Dep. Flow	Month (m^3/s)												annual
	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	
90%	35.80	31.63	34.49	35.8	37.06	36.55	46.07	51.78	76.27	41.96	36.9	35.86	488.55
70%	44.64	35.1	38.06	47.65	55.43	42.66	148.70	72.4	86.44	47.92	38.17	41.25	551.95
50%	55.18	40.1	43.2	47.6	49.85	51.81	59.72	119.03	144.14	56.51	46.18	48.8	656.3
Cum frequency distribution	Long-normal	Normal	Normal	Long-normal	Root-normal	Gumble type	Normal	Fisher-tippett 2	Fisher-tippett 2	Normal	Root-normal	normal	Gumble

4.2.1.2. Cropping intensity

Cropping intensity was one of socio- economic sustainability indicator used to evaluate cropping frequency per year. It was calculated based on survey data collected from sample households and WUA office in 2009 cropping season.

Total area harvested in the first season A (C_1) = 280ha

Total area harvested in second season B (C_2) = 200ha

Total area harvested in third season C (C_3) = 20ha

Cultivable area (CA) = 400ha

$$\mathrm{CI} = \frac{A(C1)+B(C2)+C(C3)}{CA} \times 100 = (280 + 200 + 20)/400 = 1.25$$

Depending on the result of the above calculation the study area had 125% cropping intensity. This number indicates that the scheme had very low cropping intensity considering the ample water resource and suitable irrigated land. This study found out that the scheme has low cropping intensity, shortage of water especially at end users fields and left their lands as fallow, shortage of farm inputs with reasonable price, lack of financial resource and market price fluctuations.

4.2.1.3. Crops water and Irrigation water requirements

Crop water requirement of major crops grown in the irrigation scheme which is listed above were determined using CROPWAT8.0 software. Effective rainfall was determined by using USDA SCS method. This was calculated for each crop with CROPWAT8.0 software using climate data, cropped area, planting date and cropping pattern. Reference crop evapotranspiration (ETo) value was determined using FAO Penman-Montieth equation. The net CWR and IR were determined for each irrigated crops for the 2016/17 cropping season (Feb-Jun). The crop coefficients (Kc) values were used as inputs for CROPWAT computer program from FAO Kc table. The results are summarized in Table 4.3. The precipitation deficit and net irrigation requirements in the study area are also shown in Table 4.4.

Table 4.4. Area covered and planting calendar of main crops in the area

Crop types	Area of coverage (ha)	Percentage of the total area %	Planting date	Harvesting date
Onion	151.2	84	Oct 11	Jan 13
Tomato	19.8	11	Oct 15	Feb 26
Maize	9.0	5	Oct 29	Mar 26
Total	180.0	100		

Table 4.5. Total and effective rainfall, crop water and irrigation requirements of main crops in the area

Crop types	Area (ha)	Total rainfall (mm/season)	Effective rainfall (mm/season)	Crop water requirement (mm/season)	Irrigation requirement (mm/season)
Onion	151.2	76.7	44.8	283.3	238.1
Tomato	19.8	100.1	72.6	432.2	363.2
Maize	9.0	153.7	94.5	511.8	416.7
Total	180.0				

Total CWR and irrigation water requirement for 2016/17 cropping season of Dini Sifa SSI project was determined as follows:

CWR $_{Total}$ = CWR $_{onion}$ x (Area $_{onion}$ /total area) + CWR $_{tomato}$ x (Area $_{tomato}$ /total area) + CWR $_{maize}$ x (Area $_{maize}$ /total area) = 283.3 (151.2/180) + 432.2 (19.8/180) + 511.8 (9/180) = 311.1mm/season or 559,987.2 m^3/season. Total season irrigation requirement also was determined with the same procedure and the result is 468,000m^3.

4.2.1.4. Capacity of Irrigation Canals

The design capacity of main canal is 368 lit/sec, the maximum canal carrying capacity is 400 lit/sec and the average canal discharge is 180 lit/sec. The total volume of water diverted to Doni Sifa irrigation project (Oct11-March 13, cropping season with 180 lit/sec average discharge and continuous flow) was 2,959,000m^3.

Table 4.6. Rainfall deficit and net irrigation requirements in the study area

Prec. Deficit	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Onion	32.2	-	-	-	-	-	-	-	-	36.3	76.5	91.6
Tomato	104.4	76.2	-	-	-	-	-	-	-	24.5	61.4	96.7
Maize	108	101.7	41.	-	-	-	-	-	-	8	65.3	86.4
Net scheme irrigation requirement												
mm/day	1.4	0.5	0.1	-	-	-	-	-	-	1.1	2.5	3
mm/month	44	13.5	2.1	-	-	-	-	-	-	33.6	74.3	91.9
IRR. Area (%)	100	16	5	-	-	-	-	-	-	100	100	100

4.2.1.5. Frequencies of flooding hazard

Flooding hazard had been a major threat for a long period of time up to the present. Based on the results of the survey, flooding occurred every year and sometimes more than once within a year. A farmer (a member of FGD) in the person of Gemechu Tola said that, flooding is unexpected, unpredictable and uncontrolled problem for a long period of time in the scheme. For example in 2009, there was unexpected flood in the month of May and he lost his entire onion nursery plantation field that was 128 boxes. One box represents one meter by five meter of land. Such a coincidence was unexpected since flooding hazard mostly occurred in the month of July up to let October. The survey result indicates 90% of the sample households' stated there was flooding hazard on their fields every year and rest 10% stated more than once per year.

4.2.2. Environmental Sustainability

4.2.2.1. Land Degradation in the Study Area

According to field observation current status of land degradation in the study area has reached a severe level and formed huge gully that was almost at irreversible stage. The formed gully is located at 1km distance below diversion structure. It started from Doini town main road and go down to Awash River. The gully was formed on both sides of the road that serves for the peoples of Doni town to reach Awash River. The road in between formed gully had been mostly used by the society since they were using the river for different activities such as, washing cloth, taking shower, drinking their animals and etc.

Currently, the extent of the formed gully is increasing rapidly, its depth was greater than 150m and the width was also more than 200m. Before 3 or 4 years this depth was not more than 10m and the width also not greater than 20m. By now, it is almost very near the residential area, at a distance of less than 20m. The extent of this degradation reached the most dangerous stage but no one is giving attention to address this problem. The most alarming part is that no effort has been initiated to contain this imminent threat to the community. This concern is clearly depicted in Figure 4.4.

This study revealed the main cause of degradation is that the area is situated in rift valley and the land slid by it. In addition the topography of the area also contributes to this degradation. The other factors for the rapid expansion of land degradation were lacked of drainage ditches, no flood protection structures, lacked of soil and water conservation practices.

It is highly recommend that the concerned government agency must do something to address the above issues since the problem is beyond the technical and financial capacity of the affected community. The possible measures include government intervention through construction of flood protection structures, drainage ditches, gabion structures etc. These interventions need huge capital outlay which the woreda cannot certainly afford.


(a) (b) (c) (d) (e)

Figure 4.4. Extent of land degradation in the area

These photo were captured during field observation/visit: (a) represent where the degradation start near the main road of Doni towen at the left bank of road which go dowen to Aawsh river and figure b and c also represent the left bank of degraded road that mostly used by the society. Figure d and e represent the right bank of degraded road that go dowen to Awash river.

4.2.2.2. State of soil erosion

According to the analysis of 40 years meteorological data the study area average wind speed is 7.1km/day, due to this and lack of wind breaks the soil is exposed to wind erosion. In addition to wind erosion, the area is also exposed to water erosion since on-farm irrigation water management is very poor. Actually measuring the level of soil erosion is a very difficult task but the overall condition of the scheme from erosion point of view was not good.

4.2.3. Socio-economic sustainability

4.2.3.1. Community participation

The most obvious indicator of sustainability is the ongoing operation and maintenance of the system. O&M is an integrating process which draws on community participation, health education, financing, and management as well as the technical skills required in repairing irrigation facilities WASH (1994). The participation of beneficiaries during the process of irrigation management is expected to have great contribution on sense of ownership and active participation in any scheme matters. Results of the study revealed that community participation on designing and planning the project was absent. Also, community participation on monitoring and evaluation of the project was rarely done and the beneficiaries do not think that the project belongs to them. Monitoring and evaluation are important factors of sustainability for a given project. In this case the situation clearly shows that monitoring and evaluation was absent from the very start of the project since most of irrigation system was not functioning properly. For example, the main canal gate was only functioning partially; the two gates at the diversion head structure that used to raise water head totally out of service, most of division boxes in the main canal were standing without gates. These problems happened due to lack of community participation on the planning, design, monitoring and evaluation steep of the project.

4.2.3.2. The role of women participation

Women's participation in the project activities, sub-project and community institutions were found to be limited. According to survey data gathered from Boset woreda agricultural office, 707 households were benefited from the scheme but only 21 women headed households. Actually, their role in increasing productivity and community management is great. However, no other activities were performed by women institutions during the course of the study. Moreover, women's contribution in decision making process was also examined, but found to be negligible, due to men domination of the leading and decision making process in the community organization.

4.2.3.3. Households' age family size and educational status

Based on the data gathered from sample households survey shows that the total number of households' members was 275, from this 145 were males and 130 females. It also indicates the maximum, minimum and average family size were 13, 1 and 6.88, respectively. Age structure of households members are 31.3%, 18.9%, 48.4% and 1.4%

from 18- 60 years, 12-17 years, less than 12 years and greater than 60 years, respectively. The above figures indicate that productive scheme labor is 49. 6% and the rest 50.4% are children and aged. The survey result presented in table 2 shows that educational status of the beneficiaries. According to table 4.4, 1.1%, 12%, 28.4%, 14.2% and 44.3% attended higher education/college, completed high school completed, elementary, and read and write and illiterate, respectively. The result showed that 44.3% of respondent farmers were illiterate and therefore need to be capacitated through appropriate government interventions.

Table 4.7. Households' family size and age distribution in the study area

Household characteristics	Number of HHs in the scheme	Percentage (%)	Sample Households Size		
			Max.	Min.	Mean
Sum of sample HH members	275		13	1	6.88
Male	145	52.7			
Female	130	47.3			
Age 18 -60 years	86	31.3			
Age 12 – 17 years	52	18.9			
HH age <12 years	133	48.4			
Age > 60 years	4	1.4			

Table1 4.8. Educational status of households' members of the study area

Educational status	Number	Percentage
Higher education/college	3	1.1
High school complete	33	12
Elementary	78	28.4
Write and Read	39	14.2
Illiterate	122	44.3
Total	275	100

4.2.3.4. Land tenure

Land tenure is the actual land ownership of the farmers. It has direct impact on production cost. According to survey result, the average land holding of sample households were 0.5 ha and 0.75ha irrigated and rainfed, respectively. A majority of the beneficiaries (54%) have been involved in the irrigation scheme for a period of 5-10 years; 38.7 % of the respondents have an experience of less than 5 years, and the rest 7.3 % more than 10 years. Most of the interviewed farmers (80%) inherited farming land from their parents; 15% of owned the irrigated land through rent and the 5% were on sharing basis. Price of rent for one season ranged from 1200-1600 birr for every 0.25ha.

4.2.3.5. Conflict occurrence

The sample households reported that some conflicts were experienced in the irrigation scheme. The cause of these conflicts were poor irrigation water management by head users, field destruction by animals, field boarder, poor member's participation, lacked of accountability of the management committee and bias. The result of survey also indicated that 59 % of respondent claimed that conflict occurred sometimes and 28 %, 9 % and 4 % said occasionally, frequently and never, respectively.

The result of FGD and survey questionnaires on satisfaction on distribution of water and different farm inputs revealed that 15% of respondents Saied highly satisfied, 40% respondents satisfaction was medium and 45% of respondents unsatisfied.

4.2.3.6. Economic Analysis

Results also revealed that the socio-economic conditions of the farmers did not improved inspite of ample source of water and fertile land in the service area. According to the survey results, most farmers' land is highly productive. Some problems/constraints to the improvements of socio economic conditions of the beneficiaries include: lack of farm inputs such as improved seeds, high cost fertilizers and pesticides, and other farm inputs. Water shortage at the farmers' fields is due to poor functionality of most the system's structures and often delayed repair and maintenance. This often leads to crop failure and yield reduction. Another problem in the area is the lack of adequate market outlets and price fluctuation. The farmers claim that they are lucky if they could gain a good market price for their produce but lost most of the time. Moreover, the farmers also claimed the lack or absence of technical support from development agent (DA) or concerned agency in the service area. Lack of financing resource was also another that contributes to poor socio-economic conditions of the farmers in the area. This is also responsible for the low cropping intensity and diversity in the scheme.

Economic viability of the scheme was determined depending on the selected sample household field and the required data used to assess it including, type of crop grown, production yield, production cost and selling price were collected in 2015/16 and 2016/17 cropping season from survey questionnaires and DA office. The calculations are summarized in the following tables.

Economic viability of the scheme was determined by discount cash flow analysis using Microsoft Excel software. In the analysis initial investment cost and operation and maintenance cost were used to calculate IRR and NPV. The initial investment cost was taken from the design document and O & M cost of and project benefit for 2015/16 and 2016/17 were collected from survey and 2009, 2010 and 2011 data was taken from literature the rest years data were not available and made possible assumption by considering discount rate. The survey data collected is presented in table 4.9.

Table 4.9. Area cultivated for main crops for cropping season of 2015/16 and 2016/17

2015/17 cropping season					2015/16 cropping season				
Type of crops	Cultivated area (ha)		%		Type of crops	Cultivated area (ha)		%	
	1st season	2nd season	1st season	2nd season		1st season	2nd season	1st season	2nd season
Onion	151.2	56	84	71	Onion	116.8	43.45	73	79
Tomato	19.8	23.2	11	29	Tomato	28.8	11.5	18	21
Maize	9	-	5	-	Maize	14.4	-	9	-
Total	180	79.2							

Table 4.10. Total cultivated area, production yield, production cost and income for 2015/16 and 2016/2017

2015/16						
Crop types	Total cultivated area (ha)	Production cost (birr/ha)	Total production cost (birr)	Production yield (kg/ha)	Market Price (birr/kg)	Total income
Onion	160.25	30,000	4,407,000	75000	4	4,807,500
Tomato	40.3	22,000	806,000	90000	2.5	906,750
Maize	14.4	8000	152,200	40000	5	288,000
Total	214.95		5,365,200			6,002,200
2016/17						
Onion	207.2	32,000	6,630,400	70	3.5	6,381,760
Tomato	43	25,000	1,161,000	120	3	1,548,000
Maize	9	10,000	90,000	38	5.5	188,100
Total	259.2		7,881,400			8,117,860

Source: survey data

The result of discount cash flow analysis indicated that the project is unsustainable from economic point of view because IRR, NPV and B/C ratio clearly showed the economical state of the scheme. IRR, gross B/C and net B/C ratio was -1%, 0.66 and 0.27 respectively which is unsustainable from the economic point of view. The study revealed some economical limiting factors including luck of adequate market and market price fluctuation were another Couse for farmers had low income in the scheme. Mostly the beneficiaries of the scheme about 80% produce onion throughout the year due to perishable nature, lack of infrastructure like road to market and lack of other competitive market they obelized to sale with very low price at their field. Those gaps were facilitated for brokers to do what they needed and killing farmers' economy.

4.2.4. Institutional sustainability

4.2.4.1. Structural organization of the scheme

The irrigation scheme had been managed by water users association. The main role of the management committee is collecting fee, coordinating operation and maintenance activities, water allocation and conflict resolutions. Regarding about the management committee 70% of respondents stated that structural organization was very poor, 25% stated fare and the rest 5% stated as it was good.

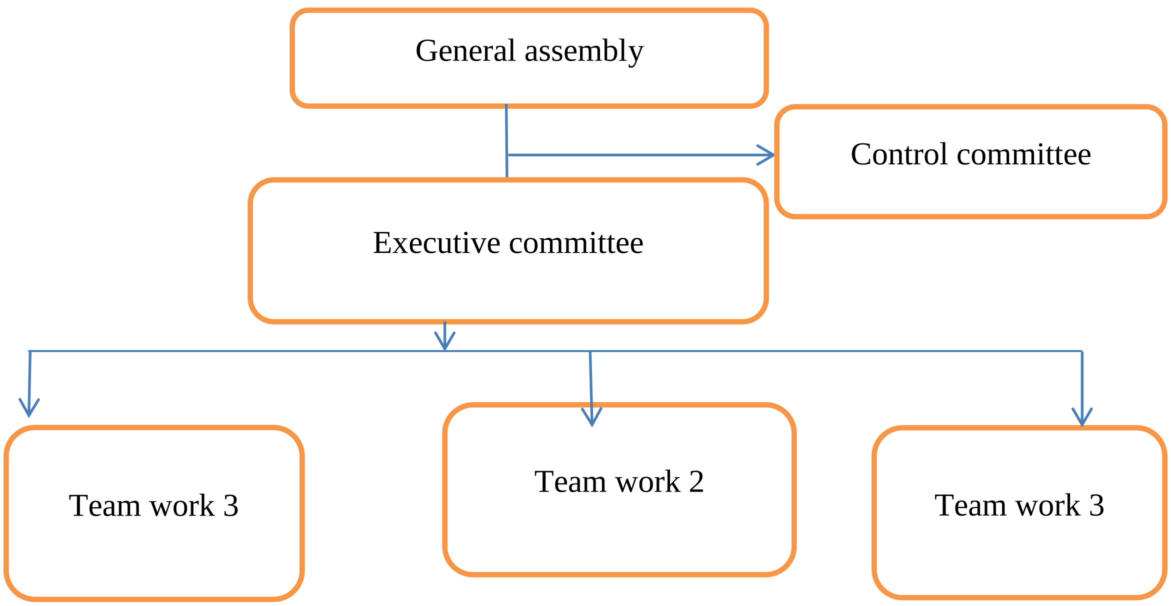

Figure 4.5 Structural organization of the management committee of Doni Sifa SSI (source: Office Doni Development Agent)

4.2.4.2. Management Committee of the Scheme

As shown in the above Figure 4.3, the structural organization of management committee of the irrigation system is composed of the general assembly, controlling committee, executive committee and work teams. The general assembly has the highest power of and all final decisions are made by it. According to the information gathered from DA office, this body meets twice a year and if there is an urgent issue the executive committee has a power to call a meeting.

The executive committee is a body elected by general assembly that follows up the day to day activities of the general assembly. In addition, the major duty of the committee is to follow-up the progress of operation and maintenance of the system; supervise water distribution and other related issues stated in the by-laws.

Further, the structural organization of the system decentralizes to team work to make the scheme activities easy and effective. Each team elects its own team leader who is accountable to the executive committee in any concerning matter. There is also a control committee elected by general assembly that is accountable to it. The overall duty of this committee is monitoring and cross checking of the different associations whether they are performing their task or not in accordance with the by-laws.

Recently the status of this organization is very weak and almost non-functional. The functions and responsibilities of the committee and its components stated above are only on theory but not applied on the ground. The poor performance of the scheme is a mirror of its weak and poorly performing management committee.

4.2.4.2. Existence of financial institution

The result of survey questionnaires, informal interviews and FGD indicted that there was no financial institutions to support the project and the only source of finance for O & M activities is service fee which cannot cover it. Source of finance to run operation and maintenance activities is main constraint for small-scale irrigation schemes. Most of small-scale irrigation in Ethiopia shares it in common this study find out the same story but in this case little bite sever. Unavailability of finance for operation and maintenance activities of the system was responsible for almost all problems including yield reduction, crop faller, Couse of conflict especially in between head and end users. Current scheme condition clearly shows the problem since most of system structures were not functioning properly and it take long time to maintain or repair.

Economic constraints

Source of finance to run the operation and maintenance activities is the main constraint for small-scale irrigation schemes. Most of small-scale irrigation in Ethiopia shares it in common. This study finds out the same story but in this case little bit severe. Unavailability of finance for operation and maintenance activities of the system was responsible for almost all problems including yield reduction, crop failure, and conflict especially in between head and end users. Current scheme condition clearly shows the problem since most of system structures were not functioning properly and it take long time to maintain or repair.

Lacked of adequate market and market price fluctuation were other causes for farmers' low income in the scheme. About 80% of farmers produce onion throughout the year. Due to its perishable nature, lack of infrastructure like farm to market road, and absence of other competitive market, they are forced to sell their products at a very low price right at their fields. These gaps make the farmers vulnerable to brokers who command total control of the farm gate price.

4.3. Sustainability gaps in the system

The third objective of the study was to identify scheme problems. This study revealed the following scheme problems as shown in table 4.11.

Table 4.11. Scheme sustainability gaps and recommended strategies

Factors	Determinant indicators	Problems/Gaps	Strategies
Technical	Conditions of water control gates at head work	The two gates that used to raise water head and also serving as spillway were totally out work.	Repair the failed gates and train the beneficiaries to use them properly.
	Conditions of main canal and secondary canals	In main canal there was no enough amount of water and there was shortage of water at D/S user's fields due to none- functional of control gates. Before head work the main canal was covered by different weeds and also the canal go through at end user fields covered by weeds and different debris, wood and crop residues.	Cleaning the canals before irrigation and also frequently. Maintain or repair the failed gates before the irrigation season started. Coordinate teamwork among WUA with local government for fund and raise farmers' awareness and their perceptions.
	Conditions of division boxes	Most of division boxes gates are not there and the one which have gates were sealed with weeds, sediment, debris and other materials.	Replace the lost gates immediately. Clean the box frequently.
	Flooding hazard	The area is flooded every year and also more than once within a year.	Construct flood protection structures and drainage ditch/channels.
Environmental	Land degradation	Land degradation was reached a severe level and almost approaches an irreversible stage. Lack of soil and water conservation practice.	It is beyond farmers' capacity so the government should intervene in controlling gullies. Practice proactive measures such as soil and water conservation.

	Soil erosion	The area is highly exposed to soil erosion	Proper tillage practices. Leave crop residue on fields. Planting trees as wind break.
	Salinity problem	Farmer's water management was poor and the soil was exposed to salinity. Improper fertilizer application.	Improve irrigation water use on-farm. Facilitate technical training on irrigation water management, fertilizers applications.
Socio-economic	Experience of farmer	When to plant, when and how much to fertilize and when to harvest are not clear to farmers Farmers experience was very poor on type of crop grown, rate of fertilizers application, on-farm water use, conservation practice, adopting new technologies to improve irrigation efficiency etc.	Building up farmers' awareness on adopting new water saving irrigation technologies, conservation practice, and irrigation water management. Facilitate technical training.
	Conflict	Conflicts experienced due to unwise water use specially head users, field destruction by animals, field boarder, poor membership's participation etc.	Educating the farmers to use water properly DA staffs and management committees should follow up the scheme progress.
	Cost of farm input	Incurred high production cost since farm inputs are not available with reasonable price such as improved seed, fertilizers, herbicides, pesticides etc… High labor cost.	Government should intervene by providing low-cost improved seeds and fertilizers and other farm inputs. Reduce fertilizers application instead use manure if necessary.
	Market price and market service	Market price fluctuation There are no market alternatives only on their fields. Brokers total control of farm gate price.	Planning grown crop varieties and timing. Direct contact with traders The government should provide different marketing service.
	Financial constraints	Lack of micro-finance facility	Establish private and government micro-finance services that offer low interest loans to farmers.
Institutional	WUC and WUA	Poor structural arrangement Management committee is not functioning properly. They don't meet regularly with farmers and also each other.	The committee should be well organized with concerned stake holders. The management committee should meet regularly. Capacity building is needed to improve the

			management skills of the committee members.
	Extension and DA agents meeting with committee to facilitate the ongoing activities	There was no meeting with committee as well as with farmers.	DA and extension agents should meet at least twice a year to facilitate support the ongoing scheme progress.
	Satisfaction on distribution water and different farm inputs	There was a biased on water distribution. The management committee lacked responsibility and accountability. Poor member's participation on scheme activities.	Improve water delivery schedule. The committee should clear and responsible for all scheme activities.

5. CONCLUSION AND RECOMMENDATIONS

The study area is highly characterized with frequent drought and food insecure inspite of ample water resource and suitable and fertile land. The study assessed sustainability of the scheme from technical, environmental, socio-economical and institutional by setting indicators which were easy to collect, measure, cost effective and fit with the scheme situation. The result of Awash River stream flow analysis indicated that irrigation water was not a constraint because the 90% dependable flow of the stream was found more than the scheme irrigation water requirement. The result of 40 years Awash River stream flow analysis indicated that 2,959,000m^3 water is available on the month of Oct11-March and the required amount of water for the scheme was 468,000$m^{3;}$ it clearly shows the scheme is free from water availability problem. The technical indicators showed that the scheme was not sustainable since most of system structures were failed or none functional (i.e. head control gates, division boxes gates), low cropping intensity and diversity, water shortage for irrigation at middle and end of the fields due to failure of system structures and poor irrigation water management specially at head user fields. In addition, the area is flooded every year due to lack of flood control structures and drainage ditches, but there was no soil fertility and severe salinity problems.

In the study area there was knowledge and skill gap on planning, design, construction, operation and maintenance of the irrigation system. Most of small-scale irrigation scheme in Ethiopia have been failed due to lack of community participation on planning, design, construction, monitoring and evaluation process, poor construction qualities and also poor agricultural extension services. In this case also the same story is repeated and the following scheme problems were revealed to include: poor irrigation water management, lack of technical knowledge how to enhance irrigation efficiency, lack of conservation practices and failure to adopt irrigation technology.

Poor external support from concerned stake holders (woreda agricultural office, development agents, NGO), lack of community participation on planning, designing, monitoring and evaluation of the project and weak structural arrangement of WUC were determinant factors for the poor scheme performance.

It was also observed that lack of technical knowledge among farmers on new technologies and management system. Most farmers were not aware of the interaction and inter-linkages between crop rotation, pest management, introduction of new crops, water and vector borne disease and the environment. Teaching farmers on new techniques and scientific findings should be considered along with provision of water for irrigation.

The findings of this study indicated that, socio-economic and institutional constraints were one of the main factors for poor irrigation scheme performance. The economic analysis also found that the scheme IRR, gross B/C and net B/C ratio was -1%, 0.66 and 0.27 respectively which is unsustainable from the economic point of view. According to the finding the scheme characterized by low income contribution for households, lack of cooperatives between water user members and also the management committee, conflict and awareness gap WUA management committee had poor structural organization, free from privet, governmental or NGO institutional organization to follow up progress of the scheme, providing farm inputs with reasonable price, technical support and facilitating loan.

In totality, the study showed that the system is unsustainable in the long run.

Recommendations

To address the gaps and to make the system sustainable, the following are recommended:

- Development of sound irrigation system is not good enough for well scheme performance without following up the progress and leaving operation maintenance activities for farmers.
- Investments in infrastructure improvements may be ineffective in the absence of continued maintenance, an outcome of weak institutions, inadequate funding, low operational and maintenance charge and lack of sense of owner ships and commitment that members feel towards maintaining and sustaining the scheme which generally resulted from top-down approach of the intervention during the intervention of the project. Thus following a bottom-up approach is ideal for irrigation development, treating farmers as "Owners" and not as "beneficiaries" of the projects. So, farmers should participate throughout the project planning, implementation and evaluation phases.
- Involve the beneficiaries and other stakeholders in the project planning, design, operation, monitoring and evaluation.
- Training of the development agents and water user association officials is essential to building the local understanding, management capabilities and community responsiveness.
- Identify and assess the project beneficiaries or target population.
- Understand the knowledge, attitudes, and practices of the target population to be able to formulate necessary intervention in the area.
- Ensure the commitment of concerned national and local institutions responsible for small-scale irrigation development and operation.

The different strategies mentioned to address the gaps identified in this study should be seriously pursued by stakeholders in order to make the system more sustainable in the long run.

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APPENDIX A

Adama science and Technology University

Research Questioners for sampled farmers and other group

A questioner designed for sampled farmers

Dear respondents,

The principal objectives of this questionnaire is to assess sustainability of Doni sifa small-scale irrigation project in boset wereda Eastern oromia, such studies on the community based small scale irrigation are useful to the planers and decision makers to draw the most appropriate irrigation development plans, which are based on food security, farmers needs and priorities. You are kindly requested to give an answer freely and openly. The questionnaires are fully for the academic research purpose, any information you give will be kept confidential. Thus, your cooperation is very necessary to achieve the desired goal of the study.

Thank you for your cooperation

Survey coordinator: Fitsum Mulugeta

Section I

Questioner for Individual Beneficiary

1. General information about irrigation system

A. General information

1. Respondent's name: ____________________ Sex: _______ Age: ________
2. Respondent's address: village: ______________ Sub District: ________________
   District: ________________
3. Administration information
   A. Project name: _________________________________
   B. Region ____________ Zone_______________ Districts_______________
   C. PA _______________ Village __________________ Irrigation Block__________

B. Information about the irrigation system

1. Source of irrigation water?
2. Water distribution to individual field. A. By gravity B. By pumping C. Other (specify)
3. Is this irrigation project important to you?
   A. Very much B. Normal C. Not that much D. Completely not
4. Is your life changed after you start to use modern irrigation?
   A. Yes B. No
5. If yes what is/ are the indicators?
   A. Construction of new house B. Sending children to school C. Food variety D. Income increase E. Constructions of new irrigation facility F. Other, specify ______________________

6. Type of irrigation practice
   A. Surface (i. Furrow ii. Basin iii. Border)
   B. Other (specify) __________________
7. Which of the canal system is working properly in this project?
   A. Primary B. Main C. Secondary D. Tertiary E. Field canal F. all G. none
8. Which system is vulnerable to damage?
   A. Field canal gate B. Tertiary gate C. Secondary canal gate D. Main canal gate
   E. Primary canal gate.

C. Household characteristic

1. Farmer's information

Name	Year of agricultural practice	Status	Sex	Education	Main occupation	Household member		
1.								
2.								
3.								

2. Land area (ha):________________
2.1. Land tenure size (ha): ________
2.1. Price for rent land (birr/ha/year): ________________

D. Crop information

1. How many times do you produce in a year? _________

2. Have you ever faced a problem of crop failure when using irrigation?

A. Yes B. No

3. Is the same crop type with last year? A. No B. Yes C. Other (specify) ____________

4.1. If your answer is no for Que.1 what is the reason for change.

A. yield reduction B. market price C. tradition D. DA policy E. other (specify) ___

II. Conflict

10. Have you irrigation water conflict experience?

A. Never B. Rarely C. Occasionally D. Frequently

10.1. Source of conflict

A. Scarcity of water B. Different land holding capacity

C. Bias of management committee on timeliness and duration of water distribution D. Other (specify) _______

10.2. Who is responsible to resolve such a conflict?

A. DA staff B. WUA C. Farmers by them self D. Other (specify) _______

10.3. What is your degree of satisfaction on conflict resolution?

A. Strongly satisfied B. satisfied C. Dissatisfied D. Strongly Dis-satisfied E. Neutral

11. Is there a rule and regulation for conflict resolution? A. Yes B. No

11.1. If your answer is yes for the above Que. What type is: __________

11.2. What is the punishment used?

A. By court B. No C. Prohibit from water use D. Eras from water use membership E. Other (specify) ____________

III. Institutional Information

12. What is/are administration problems of water user group?

A. Poor structural arrangement B. Lack of cooperation with membership

C. Lack of financial support D. Lack of support from DA E. All F. Others (specify)

13. Have you ever take training? A. YES B.NO

17.1. If you say yes, how often? A. Frequently B. Sometimes C. Rarely

17.2. Who is responsible for the training? A. DA staff B. NGO C. WUA D. WUA E. Other

14. Do you pay fee for irrigation water?

A. Yes, How much (__________birr/m^3) B. No

15. Willingness to pay. A. Very high B. High C. Low D. Very Low E. Not sure

16. Who is responsible for collecting water fee?

A. DA staff B. WUA C. Selected farmers D. Other (specify) _____

17. What is the use of collected water fee?

A. For O&M B. For upgrading and construction of new scheme C. Other 9specify)

18. Source of any financial support?

A. No B. Collected water fee C. Government D. NGO E. Other (specify)

19. Who is responsible for operation and maintenance at the field?

A. DA staff B. WUC C. Farmers D. Other (specify)

F. **Environmental information**

1. Which natural resource you think is short in your area? Prioritize

A. Water B. Agriculture land C. Pasture land

D. Forest E. Other specifies ______________

2. Why you think it is scarce/shortage

A. Population increase B. Irrigation expansion C. Infrastructure expansion D. Expansion of grazing land E. Overgrazing F. Fuel wood consumption G. other, specify

3. If your answer is yes for the above Que., why? Because

A. Lack of soil and water conservation activity B. Irrigation system (furrow or flooding)

C. Structure problem D. poor irrigation water management

E. other, specify___________

4. What type of soil conservation practice you use?

A. No B. Tillage C. Mulching D. Crop rotation E. Strip cropping

F. stone bund G. Other (specify) ________________

10. Have you ever facing flooding hazard on your irrigated area?

A. No B. Every year C. Twice in a year D. Occasionally

11. For how long is the land flooded? ____

12. What do you think about the cause?

A. There is no flood control structures B. No drains C. Blocked drains

D. Other___________________

13. How do you control flooding hazard? __________________________________

- Eventually if you have any comments, suggestion or additional information which is helpful to improve this irrigation project please: _______________________

Table 7.1. Laboratory result of soil physicals properties

Soil sample	Soil depth cm	Bulk density gm/cm^3	FC %	PWP %	Textural class
Head user	0-30 31-60 61-90	1.03 1.18 1.07	22.59 22.91 26.86	15.34 18.81 17.19	Loam Loam Loam
Mid user	0-30 31-60 61-90	0.96 1.07 0.93	22.06 21.94 22.54	16.61 17.41 18.65	Silt Loam Silt Loam Silt Loam
End user	0-30 31-60 61-90	1.21 1.01 1.18	22.99 23.91 23.48	19.46 18.83 17.54	Silt Loam Silt Loam Silt Loam

Table 7.2. Laboratory result of soil physical and chemical property

	PH	EC dsm	Average N (%)	K (mg/kg)	P(mg/kg)	Ca(mg/kg)	Mg(mg/kg)
Soil sample	7.11 7.01 6.73	0.68 0.77 0.65	0.12	140.45	17.77	2534.12	498.09

Head user	6.58 6.84 6.71	0.55 0.41 0.38	0.23	213.34	32.42	4127.31	672.19
Mid user	7.25 7.19 7.14	0.91 0.71 0.59	0.19	111.35	23.31	3654.71	589.54

(Source: Gemechis, 2014)

Economic analysis

	A	B	C	D	E	F	G	H
1			discont cash flow analysis of doni sifa SSI scheme					
2	Years	capital out(birr)	project benefits(birr)	O & M cost(birr)	Net cash flow(birr)	Present value(birr)	Cum PV of Net cash flow(birr)	PV O % M cost(birr)
3	1995	2654963	0	0	-2654963	-2654963		
4	1996		89234	34760	54474	48207.07965	-2606755.92	30761.06195
5	1997		91543	38321	53222	41680.63278	-2565075.288	30010.96405
6	1998		97132	41356	55776	38655.56585	-2526419.722	28661.78251
7	1999		99135	44101	55034	33753.38286	-2492666.339	25364.4093
8	2000		110143	54321	55822	30297.94515	-2462368.394	29483.26248
9	2001		121453	65391	56062	26927.61728	-2435440.776	31408.50883
10	2002		151856.7	71023	80833.7	34359.22456	-2401081.552	30189.0821
11	2003		206271.5	72314	133957.5	50389.43468	-2350692.117	27201.62424
12	2004		401543	189345	212198	70637.49587	-2280054.621	166237.928
13	2004		410488	234819	175669	51750.04053	-2228304.581	69174.94132
14	2005		579120	378699	200511	52272.74714	-2176031.834	98725.94057
15	2006		765431	678453	86978	20066.33671	-2155965.497	156523.1017
16	2007		1254310	879430	374880	76537.18869	-2079428.308	179548.3884
17	2008		6,002,200	5,365,200	637000	115090.9629	-1964337.345	969365.8307
18	2009		8,117,860	7,881,400	236460	37807.76745	-1926529.578	1260162.98
19								
20	Rate=	13%						
21					4. PV BENEFIT	$3,759,705.48		
22	1. NPV=	(1,926,529.58)						
23					5. PV OM	$3,031,295.52		
24	2. IRR	-1%						
25					6. GROSS B/C	$0.66		
26								
27	3. NFV							
28					7. NET B/C	0.274357857		
29								