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MSC THESIS ON

SMALL SCALE IRRIGATION PROJECT STRUCTURAL FAILURES AND THEIR MANAGEMENT PROBLEMS RELATED TO WATER LOSS in Ethiopia.

(the case of Jemjem small scale irrigation in upper Awash sub basin)

A thesis submitted and presented to the School of Graduate Studies of Addis Ababa University in Partial fulfillment of the Degree of Masters of Science in Hydraulics Engineering under Civil Engineering

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Small Scale Irrigation Project Structural Failures and Their Management Problems Related to Water Loss in Ethiopia.

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Declaration

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, a required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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Certification

The undersigned certify that he/she has read the thesis entitled**:** Small Scale Irrigation Project Structural Failures And Their Management Problems Related To Water Loss in Ethiopia.(the case of Jemjem small scale irrigation in upper Awash sub basin) and hereby recommend for acceptance by the Addis Ababa University in partial fulfillment of the requirements for the degree of Master of Science.

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Abstract

The challenges in reducing water losses of the conveyance structures such as earthen and lined canals were assessed considering the influence of participating parties (farmers, contractor and funding agencies) and contributing factors (hydrologic and hydraulic factors). The effect of conveyance efficiency, structural failure/performance, irrigation system management problems and water losses in Jemjem SSIP (which was constructed in 2004- 2006E.C), were the major problems for this study. The main objective of this study is to assess the reason why more than 50% of the water diverted is lost and to discover the solutions that can minimize the problems. To solve or estimate existing problems scientifically, the method proceeded are 'measuring flow volume of the main canal at different points using v-notch weir to estimate loss in each interval and their conveyance efficiency, calculating Manning's roughness of the main canal to compare with designed value of 'n', Estimating evaporation loss using energy balance method and estimating seepage loss of the main canal using Kostiakov A.N empirical formula and using some questionery results to estimate the influence of water management problems. The designed value was taken from the design report and the existing conveyance efficiency is obtained by measuring discharge and depth of flow of the canal at different locations. The conveyance efficiency given at the design stage was 90% for the scheme which was directly taken from FAO recommendations. However, the values obtained during the study were 34.9%. But, the conveyance efficiency selected should be based on construction materials, methods and qualities, managerial activities, technological and other factors affecting conveyance efficiency. The evaporation and seepage losses together constitute 3.63lit/sec while leakage and other operational losses account ***23.07lit/sec/ (****which is* ***56.27%)*** *of the total main canal inflow. Such a decrease in conveyance efficiency or increase in water loss is found to be due to inefficiency of management issue and due to inefficiency of contributing factors such as construction material and (hydrologic and hydraulic factors). Thus, management problems, structural under performance and a designed conveyance efficiency taken directly from* ***standard books*** *had effect on the overall performance of Jemjem irrigation project. Irrigation structures should be maintained from time to time and Gates should be operated by trained operator to create equity of water distribution and also to make water management easy. Water shed management should be well implemented in the area so that quantity of silt deposited will be reduced. Water committee should be changed to WUA and sufficient follow up should be made to overcome water management problems existing in the project and similar projects in Ethiopia.*

Key words: Conveyance efficiency, small scale irrigation, Irrigation structures, structural failures

List of Acronyms and Abbreviations

AGP: Agricultural growth Program

Ec: Conveyance Efficiency

FAO: Food and Agricultural Organization

FGD : Farmers Group Discussion

FMIS: Farmer-Managed Irrigation Systems

FSC : Farmers' Service Cooperative

GPS: Geographical Positioning System

GS Gauging station

Ha: Hectare

IIMI: International Irrigation Management Institute

lv Latent heat of fusion

MoWIE: Ministry of Water Irrigation and Electricity

NGOs: Nongovernmental Organizations

OIDA: Oromia Irrigation Development Authority

P.A.: Peasant Association

PET: Potential Evapo-transpiration

R H Relative humidity

Rn Solar radiation

SSIP: Small-Scale Irrigation Projects

WUAs: Water Use Associations

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1. INTRODUCTION

1.1 GENERAL BACKGROUND OF THE PROJECT AREA

Jemjem small-scale irrigation project is found in Ejersa Lafo district parallel to Ginchi town at distant of about 17km. The project idea is originally emanated from P.A. community and based on that under Oromia irrigation development authority Bureau central irrigation development authority has conducted reconnaissance and detail study in 1998 and1999 budget year (source feasibility study document).

The project area is about 17 km from Ginchi district capital and 2-4km far from (Addis-Ambo asphalt road) and 55km from A.A. The weir site of the project is accessible for 4km gravel paved road. The core problem for which irrigation development funded by the government needed is the alternative to uneven distribution of rainfall and to supplement the main economic base rain fed crop production by irrigation farming.

1.2 BACKGROUND AND JUSTIFICATION

Irrigation water demand has significantly increased while available water resources are becoming increasingly scarce. This is mainly due to the combined effect of climate change, persistent drought and the increase of water demands related to increase in irrigated surfaces, urbanization and tourism recreational projects. In this context, improvement of water management in agriculture, which is the biggest water consumer, is necessary to enhance agricultural productivity in order to meet food demands of the growing population.

Modern irrigation development started in Ethiopia in the 1950s in the Awash River Valley with the objective of producing industrial crops such as cotton and sugar cane and horticultural crops. Awash River Basin has a catchment area of 112,696 km2. The Awash River originates from central west part of Ethiopia, flowing 1200 km long, and provides a number of benefits to Ethiopia In the 1960s, private irrigated agriculture (most of it owned by firms from overseas) expanded in all parts of Awash River Valley and in the Lower Rift Valley of Ethiopia (Awulachew et al., 2007).

Moreover, in irrigation schemes under rotational water supply in Arid and semi Arid environment, the existing rules for water allocation are often based on applying a fixed area proportionate depth of water with every irrigation cycle irrespective of the crops and their growth stages and that for ease of irrigation schemes operation. This frequency is likely to result in excessive water depths being applied when large amount of water are available or, by contrast, water stress periods occurring when irrigation intervals are too large. Thus, the effects of these irrigation scheduling rules on crops productivity have to be assessed in order to improve water management.

The increasing water shortage and the mishandling of available water resources are currently main fear to sustainable development for most river basins of Ethiopia. Different irrigation schemes did not satisfy the net irrigation demand even though the available water is more than that due to high losses from storage, conveyance, and application to irrigation plots Mc Cornick et al (2003). Identifying the various components with their level of losses and knowing what improvements can be made are essential in making most effective use of vital water resource of Awash River basin.

Progress in conveyance efficiency will show the way to improve equity in water distribution and reduce the gap between crop water requirement and actual water use. Solitary effective approach to attain these improvements is a **good guidance for irrigation** facilities, operation in institutional, managerial and technical aspects. This guidance will benefit farmers and persons/organizations in charge of water management directly. The assessment of the potential cause of irrigation (conveyance) inefficiency is vital for sustainable functionality of irrigation schemes in Jemjem SSIP.

More weight is given to efficient use of irrigation water for maximum economic return and water resources sustainability since existing water resources become limited. This requires correct methods of measuring and evaluating how effectively water extracted from a water resource is used to produce crop yield. Insufficient irrigation application results in crop water stress and yield reduction. Excess irrigation application can result in pollution of water sources due to the loss of plant nutrients through leaching, runoff, and erosion.

Different schemes have different efficiency of irrigation water use. Available water is used more carefully in the schemes where water is limited. At the same time as in areas of abundant water, the value put on conserving water is not as much of and the tendency to over irrigate exists. Cost of labor, ease of controlling water, crops being irrigated, type of irrigation system and soil characteristics influences efficient use of water. Various terms are used to describe how efficiently irrigation water is applied and used by crop. Incorrect usage of these terms is common and can lead to a misrepresentation of how well an irrigation system is performing. Assessing the current situation and introducing improved techniques to manage water resources efficiently are vital for improving irrigation efficiencies, sustainability and productivity of irrigated agriculture (Mc Cornick et al., 2003).

Thus, hydraulic and hydrologic, the two main principal factors affecting conveyance efficiency and influence of participating party were described in this research. For the assessment of the hydraulic factor, main canal discharge was taken at different locations along the canal reach and the conveyance efficiency Ec and conveyance characteristics were calculated. The designed value for Ec was compared with the operational values. The values calculated showed that huge decrease in magnitude of conveyance efficiency.

Once more, the hydrologic factor for inefficiency was analyzed whether the river discharge was deficit or enough in meeting the crop water requirement (CWR) for the schemes and **evaporation and seepage losses were evaluated**. Thus, this study focuses on evaluation of structural failure and management problems of small scale irrigation impact on irrigation water in Jemjem project area.

The influence of participating party was analyzed that water users, contractor and funding agent didn't involve adequately in the water management of Jemjem SSIP so that to build sustainable irrigation water use efficiency.

1.3 Problem Statement

There are challenges in solving irrigation **project management problems and their structural failures** in Ethiopia. The challenges may differ from region to region in type and magnitude. There are other factors that increase the challenges of reducing small scale irrigation project management problem and their structural failures which is a source for water losses.

For example, soil type, Climate and topography of the area. When these factors combined to the problems in participating parties they drastically increase the challenges and make difficult the searching of simple countermeasures.

In practice it is difficult to assign the responsibility and cause of the problem to one party and factors only but to some extent all party share the problem and the consequences. To assess the behavior of these parties (water user, contractors and funding agents) and factors (soil, Climate and topography) and the magnitude of their contribution that makes reducing irrigation water losses , poverty alleviation and income generation ...etc more challenging was the main **reason to conduct the research.** However, the availability of adequate irrigation water supply is among the basic and essential elements in any irrigation development program.

The current problem for Jemjem SSIP was related to the fact that, water demand for farm land was not properly supplied and all Water didn't pass through normal canal. Also the water amount at the end of main canal but before secondary canals found to be much less than the amount diverted. As canal was broken at saddle parts of land before reaching the second flume, the farmers settled at downstream of the broken point become inaccessible to irrigation water and nobody was become responsible to maintain it until the study time.

The total water diverted was about **364** lit/sec as per the information obtained from feasibility study but during driest season around **50% or more** was estimated to be lost/wasted by different cases. The first case is every off canals′ gate removed by unknown persons or not installed at all and instead of gate, water is partially controlled by mud and boulders and therefore significant water leakage is obtained. The second case is breaking of main canal edges at different points and water escape at these points as canal overtopping. The third case is water flow through canals was not shut at canal head immediately after irrigation and water was returned back to the river without purpose. The command area or farm land soil is clay and black cotton soil which cracks for about 20cm during driest season was supposed to have high seepage loss which exacerbates the challenges of reducing water loss but what the soil laboratory test showed is found to be clay loam and water tight.

It is therefore essential to reduce the water losses or wastages to optimize water use efficiency and water productivity by solving the project management problem and their structural failures improvement. The unavailability of sufficient agricultural inputs and patterned extension approach, the existence of **frost**, and drainage problem, structural failure, irrigation management problem are some of the major shortcomings of the existing rain fed and **irrigation** farming system.

After assessing the challenges and the problems encountered, at the end, it was the aim and the purpose of the research to indicate possible countermeasures which can possibly reduce the challenges and pave the way to enhancements in sustainable irrigation management and rehabilitation of irrigation structures in Jemjem **project** which is applicable for similar projects in the country.

The study tried to answer the following questions:

1. Is there relation of water loss with structural failures under irrigation?
2. What are the major challenges that hinder the sustainability of Jemjem SSIP scheme?
3. Is there water loss due to miss management of irrigation water or by chance?
4. What will be the possible solution that can resolve the impact of water losses/wastage on Water Use Efficiency (WUE) in command area of Jemjem?
5. How is the existing management of the irrigation system going on?
6. How are water users organized for irrigation management? What are their key constraints?
7. What are the functions of Water User’s committee in the management of the irrigation scheme?

1.4. Objectives of the study

1.4.1 General objective

The major objective of this study was to assess the relationship between water losses or water wastages with irrigation management problems and irrigation structural failures and to pave the way to enhancements in the sustainable irrigation management which is supposed to maximize irrigation efficiency.

1.4.2. Specific objectives

To assess existing structural performances to evaluate the extent of structural failures.

To assess conveyance loss (operational, seepage, evaporation and other losses) of the main canal.

To assess factors (hydraulic and hydrologic factors) that affect main canal conveyance efficiency.

To assess existing water use management and recommend future reasonable irrigation water use management.

2. LITERATURE REVIEW

During the study, different literatures and design reports were reviewed to design concept map of Jemjem SSIP study as it can be realized from the following topics.

2.1 GENERAL DESCRIPTION OF IRRIGATION

Irrigation is the delivery of water to farming crops by non-natural means, planned to allow farming in arid regions and to offset the effect of drought in semi-arid regions. Even in areas where total seasonal rainfall is sufficient on average, it may be poorly distributed during the year and variable from year to year. Where customary rain-fed farming is a high-risk enterprise, irrigation can help to ensure stable agricultural production (FAO, 1997).

2.1.1. DESCRIPTION OF SMALL SCALE IRRIGATION

The first issue in any conversation of irrigation, as stated by Turner (1994) is the description. Unquestionably the application of water to plants is irrigation. There could be great differences between countries and agencies over what is meant by "small". In truth, small according to the Indian definition is regarded as large in Africa. Turner (1994) points out those irrigation systems can be classified according to size, source of water, management style, and degree of water control, source of innovation, landscape niche or type of technology. Most- authors, however, agree that concepts of local management and simple technology should be combined with size, and the best working definition seems to be that used by the UK Working group on Small Scale Irrigation (SSI): small scale irrigation is 'Irrigation, usually on small plots, in which farmers have the major controlling influence and using a level of technology which the farmers can effectively operate and maintain'.

There is also a case for using the term 'farmer-managed irrigation systems' (FMIS), as used by the International Irrigation Management Institute (IIMI), which removes the confusion with authority-managed small-scale irrigation. According to Jorge (1993) irrigation system fall in two broad categories: those in which the principal management responsibility is exercised by government agencies with the farmers playing a subsidiary role, and those in which most management activities are carried out and decision made by the farmers themselves with the government farmers assume the dominant role providing periodic technical or logistical support. The latter category in which is referred to as Farmer-Managed Irrigation Systems (FMIS).

In general, an important characteristic of FMIS is that the farmers also control and manage the water abstraction from its source. Governments often classify these systems as "small-scale irrigation system" or "minor irrigation systems," although examples of FMIS may be found with command areas of hectares. FMIS are also known as traditional, indigenous, communal or people's systems. The precise set of activities and functions that the farmers and their organizations perform varies from country to country and from system to system.

2.2 Irrigation development in Ethiopia.

Though the distribution is not uniform, Ethiopia has a total volume of 123 billion cubic meters of surface water and about 2.6 billion cubic meters of groundwater. The western half of the country receives sustainable amounts of precipitation and has many perennial rivers and streams while the precipitation is marginal in the eastern half of the country. The Ethiopian highland is the source of the Abay, Awash, Tekeze, Mereb, Baro-Akobo and Omo rivers that flow to the west and southwest.

The Baro-Akobo basin is potentially the largest possible irrigable area (about 483 thousand hectares) though only a negligible portion of it has been developed probably because of the large investment cost required and its distance from the central market, which makes it less favorable for commercial agriculture. Awash River is the only river extensively used for commercial plantations of industrial and horticultural. Out of the total irrigated area of about 161,125 ha, over 43% is found in the Awash River basin. The remaining potential of the Awash River for irrigated agriculture is in the order of 136,220ha (McCornick et al, 2003).

2.3. THE GENERAL PROBLEMS OF SMALL-SCALE IRRIGATION

Even though small-scale irrigation may have numerous returns, it is never protected from problems. The problems have turned out to be more serious in drought prone areas where small-scale irrigation is predictable to solve problems of declining agricultural productivity. Small-scale irrigation in drought-prone areas has **two sets of problems**.

The first category includes problems that are associated with the specific environmental characteristics of the agro-ecosystem. **The impacts of drought-proneness and environmental degradation on small-scale irrigation are illustrated** by a concept map that has been compiled based on a literature survey. **The second** category includes common problems that **drought-prone and degraded areas share with all other small-scale irrigation systems**, irrespective of their agro-ecological context.

These are: 1. Problems related to the physical nature of the irrigation systems,

E.g. Loss of water through seepage;

2. Problems related to the application of irrigation water,

E.g. Upstream users abstracting too much water;

3. Problems related to marketing produce,

E.g. Transportation issues;

4. Policy-related problems,

E.g. Security of land tenure;

5. Engineering-related problems,

E.g. Lack of experience in planning and designing irrigation systems;

6. Problems related to the irrigation economy,

E.g. Competition between rain-fed and irrigated agriculture; and

7. Community issues, e.g. Levels of farmer participation.

2.4 ASSESSING IRRIGATION STRUCTURE PERFORMANCE

Irrigation performance describes the success of the physical system operating decisions to deliver irrigation water from a water resource to the crop. Several efficiency terms are used to evaluate irrigation system performance FAO (1989). This relates the number of structurally functional schemes to total number of schemes implemented during the period.

2.5 SOCIAL AND INSTITUTIONAL (MANAGEMENT) PERFORMANCE:

This is the ratio of number of managerially functional schemes to that of total schemes implemented. The causes for underperformances related to structural and management problems were assessed using information gained from field investigations and key informant interviews during 2017.

2.6. CONVEYANCE EFFICIENCY OF A CANAL

Conveyance efficiency is defined as; Irrigation water is normally conveyed from a water source to the farm or field through natural drainage ways, constructed earthen or lined canals, or pipelines, Irmark et al (2011). Many conveyance systems have transmission losses, meaning that water delivered to the farm or field is usually less than the water diverted from the source. Water losses in the conveyance system include canal seepage, canal spills, evaporation losses from canals, and leaks in pipelines.

$\eta_c = (Q_o/Q_I) \times 100$ where: η_c is conveyance efficiency

Q_o is discharge measured at outlet of canal

Q_I is discharge measured at inlet of canal

Different soils have different characteristics of water permeability and again have different water conveyance efficiency. Similarly, different linings have different conveyance efficiency taken as standard value for ease of design. For Jemjem soil type which is clay loam, the standard value of η_c is 90% which was used for design purpose. To increase canal conveyance efficiency different lining measures are taken. At the place or at soil type having serious seepage, canals are usually lined with locally available impervious materials such as cement concrete, shotcrete, brick or concrete tile, asphaltic concrete and bolder.

(Source, Irrigation engineering book by Santosh Kumar Garg)

2.7. THE IRRIGATION PERFORMANCE INDICATORS

Indicators are used to measure performance. An indicator describes the level of actual achievement in respect of one of the objective of irrigation. Indicators are used to simplify the otherwise complex internal and external factors affecting the performance of irrigated agricultural systems. Indicators used in this research are relative values that compare actual achievements with target values.

2.7.1. IRRIGATED AREA PERFORMANCE:

This is the total area under irrigation versus total designed command areas of already implemented irrigation project during a particular year or averaged over years.

2.7.2 BENEfiCIARY'S TARGET PERFORMANCE:

This is the ratio of actual number of beneficiaries using irrigation schemes and planned or targeted number of beneficiaries. For capturing the potential of irrigation, secondary data sources were used based on feasibility study document and review of literature. For the assessment of broad national irrigation performance, the database developed for this purpose can be used according to Awulachew et al. (2007).

2.7.3 ANALYSIS OF CAUSES OF UNDERPERFORMANCE OF SMALL-SCALE IRRIGATION

The performance indicators considered for small-scale irrigation focused on studying major causes of underperformance of poorly performing schemes. Failure or sub-optimal operation of small-scale schemes are due to numerous factors that can be categorized in two major groups related to **structural (hardware)** and **management (social and institutional)** factors.

2.8 FACTORS AFFECTING CONVEYANCE EFFICIENCY

There are many factors which affect irrigation efficiencies.

Few factors are described below.

1. Soil salinity and water logging
2. Performance gaps and technological transfer

3. Effects of hydraulic parameters

4. Hydrological effect

5. Agronomical effect

2.8.1 Water logging and soil salinity

Throughout the Lower Awash Valley drained marshes and swampy soils become infertile and acid because of oxidation of sulpher and production of sulphuric acid in the drained soils. Salinity problems are recognized. In poorly drained soils wilt syndrome to cotton is produced under anaerobic condition in the presence of easily oxidizable organic matter, presently hydrogen sulphide and reduction of NO3, Fe, Zn and Cu, this affects growth of cotton root causing damage and other deformation in plants.

In Upper Awash, the Awash River floods especially Bacho plain during the rainy season and over flow annually on Jimma road which is located about 30 km West of Addis Ababa. The flood covers both sides of the Addis Ababa-Jimma highway (Taddese, 2000). Rhoades (1997) reported estimates that as much as 20 percent of the irrigated land may already be experiencing yield declines due poor drainage (water logging and salinization) caused by over-irrigation as cited by Walker (2003). Approximately 70 percent of initial fresh water withdrawals are allocated to agriculture where irrigation is the predominant agricultural use, Walker (2003). Generally project efficiency may be as low as **40 percent**.

Due to the removal of water, salt concentration effects occur in the soil by the consumptive use of crops and other natural vegetation. Irrigation along with the inter-basin export of high-quality water and evaporation from the water surfaces of streams and lakes are major causes of increased salinity levels caused by concentrating effects. Salts may also accumulate in the soil by the chemical weathering of the soil and substrata by irrigation water and natural sub-surface flows. Also known as “salt loading,” it contributes to the concentrations in water supplies along with too much fertilizer applications, municipal and industrial wastes, and point sources such as mineral springs, flowing brine wells.

The land will become unproductive, if the salts accumulating in the root zone because of evapo-transpiration or weathering are not periodically leached from the crop root zone, though the water which passes through the root zone carrying the excess salts may be severely restricted from further travel by subsurface conditions. When this occurs, this leachate will eventually build up into the root zone, causing high salinity levels and poor aeration. In many areas, drainage is more than adequate, movement of salts from irrigated lands contaminates local groundwater basins, and stream flows (Walker, 2003).

2.8.2 Performance gaps and technological transfer

Irrigation sooner or later failed in many regions of the world either because lack of the essential knowledge for irrigation management or incapability of the available knowledge and technology to survive with the problems was being created Kamara and Mc Cornick (2012). According to Yusuf (2004), farmers in the irrigation scheme cannot just open and close their gates. Farmers who are located closer to the source are over irrigating and the downstream users receive no water, which is the cause of irrigation inefficiency in jemjem too.

A significant amount of knowledge about current irrigation practices and the measures required to improve irrigation efficiency exists in terms of gaps in knowledge, but has not been well transferred to the general public practitioners in the field. The biggest gap therefore, is communicating the knowledge to stakeholders Yusuf (2004). There are four potential kinds of performance gaps that can occur with irrigation systems (Yusuf, 2004).

2.8.2.1. Technological performance gap.

Such type of gaps occur when the infrastructure of an irrigation system lacks the capacity to deliver a given hydraulic performance standard. The normal solution to technology performance gap is to change the type, design or condition of physical infrastructure.

2.8.2.2. When a difference arises between how management procedures are supposed to be implemented and how they are actually implemented

It comprises how people adjust gates, maintain canals and report information. This can be called a gap in implementation performance. A problem of this kind generally requires changes in procedures, supervision or training.

2.8.2.3. A Difference between management targets and actual achievements

Examples of management targets are irrigation efficiency, the size of area served by irrigation in a given season, cropping intensity, water delivery schedules and water fee collection rates. This can be called a gap in achievement. Such problems are generally addressed either by changing the objectives (especially simplifying them) or increasing the capacity of management to achieve them such as through increasing the resources available or reforming organizations.

2.8.2.4. Impacts of management.

It is a difference between what people think and what actually results. These are gaps in impact performance and include such measures as agricultural and economic profitability of irrigated agriculture, water productivity, poverty alleviation and environmental problems such as water logging and salinity. If management procedures are followed and targets are being achieved, but ultimate impacts are not as intended, the problem is not that the managing organization has performed badly, since the effects are generally beyond its direct control. The problem is that the objectives of the organization do not produce the desired impacts. This is more a problem of policy than management.

Furthermore, Tom et al (1999) has discussed on irrigation efficiencies and identified some of the causes of irrigation inefficiencies as follow:

Inefficient use of water – a precious Resource: Sub-optimal use of limited surface water run-off being channeled into small-scale irrigation schemes.

There were two reasons for this inefficient use of water:

-Leakage from unlined canals or from breakages in the canal system; and

-Faulty use of irrigation water (over-watering in flood irrigation regimes).

2.8.3. Effects of hydraulic parameters on conveyance efficiency

Different findings stated that in the canal irrigation system there is insufficient allocation of water, lack of proper and timely regulation of water, poor repair and maintenance of irrigation channels, inefficient use of water, water logging and salinity problems Catterson (1999). According to Horst et. al (2005) cited by Catterson (1999) the causes for low application efficiency were very high advance time, short intervals between irrigations, and excess water application related to extended cut-off times. Moreover, Catterson (1999) specified as the most cause of irrigation inefficiency as canal blockage because of sediment build-up and grass invasion.

2.8.4. Hydrological effect on conveyance efficiency

Temporal distribution characteristics, quality and the quantity of the source of irrigation water have a significant bearing on the irrigation efficiency. Crop water demands are essentially continuous during the growing season, although varied in magnitude. A small, readily available water supply is best utilized in small capacity irrigation system, which incorporates frequent application. The depths applied per irrigation are therefore small in comparison to systems having a large discharge available less frequently Walker (2003).

As no water measurement device at source of supply, water sources for irrigation are often not accurately known because of the different problems such as inaccurate continuous recording of flows that vary with time, undocumented or poorly documented splitting of flows in irrigation canals, poor record keeping, inadequate rain fall records, and inaccurate separation of rain fall from irrigation water (Burt et al.1997).

Since they vary significantly between localities and for specific conditions, it is difficult to give general guidelines on the water requirements of irrigated crops. For instance, heavy soils hold more water than light soils, so that the amount of water to be applied per irrigation and the interval between irrigations is different.

Water consumption by a crop depends on its stage of growth; it is greatest when an actively growing plant canopy completely shades the ground surface, maximizing interception of solar radiation (Burt et al., 1997).

2.8.5. AGRONOMY EFFECT ON CONVEYANCE EFFICIENCY

According to (Bos and Nugteren, 1990), farm size can affect distribution efficiency in which small size farm(less than 3ha) has greater distribution efficiency than large farm (greater than 10ha) because of the possibility of adjusting irrigation intervals in short period for smaller farm.

Scheduling irrigation is more often determined by cultural operations rather than the cultural operations being scheduled by the need for irrigation. Stand establishment, weed control, maintenance of crop vigor, control of disease, and seedbed preparation are agronomic considerations that impact irrigation system performance and need to be considered in an evaluation (JM Lord and James, 2000).

2.9. DISCHARGE MEASURING STRUCTURES

There are so many structures used to measure discharge in the literature. The descriptions of the following structures are taken from Garg (2005).

2.9.1. NOTCHES

Notches or gauge plates are constructed from thick metal plates, and used in laboratory and to measure small streams in the field. Notches have triangular (v) and rectangular types.

A v notch weir is used to meter flow in an open channel. The v notch weir is very good for measuring a low flow rate of open channel flow. The head over the v notch is measured and correlated with flow rate through the open channel. A v notch weir equation will give the open channel flow rate.

The name for a v notch weir is very descriptive, as you can see in the picture and diagrams in the next couple of sections. A v notch weir is simply a 'v notch' in a plate that is placed so that it obstructs an open channel flow, causing the water to flow over the v notch. It is used to meter flow of water in the channel, by measuring the head of water over the v notch crest. The v notch weir is especially good for measuring a low flow rate, because the flow area decreases rapidly as the head over the v notch gets small. The upper edge of the section is always above the water level, so the channel is always triangular simplifying calculation of the cross-sectional area. Under laboratory conditions, V-notch weirs typically achieve accuracies of 2% to 5%, while field condition accuracies from 5% to 15% may be expected weir equations are discussed in the next two sections. The diagram at the left shows some parameters and terminology used with a sharp crested weir for open channel flow rate measurement.

The head over the weir is shown as H in the diagram; the height of the weir crest is shown as P; and the open channel flow rate or discharge is shown as Q.

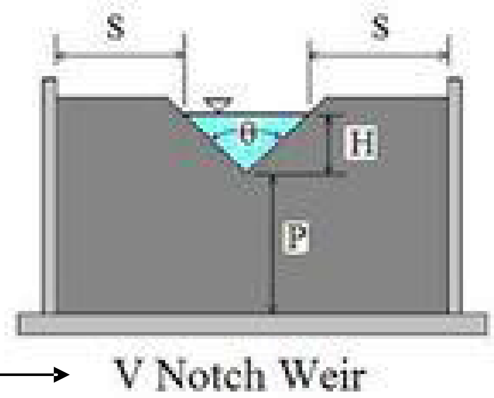


Fig 2.1 V-notch weir

Fig 2.2 Front view of v-notch

2.9.1.1 Fully contracted, 90 degree, v notch weir equation

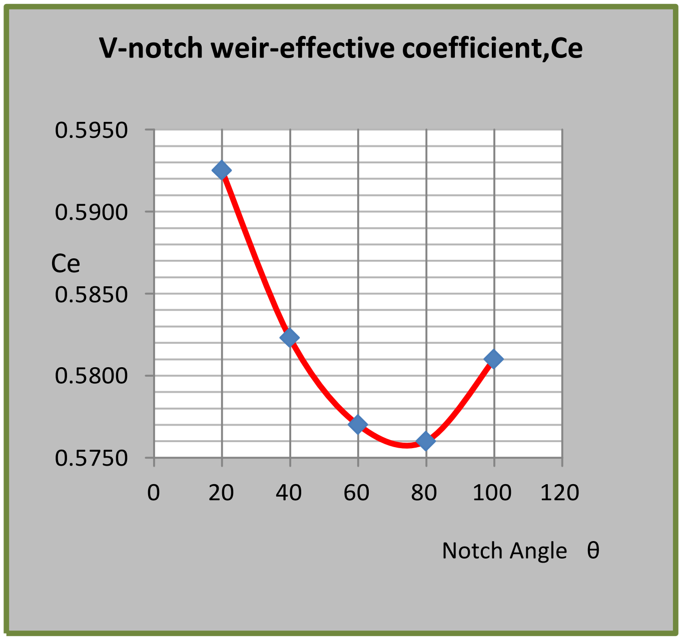
The equation recommended by the Bureau of Reclamation in their *Water Measurement Manual,* for use with a fully contracted, 90^o, v notch, sharp crested weir with free flow conditions and 0.2 ft $\leq$ H $\leq$ 1.25 ft, is: $Q = 2.49H^{2.48}$, where Q is discharge in cfs and H is head over the weir in ft. The conditions for the v notch weir to be fully contracted are: $P \geq 2H_{max}$, $S \geq 2H_{max}$. The diagram at the left shows the parameters H, P, θ and S for a v notch weir as used for open channel flow rate measurement.(see fig 2.3 above)

2.9.1.2. V-Notch weir equation for notch angle other than 90 degrees

For notch angles other than 90^o, the Kindsvater-Carter equation, as given below, from the Bureau of Reclamation, Water Measurement Manual, should be used.

That equation is: $Q = 4.28\ C_e\ \text{Tan}\ (\theta/2)(H + k)^{5/2}$, where Q and H are as previously defined, θ is the angle of the v notch, C_e is the effective discharge coefficient, and k is a head correction factor. The diagram at the left is a graph of C_e as a function of notch angle, θ, and the diagram at the right gives k as a function of θ.

(Written by:Harlan Bengtson. edited by:Lamar Stonecypheer. updated:9/9/2010)



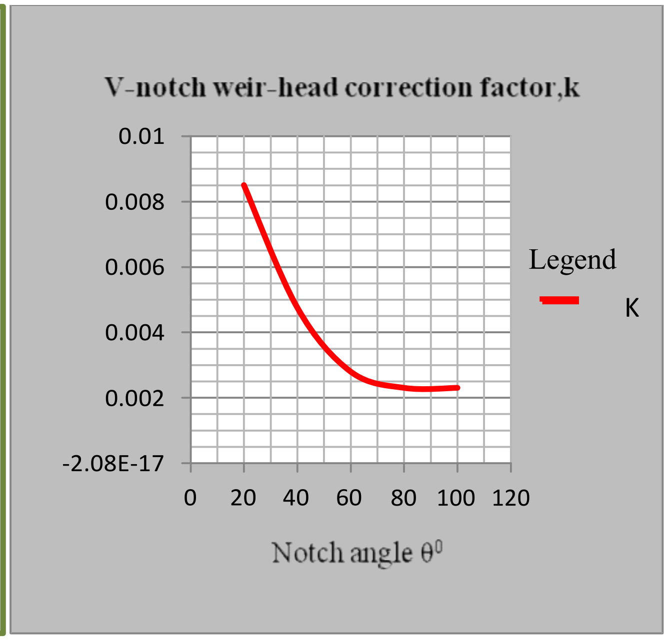


Fig 2.3 Ce gragh of v-notch

Fig2.4 K head correction factor

Source: (written by:Harlan Bengtson. edited by:Lamar Stonecypheer. updated:9/9/2010)

2.9.2. Concrete or masonry weirs

The weirs should be used for measuring discharges with head less than 0.066 m and 0.3 m of the minimum length of the weir in open channels. The discharge values obtained by weir measurements vary from 95%- 105% of the true discharges.

2.9.3. Control meters or standing wave flumes

A control meter is a structure, which is constructed across a stream; by which critical depth can be produced by changing a subcritical channel flow into super critical flow, and vice versa. The throat is produced either in rectangular or trapezoidal in which the floor of the throat produced is level.

2.9.4. Parshall flume

Parshall flume is a type of constricted standing wave flume widely used for discharge measurement.

2.9.5. Current meters

A current meter is the best instrument for measuring the velocity of a natural stream, and generally and universally adopted for this purpose.

2.10. SMALL-SCALE IRRIGATION INVOLVEMENT

Involvements into existing small-scale irrigation systems cannot be done effectively except the existing farming system is taken into consideration. If small-scale irrigation is to make a significant and affirmative contribution for people, it is crucial that it fits into their livelihood systems (Guijt and Thompson 1994). Practices of countries that have had successful small-scale irrigation show that such systems have very often developed as part of the original farming system (Carter 1989).

3. MATERIALS AND METHODS

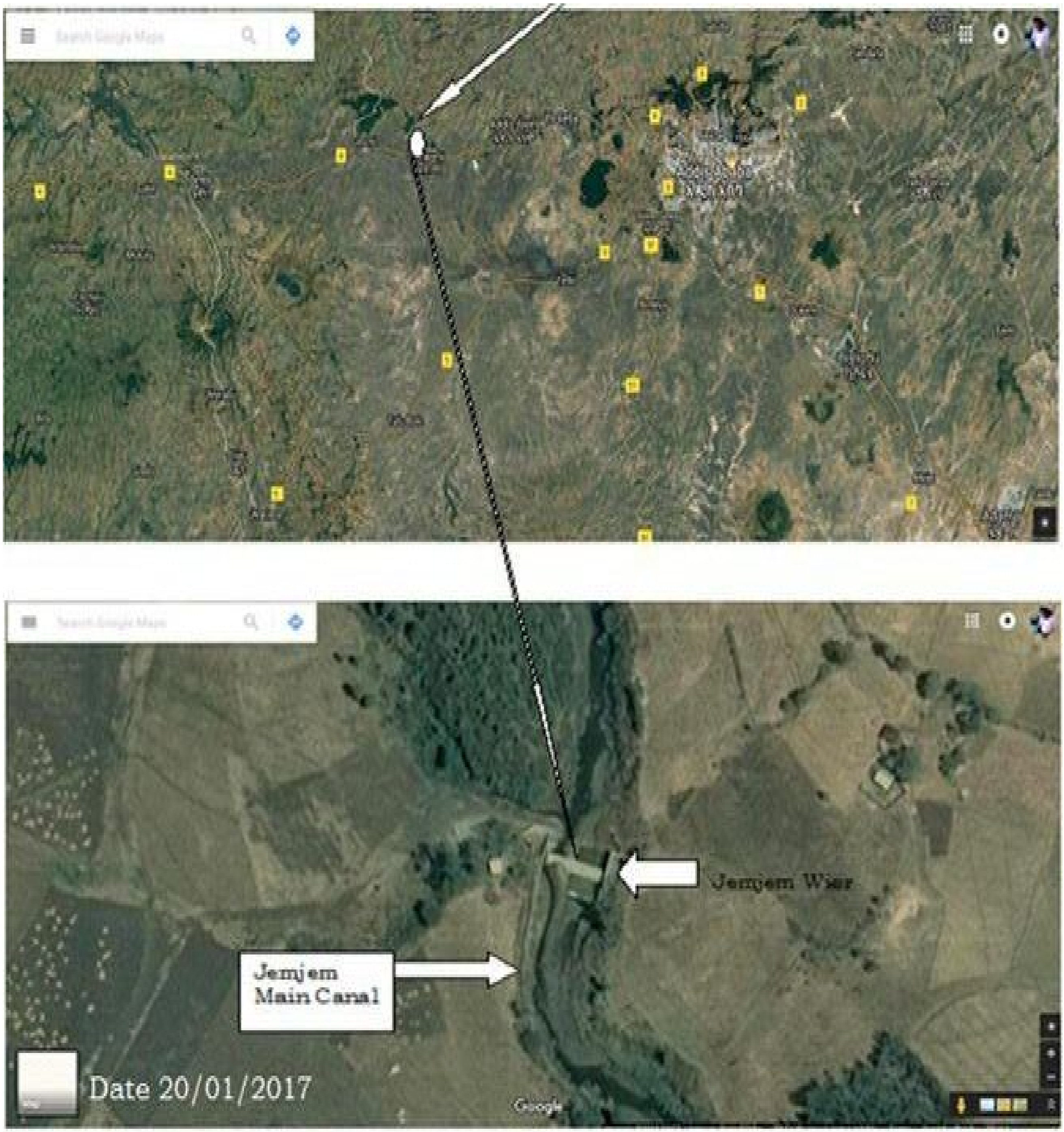
3.1 LOCATION AND DESCRIPTION OF THE STUDY AREA

TABLE 3.1 IMPORTANT FEATURES OF THE STUDY AREA

ACTIVITIES OR FEATURES	DESCRIPTION
Name of the project	Jemjem irrigation project
Region / Zone / District	Oromia /west Shoa /Ejersa Lefo woreda
Location coordinate	$9^0$0'-$9^0$3' North and $38^0$14' -$38^0$15' East
Altitude of command Area	2160m asl
Average annual rainfall	1180 mm
Net Command Area	130 hectares
Source of water	Jemjem River
Irrigation Duty	2.8 liters /second /hectare
Irrigation crops	-Onion -garlic -Cabbage -B/root -Peppers
Main canal	3250m earthen
Number/length of secondary canal	5/11070(total)
Cut off (main drain)	3250m
Division box	5 in number
Turnouts	77 in number
Field-off takes	15 in number
Drops	118 in number
Aqueduct	4 in number
Pipe culverts	5 in number
Diverted water discharge	0.364m3/sec

Source: Feasibility study document (July, 2012)

...continued



Source= google earth ,Lcation of the weir is N0902.768,E03814.758
Elevation =2205m ASL

Fig.3.1 Shows top view of Jemjem weir by Google earth

...continue

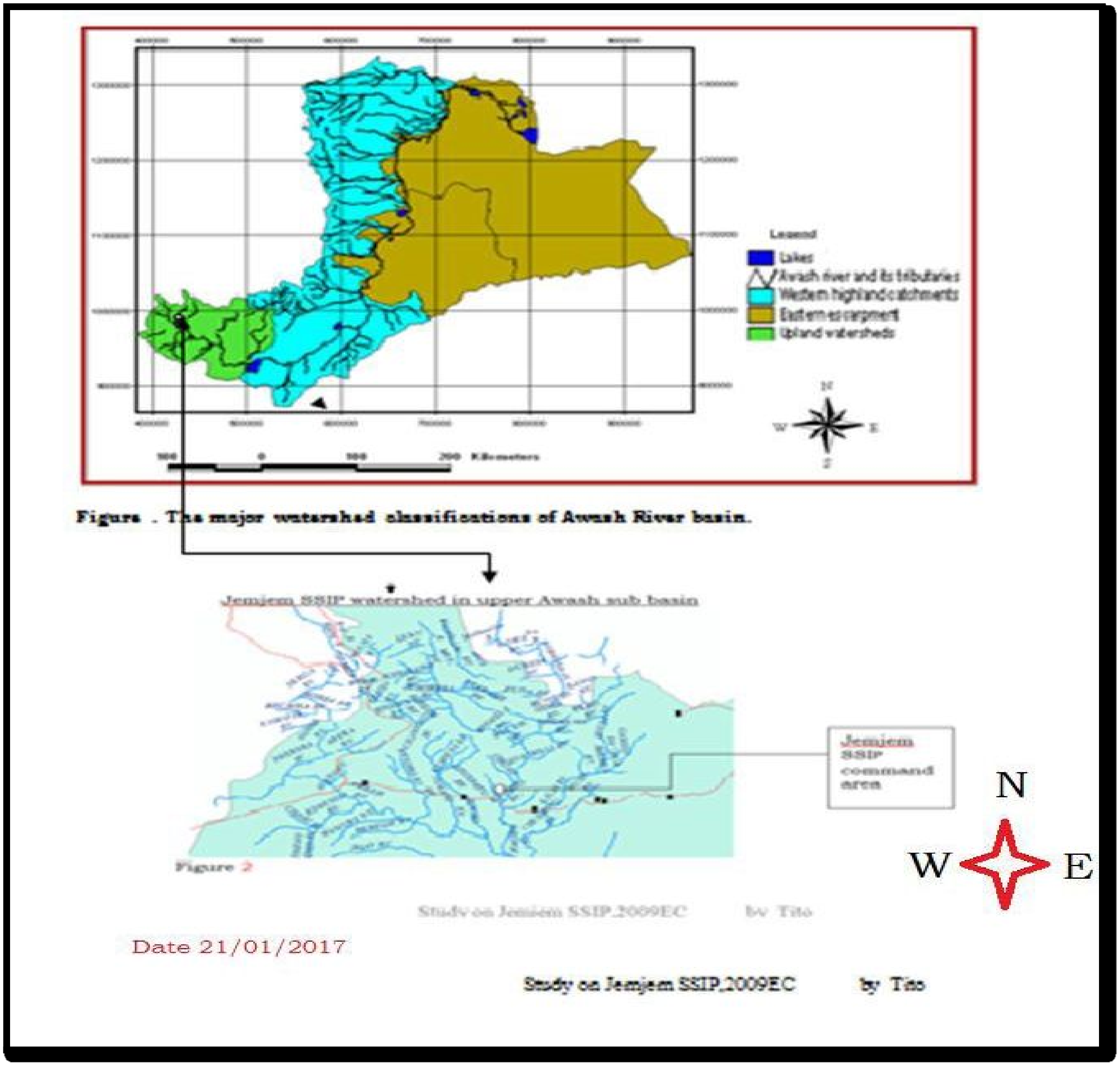


Fig 3.2 The major watershed classifications of Awash River basin and Jemjem location.

3.1.1 WATER RESOURCES OF THE JEMJEM RIVER

According to Taddese et al (2000), Plateaus over 2500 m receive 1400-18000 mm/yr, mid-altitude regions (600-2500 m) receive 1000-1400 mm/yr, and lowlands get less than 200 mm/yr. The rainfall distribution, especially in the highland areas is bimodal, with a short rainy season in March, April and the main rains from June to September. Jemjem which is in mid altitude has water source from valleys having springs like Danisa, Bereda, Meti Legebatu and Welase carry water the whole year, while 22 springs only function during the rainy seasons. Mean annual temperature range from **$11.7c^{o}$ to 22_{C}^{0}** in June. The mean annual stream flow is **2.03** m^3/s. Total means annual water resources of the Jemjem River shed amounts to some **64 Mm3** of which some **1.3Mm3** is currently utilized, the balance being largely lost to Awash River and elsewhere in the ground system. The designed amount of water for Jemjem Command area is diverted in to the main canal by the weir shown by fig 3.3 bellow.

Fig 3.3 Jemjem SSIP weir view from down stream

The Upper Awash Basin and its major tributaries have been subjected to major environmental stress. The demand for natural resources by the high and fast growing population remains a major challenge to effective agricultural and forestland management. The high pressure on forest resources in particular, has led to the exploitation of fragile watersheds and ecosystems that have resulted in loss of vegetation and subsequent soil erosion in the lower part of the Awash River Basin (Taddese et al, 2000).

3.1.2 Hydrological description of Jemjem river

Diagnosis and opportunities (2006) described the pivotal role of Hydrology in erosion, land degradation, reduced soil fertility and productivity, and siltation. According to it, Ethiopia's high intensity storms cause significant erosion. The erosive effects of rainfall are significantly augmented or increased by Ethiopia‟s mountainous terrain, severe deforestation, and traditional agricultural practices of cultivating steep slopes without protective measures. The loss of forest cover, in turn, is generally associated with greater hydrological variability. **Jemjem River catchment has five main valleys such as Goro, Gora, Goba, Korriso and Legebatu which have** p**erennial streams.** They cover around land area of **60** square kilometer and serves as home to more than15 thousand peoples. The highland part of the catchment is adjacent to the state forest known as Chilimo which has good cover and high rainfall. The monthly mean river flow depends upon the availability of rain in the catchment and the rain in turn depends upon the sustainability of good land cover and land use system.

3.1.3 Climatic conditions of Jemjem area

Rainfall patterns in parts of Western regions exhibit distinct bimodal distribution. The first rains fall between mid-March and the end of May and are locally known as the short rains. The second rains, the long rains, are received between mid May and the end of October. Average seasonal rainfall is between 920-1180 mm. Temperature ranges between10.2-25 ^{0}C. Jemjem division rainfall distribution is bimodal with peaks from July to September (long rains), and March to May (short rains). Annual rainfall varies from about 800mm at an altitude of about 2160m above sea level (ASL). The temperature is high at the lower altitudes ranging from 25^{0}C to 30 ^{o}C but reduces to between 10.2 and 20 ^{o}C towards the higher altitudes of 2700m ASL. Mean annual evapo-transpiration which is 1445mm Jemjem division exceeds the rainfall.

The equation is done based on the Pennman-Monteith formula given on FAO Irrigation and Drainage Paper # 24. And the necessary climatic data were taken from the computer retrieve as in the following table.

TABLE 3.2: JEMJEM AREA CLIMATE DATA 1

Months	Min.Temp. ^{O}c	Max.Temp. ^{O}c	R.H (%)	Wind speed (km/hr)	Sunshine hr/day	Radiation (MJ/M2/day)	ET(mm/day)
J	11.2	26.3	53	130	8.3	19.7	**4.0**
F	12.1	27.4	49	147	7.9	20.3	**4.5**
Mar	12.8	27.2	50	147	7.3	20.6	**4.7**
AP	12.7	26.5	58	138	7.2	20.6	**4.6**
May	12.4	24.6	63	130	6.3	18.8	**4.1**
J	11.7	22.0	78	95	4.9	16.3	**3.3**
J	12.2	23.3	89	104	2.9	13.4	**2.6**
Aug	11.9	23.5	90	95	8.5	22.2	**3.8**
S	11.1	25.0	83	104	4.8	16.7	**3.2**
O	10.7	25.1	60	156	7.8	20.5	**4.3**
	10.2	25.5	49	147	9.1	21.2	**4.3**
	10.3	**25.5**	**55**	**147**	**9.1**	**20.3**	**4.1**

Highlighted color Represents the highest value

Source is feasibility study document (July, 2012)

3.1.4 SOIL CONDITIONS OF COMMAND AREA

Moisture contents of the soils of the selected irrigation fields before and after irrigations was planned to determine by taking soil samples at different depths of the profiles. As the data obtained from Jemjem project feasibility study indicated, from the given analysis result**, PH** showed somewhat alkaline behavior **(**>7) and especially the lower horizon is approaching its alkalinity condition**. E.C** is almost negligible and there is no any hazardous condition in the future irrigation development. **O.M** and **T.N** show low to fair distribution but still they are not adequate and need treatments. In case of **soil texture**, clay is dominant and is somewhat difficult in workability.

3.1.5 PROPOSED AGRICULTURE (IRRIGATION)

Crops are selected based mainly on the existing climatic condition, soil type and other related situations. Thus, accordingly, the following crops are selected (Proposed) for irrigation development

TABLE 3.3 PROPOSED AGRICULTURE (IRRIGATION)

Crops	Sowing/ Planting date	Harvesting date	Total/base Period (days)	Area (Ha)	Varieties
Onions	Nov.1	Mar.17	122	50	Adama red
cabbage	Jan.1	Apr.1	90	15	Copenhagen
Peppers	Dec.1	Apr.1	90	35	Chilli,Local
Carrot	Dec.1	Apr.1	90	15	Nantus
B/root	Dec.1	Apr.1	90	15	Detroit

Source, Feasibility study document (July, 2012)

TABLE 3.4 ACTUAL AGRICULTURE (IRRIGATION) DURING THE STUDY(EXCEPT THE *)

Crops	*Sowing/ Planting date	Harvesting date	*Total/base period (days)	*Planned Area (Ha)	Duty (lit/sec) /ha	Measured Area (Ha)	Demand (lit/sec)	Remark
Onions	Nov.1	Mar.17	122	50	0.5	11.5	5.75	
cabbage	Jan.1	Apr.1	90	15	0.5	3.75	1.875	
Peppers	Dec.1	Apr.1	90	35	0.5	2.375	1.1875	
Carrot	Dec.1	Apr.1	90	15	0.5	0	0	
Garlic	Dec.1	Apr.1	90	15	0.5	8.25	4.125	
B/root	Dec.1	Apr.1	90	0	0.5	2.75	1.375	
Tomatoes	Dec.1	Apr.1	90	0	0.5	8.5	4.25	
potatoes	1-Mar	1-Jun	90	0	1.45	1.125	1.63125	
Maize	1-Mar	1-Jun	90	0	1.76	0.125	0.22	
			Total	130		38.4	20.41	
				Cultivated land		36.6		
				Total land under farm		75		
				Percent Crop on the field		29.54%		

*source, Ejersa Lefo District Irrigation Authority report

3.1.6. ECONOMIC BASES OF THE PROJECT AREA

Agriculture is the base for Jemjem area community. The pasturages in the area depend on open grazing in as natural range or a source of feed for their livestock. The availability of the natural pasture is determined by the intensity and distribution of rain fall in the range through crop production which accounts large percent of the livelihood and the prevailing society were largely governed. Animals like cattle sheep, Goat, donkey and mule are reared widely. Crop production is also complimentary to animal rearing. Because of its perennial nature, animal and human drinking is this River. Crop types like maize, Teff, Wheat, H. Bean are produced. (Source, feasibility study)

Generally according to data from the P.A, informant beneficiary farmers and field observation, we can conclude that their Economic base is agriculture, which is mainly crop production and supplemented by animal rearing. (source: Feasibility study)

3.1.7. LAND USE AND LAND TENURE

According to the data obtained from district agriculture and rural development office the total land area of the project area is about 1600 Ha. The land use classification indicates that the project area is used for agriculture, forest, grazing which indicate that this main economic base, animal production based on range grazing. The theoretical land use classification of Jemjem peasant association is shown as indicated in the following

Table.3.5 Land use land cover 1

. No	Description	Area in ha.	Coverage %
1	Cultivated land	1029	64.3
2	Forest Land shrubs	122	7.6
3	Grazing land	366	22.8
4	settlement	83	5.19
	Total	1600	100

Source:-feasibility study of the project (July, 2012)

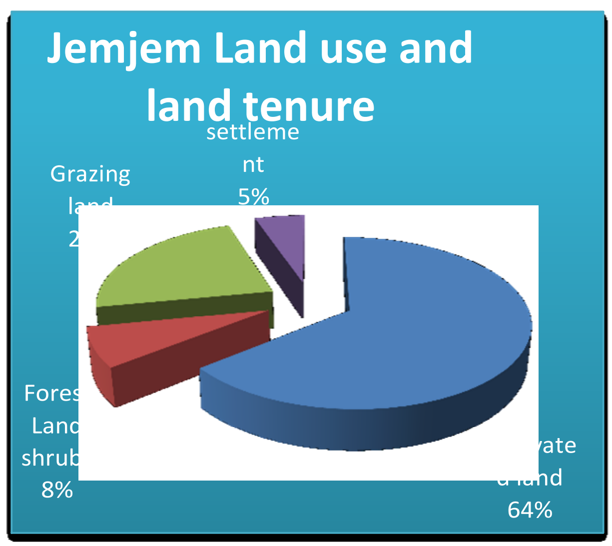


Fig 3.4 land use land cover

3.1.8 JEMJEM IRRIGATION SCHEME

The method of water abstraction is gravity diversion. **Jemjem** is a semi-arid region. Currently however, schemes those were operative under the communities or private developers in the surrounding areas growing mainly onion, tomatoes and Garlic. However, large areas of irrigable land have been left uncultivated. The reasons behind these are; absence of maintenances of broken canals, and a lack of capacity at water committee to implement and control water management. It is planned to irrigate about 130 hectares of land for smallholder farmers and more than 75 hectares of land have been irrigated so far. By now the **Jemjem River** is not as good as overcommitted and has no scope for further development. Water is pumped from **the** River downstream of the weir through different pumping stations located along the river and some out off the command area is fed from this pumping station through earthen canal system. Pumps run intermittently to store pond water in the river, which are installed at different locations in the river, and the lands out off planned area are irrigated partly from the water supplied directly by the pumps.

3.1.8.1 Conveyance efficiency of the main canal

3.1.8.1.1 General description of the main canal

This section deals with the analysis of conveyance efficiency of major canal from head to tail. **Jemjem** was designed and constructed to take maximum of 0.364 m3/sec of water from the river by Diversion Weir about **4 km** upstream of **Jemjem bridge** of main As**phalt road laid Addis Ababa to Ambo** (check figure3.3). (Source is feasibility study document).

The design report written by Oromia water, mineral and energy Bureau design team describes that the diverted irrigation water is conveyed through the Main Canal of total length about 3.25km. At 1.12km a secondary Canal (SC -I) bifurcates towards the Shuma-1 area and the other secondary Canal-II (SC-II) going towards Shuma-2 after 700m .The designed discharge of secondary Canal-I and secondary canal-II were 0.026m3/sec and 0.02m3/sec respectively. With the allotted discharge of 0.364m3/sec about 130 hectares of the command areas located in **Jemjem** can be irrigated. (see fig3.3)

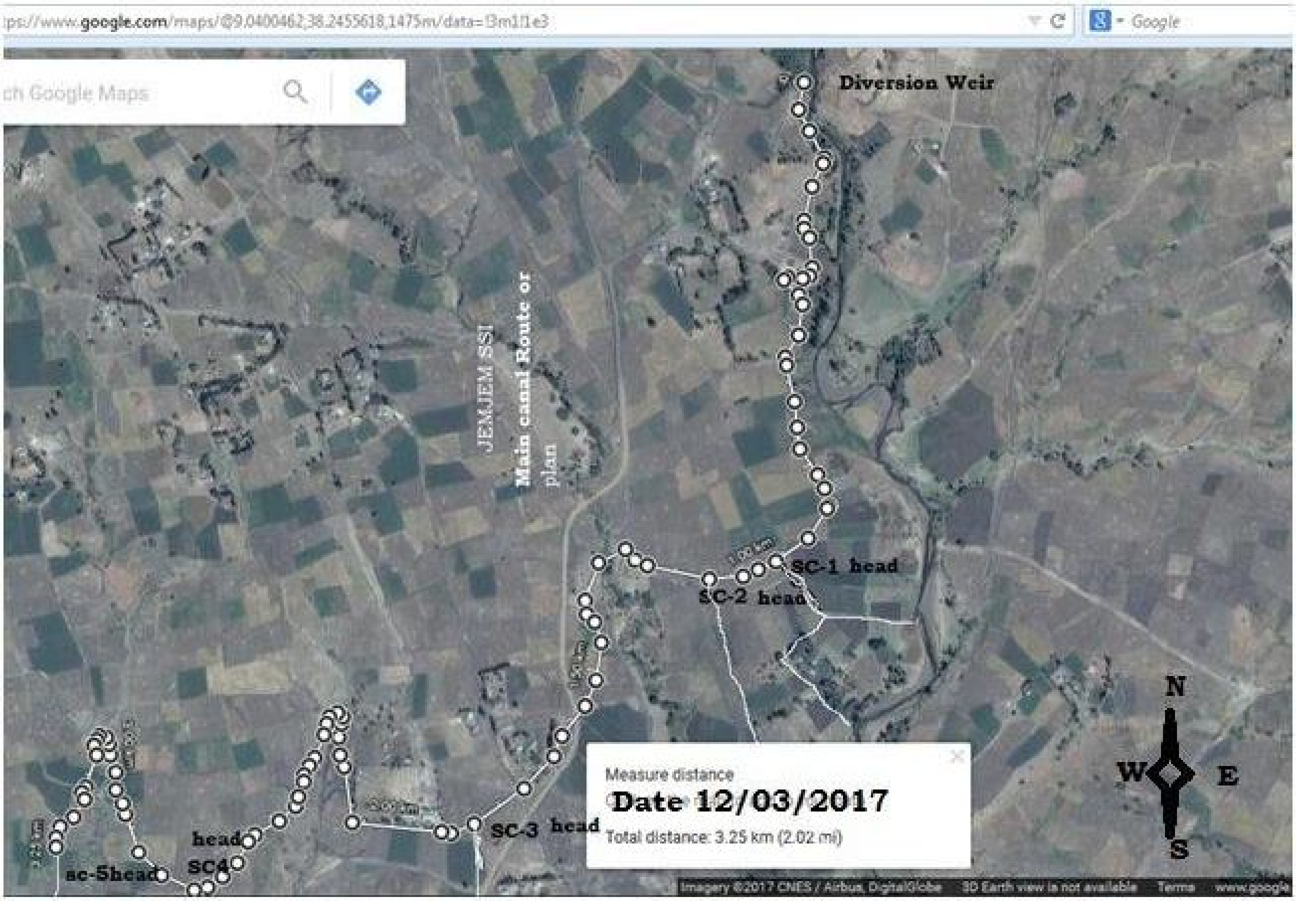


Figure 3.5.Main canal Plan view from Google map

However, while the research carried out, the discharge released from the weir was 0.041m3/s and the total command area developed was estimated to **75ha (see table 3.4)**. Irrigation water from **Jemjem** River was conveyed and distributed to the farms through a network of canals by gravity for all of the command areas except Yubdo.

3.1.8.1.2 Geology of the main canal

The Geological formation of the canal route of 3.25 km investigation was made by field observation on the soil trench excavated during the construction of the project and compared with table (Material description along the main canal line at **Jemjem**) obtained from agronomy report of the project design. The regional geology of the project area is related with Alkaline and transitional basalts. The top part of the catchment and the project area is covered by **dark brown to reddish brown, friable, loose and unconsolidated clay soil**.

3.1.8.1.3 Main canal route litho logs and description

The main canal route of the project was made based on visual observation and test pitting at the selected area

Table 3.6 Geological description of the main canal route

Test pit designated	Pit location (chainage)	Total depth (m)	Litho logs and Description	Remark
TP_1	060	0-1.80	0-1.80 dark to brown clay	Water tight
TP2	080	0-1.50	0-1.50 dark to brown clay	Water tight

Source; Feasibility study (July, 2012)

3.1.8.1.4. Type and shape of the canal

There are two types of Canals, earthen and lined canals. Starting from the weir to 200m distance the canal **shape** is rectangular which was constructed from concrete. In the remaining areas, the earthen canal constructed differ in sections and trapezoidal shaped with side slope of 1.5 H x 1 V was adopted.

Table 3.7 Chainage of the main canal 1

Item no.	Canal name	Chainage (km)	
		From	To
1	Lined Main canal	0+000	0+200
2	**Main canal after 200m Lined canal**	**0+200**	**3+250**
2.1	Branch of Secondary canal-1	0+200	1+120
2.2	Branch of Secondary canal-2	1+120	1+820
2.3	Branch of Secondary canal-3	1+820	2+020
2.4	Branch of Secondary canal-4	2+020	2+890 non functional
2.5	Branch of Secondary canal-5	2+890	3+250 non functional

Source: Item1-2.5 from Feasibility study document (2012G.C) and all checked by survey (2017GC)

3.1.8.1.5 Discharge capacity of the main canal

The main canal off taking from the diversion weir and serving the command areas was designed and constructed for 24-hour continuous flow. The total length covers 3.25 km. For the purpose of accessibility and canal capacity, the canal up to secondary canal-5 has been divided in to five reaches:

From the head regulator to about 1.12 Km in shuma-1 village

From 1.12 Km to1.82 km at shuma-2 village

From 1.82 km to 2.02 km at shuma-2 village (Ature and Sidama villages)

From 2.02 km to 2.89 km at Yubdo(Ada′a-1) and the last reach is from 2.89 km to 3.25 km to Yubdo(Ada′a-2) command areas. See table 3.7 below

The designed canal discharge capacity varies within the canal stretch, 0.364m3/sec, 0.338m3/sec, 0.318m3/sec and 0.156 m3/sec for different sections within 2.02 km to convey irrigation water to the command areas located south of the main canal which is laid from North east to South west. However, the discharges measured at these sections during the research were 0.041m3/sec, 0.038m3/sec, 0.024m3/sec and 0.0143 m3/sec respectively. Due hydraulic and hydrologic characteristic changes water loss by seepage and evaporation were 0.32lit/sec and 3.01lit/sec per each month respectively.

Table 3.8.Designed distribution system of Jemjem SSIP Irrigation water

Canal	Canal Chainage	Q (m^3/Sec)	V (m/s)	n	m	s	b	d	D
MC	3+250	0.364	0.56	0.025	1.5	0.0010	0.59	0.49	0.8
SC-1	1+120	0.026	0.31	0.025	1.5	0.0013	0.3	0.16	0.41
SC-2	1+820	0.02	0.27	0.025	1.5	0.0013	0.5	0.11	0.36
SC-3	2+020	0.162	0.48	0.025	1.5	0.0013	0.75	0.29	0.54
SC -4	2+860	0.028	0.3	0.025	1.5	0.0013	0.5	0.13	0.38
SC-5	3+250	0.067	0.38	0.025	1.5	0.0013	0.5	0.22	0.47
TC-1	1+370	0.025	0.35	0.025	1.5	0.0020	0.35	0.13	0.36

Source,-feasibility study (July, 2012)

3.2. Materials Used

The materials used were stationeries, interview questions, GPS, 90^0 V-notch Weir, digital camera, water level, 100m string, plum pop, three straight poles and roll meter for observation studies. After all these preparations were finished, travelling to the proposed site or agencies was conducted and at the project site observational studies took place and in an office questionnaires and interviewing were followed.

3.3 Methodologies Used for Data Collection

Both quantitative and qualitative research approach has been applied in collecting and analyzing data.

3.3.1. PRIMARY DATA COLLECTION METHODOLOGIES

The data collection was started in March 2017. The first activity done was frequent field observations in order to get the general insight of irrigation project. By that time, Water Use Committee, Professional staffs of the district and some farmers were consulted about water use practices, highlight of the status of the projects and inefficiencies encountered. Based on the first data collected, data check list was revised; best questionnaires were prepared for the next field survey. The data collected include canal longitudinal and side slopes, volume of water at different points starting from main canal inlet to the end of main canal, interview data of water users and other groups like wereda staff members, counted number of each type of structures (see table 4.1) with their defects noted and measured data of command area under irrigation (see table 3.4).

3.2.2. SECONDARY DATA COLLECTION METHODOLOGIES

Secondary sources kept by the responsible bodies or officials at the irrigation project, at Woreda Agricultural Office, at Irrigation Office at Regional, Zonal, and Central level was collected as much as possible. Based on the questionnaire developed interview was made to get the perception of the farmers about the water distribution within the project. Much effort has been spent through survey and observations of different documents at different places to check the reliability and consistency of these data.

Climatic data only rainfall of the site was collected from the National Metrological Service Agency. Rivers flow data was collected from Ministry of water irrigation and electricity. The design document of the irrigation project was collected from the sponsor organization (AGP) and used as a source of information on the different data of the irrigation project. For this end, qualitative and quantitative, some primary and secondary data was captured through a combination of Site survey and different level sector visit.

Generally the study involves the following procedures

- Collection of relevant data such as:
  - Metrological data of the selected stations(daily rainfall),
  - Hydrological data(daily flow records) of the key hydrological stations,
  - Soil and land use land cover data of the catchment,
  - Irrigation and ecological flow demand data,
- Flow data analysis:
  - In-filling missing records using excel software,

Measuring flow volume at different points of the main canal reach using 90^0 v-notch weir to calculate water loss and canal conveyance efficiency using the formula, $\eta_c = (Q_o/Q_I) \times 100$

Where: η_c is conveyance efficiency

Q_o is discharge measured at outlet of canal

Q_I is discharge measured at inlet of canal

- Calculating Manning's roughness (n) using the formula, $n = \frac{A(3\sqrt{R}\overline{2\ S}}{Q}$

  Where: A is cross sectional area of the canal

  R is hydraulic radius of the canal

  S is longitudinal slope is the canal bed , side slopes and comparing with designed values using measured main canal dimensions to evaluate an effect on canal dimensions and conveyance efficiency changes.

- Estimation of the main canal evaporation loss using the energy balance method, i.e.

  E=1000(Rn-Hs-G)/(Lv*gw) Where: E is evaporation in lit/s,

  Lv is latent heat of vaporization in KJ/kg,

  Rn is net radiation flux in W/m2,

  Hs sensible heat flux in KJ/kg,

  G ground heat flux in KJ/kg, is density of water in Kg/m3

  Assuming Hs and G being zero, E =1000*R/**(Lv*gw) where,** **Lv= Rn -2.36*T^oc**

- Estimation of the main canal seepage loss using the Kostiakov A.N. Formula (empirical formula)

  S=s* L Q/100 Where: - S: Water losses per Km of canal length (in %).

  L: Length of canal (Km).

  Q: Water flow in (m3/s).

  s: Water loss by seepage (% per Km), given by: **s = A1/Q^M**

Where A1 and M are empirical constants depends on **soil permeability** as shown in Table (4.9).

Table 3.9 Values of constants A1 and M (Abu Gulul,1975)

	Soil permeability		
Empirical constants	Low	Medium	High
A1	0.7	1.9	3.4
M	0.3	0.4	0.5

- Evaluating structural performances using indicators to specify the existence of structural failures i.e. the ratio of the number of functional similar structures to number constructed similar structures.

- Measuring command area cultivated, irrigated, and covered with crops to estimate existing crop water requirement.
- Interviewing water users, Wereda staff members and funding agents to gather their perceptions about Jemjem SSIP water management issue to relate with loss of water due to mismanagement.
- Summarizing different forms of water losses from the main canal and estimating: the extent of water loss, its reason for loss, responsible body for these losses and finally recommend the better way of irrigation management that helps to increase production.

4. RESULTS AND DISCUSSIONS

In this section, results and discussion obtained from the analysis of different data collected are presented for the Jemjem scheme. (Source; field survey)

4.1. PERFORMANCE OF IRRIGATION STRUCTURES

Irrigation performance relates the number of structurally functional schemes to total numbers of schemes implemented during the period. Table 4.1 shows functional and nonfunctional structures of the scheme and the calculated percentage of each functional structure visited during 2017G.C. Accordingly, the lined main canal which is **200m** long conveys 40lit/sec water and therefore performance is 97.6% with considering the canal leakage near the weir which is estimated to be **1 lit/sec**.

Table 4.1 Structural Performance Of Jemjem SIIP

Type of the Structure	Size of Designed structures	Functional system	Non Functional system	Perfor mance In 100%	Remark
Main canal	200m lined	200m	0	100	But Leakage observed near the Weir is unaccounted
	3050m earthen	1820m	1230m	59.67	closed and ploughed ,Overflow, breakage, and filled with soil are observed at some places
Number/length of Secondary canal	5 in number	3	2	60.00	
	11,070m in length	6642m	4428m	60.00	
Division box	5 in number	3	2	60.00	But All division boxes have no flow control gates
Turnouts	77 in number	13	64	16.88	
Field-off takes	15 in number	10	5	66.67	For Small plots near the river
Drops	118 in number	39	79	24.58	But Some are partially damaged
Aqueduct	4 in number	2	2	50.00	One of the non functional part is totally destructed by sabotage
Flume	2 in number	1	1	50.00	The non functional part is cracked and may be destructed in short time
Pipe culverts	5 in number	4	**1**	80.00	
Overall Structural performance is estimated to be				**57.07%**	

The earthen main canal in functional part has different defects such as canal overtopping, leakage through gates, of division box, gate closed with mud, canal filled with mud and grasses grown in the canal. Similarly, the earthen main canal in nonfunctional part has different defects such as canal breakage, canal and division boxes filled with soil and canal closed and ploughed by farmers. The secondary canals are five in number for which three are functional and after the 3rd secondary canal two secondary canals are non-functional since the canal broken at one point. Their total length is **11,070m** of which **6,642m** is functional and the rest including **137m** tertiary canal was nonfunctional. The functional secondary canals itself has no water control gates on their turn outs similar to the main canal division boxes which were a cause for water wastage that is flowing through canal and return back to the river without purpose. The secondary canals which totally have length of **4,428m** are found in the broken part of the Main Canal and therefore nonfunctional.

All division boxes and turn outs are without gates. Drops within the functional system were operating good except some cracks seen on some drops and those under nonfunctional system some were buried under the soil. Four aqueducts were constructed of which 2 are within the functional system and the remaining two are within nonfunctional system. One of the aqueducts of non functional part is totally destructed by violator. Generally, the scheme structural performance is found to be **57.07%** as the analysis observed in the table 4.1 above

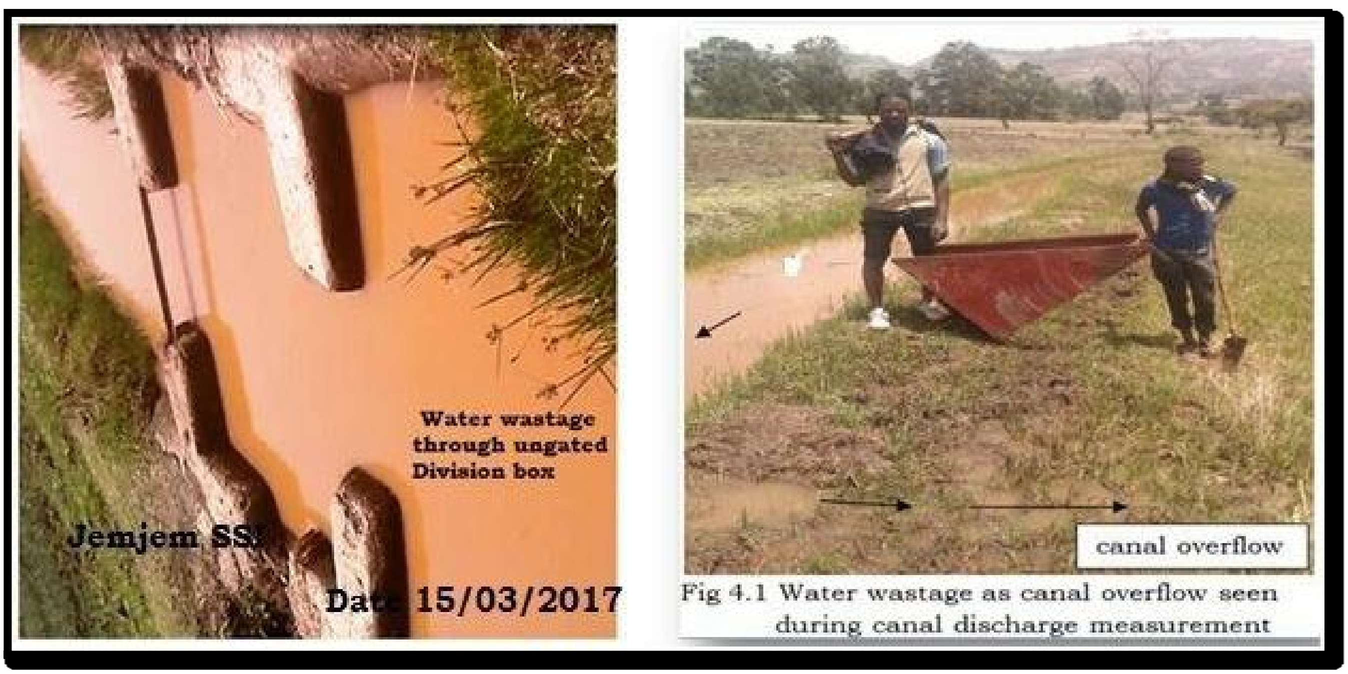


Fig 4.1 Shows water wastage through division box and canal overflow

4.1.2 DETERMINATION OF AMOUNT OF WATER THAT PASS THROUGH THE MAIN CANAL

To determine the amount of water passing through the canal i.e. Q1=0.041m3/sec, Q2=0.038m3/s, Q3=0.024m3/sec, and Q4=0.0143m3/sec, a **90^0 v-notch** weir was installed at different points along the route and frequent readings were taken. During the determination of the amount of water that is passing through the canal, measuring from downstream to upward along the canal was undertaken to avoid repeated flow measurement and to release water to water users remained back of the measuring point but named Q1, Q2, Q3 and Q4 from diversion head to end of the canal.

4.1.2.2 Conveyance efficiency of the main canal

The conveyance efficiency of the main canal in three intervals is 0.93 * 0.63 and 0.60. Conveyance efficiency of 0.93 is the efficiency before the start of the secondary canal-1that is 1.12km from the weir which is obtained dividing 0.038 m3/s by 0.041 m3/s while conveyance efficiency of **0.63** is the efficiency from the secondary canal-1to secondary canal-2 which is 700m from secondary canal-1 and **0.60** is the efficiency from the start of the secondary canal-2 to the secondary canal-3 head 200m distance which is obtained dividing 0.024 m3/s by 0.038 m3/s and 0.0143 m3/s by 0.024 m3/s respectively.

Table .4.2 Summary of major conveyance system of main measured by 90 v-notch

SN	Discharge at 200m from the weir		Discharge at SC-1 from the weir		Discharge at SC-2 from the weir		Discharge at SC-3 from the weir		Remark
	H(m) 90^0 v-notch	Q1 (m3/sec)	H(m) 90^0 v-notch	Q2 m3/sec)	H(m) 90^0 v-notch	Q3 (m3/sec)	H(m) 90^0 v-notch	Q4 (m3/sec)	Overall efficiency (0.014/0.041)*100 is **34.9**%
1	0.245	0.041	0.237	0.038	0.196	0.024	0.160	0.0143	
Conveyance efficiency from weir-sc1 (0.038/0.041)*100 is 92.70% -lined canal									
Conveyance efficiency from sc1-sc2 (0.024/0.038)*100 is 63.2%-earthen canal									
Conveyance efficiency from sc2-sc3 (0.0143/0.024)*100 is 59.6%-earthen canal									

The overall efficiency of the main canal has found to be 34.9% as calculated in the table above. Similarly (**Adam T., 2013),** Hydraulic and Hydrologic Factors on Conveyance Efficiency: Case of Fentale and Tibila Irrigation Schemes was showed that efficiency calculated was 34.4% for Fentale and it was much lower than the standard value 95% taken during the design. But for Tibila case, 89% was obtained since geo-membrane and cement concrete were used on main canal where there was doughty to excessive seepage and as it was at good condition up to date of research.

Figure 4.2 Full canal flows as silt deposited in lined part of the MC

4.1.2.3 Hydraulic factors on the conveyance efficiency of the main canal

In this study, the hydraulic effect on conveyance efficiency change (decrease) was manipulated on the change on the Mannings roughness coefficient (**n**).The formula is n= $\frac{A(3\sqrt{R2^*S})}{Q}$

Change of Hydraulic parameters such as hydraulic radius has a great effect on the conveyance efficiency of the canals

Table 4.3 Comparison of calculated and designed value for n for Jemjem

Canal section	Bed slope	Bed Width (m)	Water depth (m)	Side Slope	Measured Area (m2)	Wetted Perimeter (m)	Hydraulic Radius (m)	Flow Discharge (m3/s)	Roughness coefficient n calculated	Designed roughness coefficient (n)
From the weir to about 0.2 Km	0.001	0.8	0.8	0	0.640	2.4	0.267	0.041	0.2040	0.014
From 0.2Km to 1.120km sc-1	0.001	0.8	0.50	0.46	0.943	3.2	0.295	0.038	0.3476	0.025
From 1.120 km to 1.82km sc-2	0.001	0.9	0.45	0.5	0.810	2.9	0.279	0.024	0.4555	0.025

From 1.82 km to 2.02km sc-3	0.001	0.93	0.35	0.6	0.693	2.4	0.235	0.014	0.4763	0.025
From 2.020 km to 2.89 km sc-4	Non functional Part of the system									
From 2.89 km to 3.250 km sc-5										

Source, field survey (2017GC)

The values of the calculated **n** for different sections on the main canal were between 0.2040-0.4763. However, the designed values range from 0.014-0.025 for the same canal on which n was calculated. The value is increased. The increase in the value affects the amount of discharg**e** (made to decrease) due to the canal material(s) change(s) such as silt deposition on the canal bed, grass grown in the canal (see fig4.4).

4.1.2.4 Hydrologic factors on the conveyance efficiency of the main canal

River flows 80% dependable

For Jemjem the 80% dependable flow has been calculated for key station (Jemjem station), which is downstream of the diversion site.

Table 4.4 Jemjem Mean monthly Flow

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Flow	0.103	0.114	0.153	0.258	0.285	1.050	5.490	9.831	5.664	1.020	0.278	0.129	24.3755

The 80% dependable flows for this station is shown in table 4.5 below.

Table 4.5 80% dependable mean river flow (m3/sec) of Jemjem

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Jemjem St.	0.103	0.114	0.153	0.258	0.285	1.050	5.490	9.831	5.664	1.020	0.278	0.129
80% dependable flows	0.082	0.091	0.122	0.206	0.228	0.840	4.392	7.865	4.531	0.816	0.223	0.103

The volume of the mean monthly 80% dependable flow of the river was calculated in Mm3 in order to inspect excess water availability. As it can be seen from the table 4.5 above flow in the month January and February is the minimum of the year but it is exceeds the existing diverted flow which is 0.041m3/sec and very much less than the base flow estimated during the project design which was 0.364m3/sec. So it is obvious to understand that seven months of the year 80% dependable flow is less than the flow used to design the canal, in other words only five months flow of the year meets the design demand of the project. These flow variations from its designed amount resulted into different hydrological factor influences on the canal flow such as change in canal roughness, increase in water depth and silt deposition. Again it increases the top surface area of the canal and wetted perimeter of the canal which increases the evaporation and seepage loss of the canal respectively.

Table 4.6 Increased surface area and Mannings roughness coefficient of main canal

Canal section	Bed slope designed	Bed slope measured	Bed width (m)	Water depth (m) designed	Water depth (m) calculated	Measured Side slope	Flow discharge (m3/s) designed	Measured	Manning"s roughness Coefficient n Designed	Manning"s Roughness coefficient n calculated	Measured Wetted perimeter (m)	Designed Wetted perimeter (m)	A (m2) designed	A (m2) Cal.	Sur. A inc. (m2) wetted	Top water Sur. A inc. (m2)
From the weir to 0.2 Km 200m	0.001	0.001	0.8	0.65	0.8	0	0.364	0.041	0.014	0.204	2.4	2.1	0.52	0.64	60	0
From 0.2Km to 1.120km sc-1 920m	0.001	0.001	0.8	0.5	0.5	0.46	0.364	0.038	0.025	0.3476	3.19	2.40	0.675	0.943	728.64	896.08
From 1.120 km to 1.82km sc-2 700m	0.001	0.001	0.9	0.5	0.45	0.5	0.364	0.024	0.025	0.456	2.91	2.40	0.675	0.81	357	490
From 1.82 km to 2.02km sc-3 200m	0.001	0.001	0.93	0.5	0.35	0.6	0.364	0.014	0.025	0.4763	2.29	2.40	0.675	0.693	21.89	19.33
	Total													**1,167.53**		
From 2.020 km to 2.89 km sc-4	Non functional Part of the system															
From 2.89 km to 3.250 km sc-5																

4.1.3. Evaporation loss from the main canal

Evaporation loss from increased area of the canal is calculated using Energy balance method as: Evaporation from open increased canal surface is (Chow et al., 1988) summarized in table 4.7 below.

The evaporation rate can be calculated from the pan using the energy budget equation which offers the advantage of an ease of use but the simulation results do not agree completely with the measurements taken.

Table 4.7 Evaporation (l/s) loss from in increased canal sections

Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Rn	228	235	238.4	238.4	217.6	188.7	155.1	256.9	193.3	237.3	245.4	235
	To	18.75	19.75	20	19.6	18.5	16.85	17.75	17.7	18.05	17.9	17.85	17.9
	Area(m2												
lv	0	-44.25	-46.61	-47.20	-46.26	-43.66	-39.77	-41.89	-41.77	-42.60	-42.24	-42.13	-42.24
E(l/sec)		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
lv	896	204266.55	210536.89	213583.04	213583.98	194947.70	169054.30	138943.22	230166.32	173173.53	212602.29	219860.81	210541.26
E(l/sec)		1.0002	1.0002	1.0002	1.0002	1.0002	1.0002	1.0003	1.0002	1.0002	1.0002	1.0002	1.0002
lv	490	111675.75	115103.39	116768.80	116769.74	106580.34	92423.23	75957.11	125839.23	94674.40	116234.76	120203.87	115107.76
E(l/sec)		1.0004	1.0004	1.0004	1.0004	1.0004	1.0004	1.0006	1.0003	1.0004	1.0004	1.0004	1.0004
lv	19	4362.99	4495.94	4561.07	4562.02	4162.55	3607.81	2956.19	4924.11	3693.89	4544.77	4701.46	4500.31
E(l/sec)		1.0101	1.0104	1.0103	1.0101	1.0105	1.0110	1.0142	1.0085	1.0115	1.0093	1.0090	1.0094
E(l/sec)	Total	3.0107	3.0110	3.0110	3.0107	3.0111	3.0117	3.0150	3.0090	3.0122	3.0098	3.0095	3.0099

The decrease in the command area due to evaporation loss is explained in the (table 4.8 below).

Table 4.8 Command area lost due to evaporation loss

	Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Net command area	(ha)	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4
Project supply (max)	l/s/ha	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53
project supply (total)	l/s	20	20	20	20	20	20	20	20	20	20	20	20
Evaporation loss	l/s	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Command area decreased per month	ha	**5.6443**	**5.6443**	**5.6443**	**5.6443**	**5.6443**	**5.6443**	**5.6443**	**5.6443**	**5.6443**	**5.6443**	**5.6443**	**5.6443**

Remark: Net command area and project supply was obtained by site survey of the project.

Flow estimated to cover 5.64ha is lost per month as the table 4.8 above indicates.

4.1.4 Seepage losses from the main canal due to increased surface area of the canal

There are many methods to estimate seepage losses from canals among:

- Kostiakov A.N. Formula (empirical formula) (Abu Gulul, 1975)

Seepage losses along the canal line using the material descriptions in the table 3.9 is summarized as follows in the table 4.9

Table 4.9 seepage loss due increased of Manning's roughness coefficient

SEC	A(m2)	A1	Q(m3/sec)	M	QM	s	L(km)	S=s*Q*L/100
1	60	1.9	0.041	0.4	0.27868	6.817734	0.20	0.013635468
2	728.6	1.9	0.038	0.4	0.27034	7.028136	0.92	0.064658852
3	357	1.9	0.0240	0.4	0.22495	8.446351	0.70	0.059124454
4	21.9	1.9	0.0143	0.4	0.18287	10.39009	0.20	0.020780174
Total							**2.02**	**0.1582**

The total discharge lost due to seepage is **0.32lit/s** (sum of **seepage** from all sections).

Table 4.10 Command area lost due to seepage loss

Month	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Net command area	ha	38.400	38.400	38.400	38.400	38.400	38.400	38.400	38.400	38.400	38.400	38.400	38.400
Project supply (max)	l/s/ha	0.532	0.532	0.532	0.532	0.532	0.532	0.532	0.532	0.532	0.532	0.532	0.532
project supply (total)	l/s	20.410	20.410	20.410	20.410	20.410	20.410	20.410	20.410	20.410	20.410	20.410	20.410
Seepage loss (0.32) l/s	ha loss per month	**0.602**	**0.602**	**0.602**	**0.602**	**0.602**	**0.602**	**0.602**	**0.602**	**0.602**	**0.602**	**0.602**	**0.602**

Remark: Command area lost is 0.6ha and project supply was obtained by site survey of the project.

Table 4.11 Evaporation loss from designed canal

Month	Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Rn	228	235	238	238	218	189	155	257	193	237	245	235
	To	18.8	19.8	20	19.6	18.5	16.9	17.8	17.7	18.1	17.9	17.9	17.9
	Area(m2)												
Iv	1932	440451.75	453973.39	460541.6	460542.54	420359.54	364528.63	299611.31	496289.03	373413.00	458421.36	474070.67	453977.76
E(l/sec)		1.0001	1.0001	1.0001	1.0001	1.0001	1.0001	1.0001	1.0001	1.0001	1.0001	1.0001	1.0001
Iv	1890	430875.75	115103.39	116768.80	116769.74	106580.34	92423.23	75957.11	125839.23	94674.40	116234.76	120203.87	115107.76
E(l/sec)		1.0001	3.8587	3.8587	3.8587	3.8587	3.8588	3.8593	3.8584	3.8589	3.8585	3.8585	3.8586
E(l/sec)	Total	**2.0002**	**4.8588**	**4.8588**	**4.8588**	**4.8588**	**4.8589**	**4.8594**	**4.8585**	**4.8590**	**4.8586**	**4.8586**	**4.8587**

Average monthly evaporation from the main canal as per the design area is **4.62lit/sec**. It is calculated using energy balance method similarly as it was done for increased surface area of the canal. This calculation is done to check the result of increased surface area evaporation indirectly in the following summary table.

Table 4.12. Evaporation loss from recent main canal area in 2017 GC

Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Rn	228	235	238.4	238.4	217.6	188.7	155.1	256.9	193.3	237.3	245.4	235
	T^o_c	18.8	19.8	20	19.6	18.5	16.9	17.8	17.7	18.1	17.9	17.9	17.9
	Area(m2)												
lv	2901.6	661520.55	681829.39	691694.24	691695.18	631344.50	547492.15	449996.27	745379.27	560836.68	688507.44	712010.51	681833.76
E(l/sec)		0.6659	0.6659	0.6659	0.6659	0.6659	0.6659	0.6659	0.6659	0.6659	0.6659	0.6659	0.6659
lv	2309.2	526453.35	542615.39	550466.08	550467.02	502438.26	435706.27	358115.03	593191.71	446325.76	547930.92	566635.55	542619.76
E(l/sec)		1.0001	1.0001	1.0001	1.0001	1.0001	1.0001	1.0001	1.0001	1.0001	1.0001	1.0001	1.0001
E(l/sec)	Total	1.6660	1.6660	1.6660	1.6660	1.6660	1.6660	1.6660	1.6659	1.6660	1.6660	1.6660	1.6660

Ave monthly evaporation from the main canal as per the design area is **1.67lit/s**ec. It is calculated using energy balance method similarly as it was done for increased surface area of the canal. This calculation is done to check the result of increased surface area evaporation indirectly in the following summary table. The difference between designed and recent canal evaporation loss is found to be high. The grass covered the main canal area and an increase in depth of canal significantly reduces the evaporation loss than it was during the first irrigation time. Change in climate changes the rate of evaporation loss from irrigation field (Haileyesus H. June, 2011). It is obviously due to change in canal dimension due change in both hydrologic and hydraulic effects.

Table 4.13 Summary of main canal water losses

Main canal Water Losses from direct measurement(lit/sec)								Main canal Water Losses from indirect measurement(lit/sec)					
Chainage	Discharge		Water loss	Total canal area				Increased area of canal		Loss from D and R			
	at start	at end						Evaporation Loss	Seepage loss	Evaporation Loss		Seepage loss	
	R	R	R	Top surf.		Wetted surf.		R	R	D	R	D	R
Weir-sc1	41	38	3	D=3822m2	R=5210.8m2	D=5440.83m2	R=4373.05m2	1.23	0.062	Refer table 12&13			
sc1-sc2	38	24	14					1.37	0.041				
sc2-sc3	24	14.3	9.7					0.89	0.004				
		Total	26.70					3.01	0.32	4.62	1.67	1.58	1.96
Total 26.7lit/sec loss is due to :										Diff.=2.95		Diff.=0.38	
Evaporation													
Seepage													
Leakage								sum=3.33		sum=3.33			
NB-Inf rate=0.000361lit/sec or (1.3-3.8mm/m2) from Garg book													
Total evaporation and seepage loss is 3.63lit/sec													
Therefore, water loss due to mismanagement and operation is found to be (26.7lit/s-3.63lit/s)=**23.07lit/sec**													

Legend: - D= design Area, R=recently measured area

From the total 26.7lit/sec water loss calculated gives 65.12% that is due to, evaporation and seepage losses together are 3.63lit/sec while leakage and other operational losses account **23.07lit/sec** of the total main canal inflow.

4.1.5 Reliability of irrigation water supply

Unreliability of irrigation water supply due to the poorly functioning irrigation infrastructure and due to illegal water users (vandalism) was confirmed by 32.5 % of the irrigation scheme users. Unauthorized water users, seepage, canal over flow and herds of cattle drinking from the canals also contributed to water supply unreliability.

Figure 4.4 Desilted lined MC and earth canal covered with grass

4.1.6 Irrigated area performance

This is the total area under irrigation versus total designed command areas of already implemented irrigation project during a particular year or averaged over years.

Table4.14 Irrigated area performance since 2015

S .n	Year	Irrigated command areas (ha)	Designed command areas (ha)	Percent (%) performance
1	2015	23	130	17.7
2	2016	50		38.5
3	2017	75		57.7

As it can be seen from the table 4.14 the irrigated area has been performing good from year to year irrespective of structural and management problems.

4.1.6. Beneficiaries target performance

The ratio of actual number of water users using irrigation schemes and planned or targeted number of beneficiaries shows the beneficiaries′ target performance. Out of 312 beneficiaries house hold only 119 house hold has been irrigating their farm and therefore the performance is below the target.

4.2. WATER MANAGEMENT ISSUES

Table 4.2.1: Sexes of household heads and their participation in the affairs of the scheme

Do you participate in the affairs of the scheme? Sex of the household head

Table 4.2 .1: Sexes of household heads and their participation in the affairs of the scheme					
Do you Participate in the affairs of the scheme?		Sex of the household head			
		Male	Female	Total	Percent
Responses	Yes	95	0	95	
	No	19	5	24	
	Total	114	5	119	
	Percent	95.8	4.2	100%	

Source: Field survey (2017GC)

As it can be brightly seen from table 4.2.1, of the total 119 household heads of the irrigation beneficiaries, 95.8% were headed by males and 4.2% were headed by females. The above table shows that almost all male beneficiaries participate in the affairs of the irrigation scheme. All the female beneficiaries do not participate in the affairs of the scheme. In Ethiopia, large amounts of women's time is spent in household reproduction activities such as gathering firewood, collecting water, preparing food, caring of children, other household duties and their responsibility as household heads along with their farm activity and these may prevent them in participating in the affairs of the scheme.

Table 4.2:2 Age and level of education of the household head							
Responses		**Level of Education of the Household head**					Total
		Illiterate (can't read and write)	Can only read and write	Grade 1-4	Grade 5-8	Grade 9-12	
Edge of the household head	18-28	0	0	5	19	13	37
	29-38	11	0	8	13	0	32
	39-48	5	0	5	16	0	26
	49-58	5	0	3	8	0	16
	59-68	0	0	0	0	0	0
	Above 68	8	0	0	0	0	8
	Total	29	0	21	56	13	119

Source: Field survey (2017GC)

Table 4.2.2 shows the summary of age and level of education of the households' heads in Jemjem Small Scale Irrigation scheme. Age of the household head, 21.8% was in the range of 39-48 years. Regarding the level of education of the household head, the majority (24.4%) were illiterate (can't read and write). In addition, the Oromia regional standard for rural household size was 6.

4.2.1 Irrigation management practices within Jemjem SSIP system

In the study area small scale irrigation management activities include water use activities such as allocation and distribution, control structure activities which refers to construction, operation and maintenance and organizational activity which includes activities like resource mobilization, conflict resolution and decision making.

4.2.1.1. WATER MANAGEMENT

4.2.1.1.1. WATER ALLOCATION

Water may be supplied on a continuous or a rotational basis in which the flow rate and duration may be relatively fixed. In those cases, the flexibility in scheduling irrigation is limited to what each farmer or group of farmers can mutually agree upon within their command area. With this regard, Jemjem small scale irrigation is adopting a continuous system, secondary canals receive water when needed, and the individual farmers within a given area receive the water at the present time.

In the study area, the water committee is not in charge of water allocation and coordination of rotational water distribution. **Irrigation agronomists and Development Agents** are also supposed to provide technical assistance to water committee in water allocation, in preparing the annual schedule of water distribution and in defining the water rights of members based on study on water requirements of different crops and irrigable plot area and measurement of the yearly water supply.

The focus group discussion with beneficiaries revealed that in terms of implementation, no water allocation and farmers divert water from the main canal by guess. Beneficiaries do not know when to irrigate their farm. Amount and time of water supply are not defined with the water requirement of different crops grown and area of irrigable plots managed by households. This resulted in a major problem in the implementation of rotational distribution of irrigation water.

4.2.1.1.2 Water distribution

Table 4.2.3: Responses related to getting enough irrigation water and reasons for not getting enough irrigation water				
Do you get enough water?		Frequency=714	Percent	Remark
Responses	Yes	666	93.3	
	No	48	6.7	
	Total	714	100	
What are the major reasons for not getting enough water?		Frequency=48	Percent	Remark
Responses	Water scarcity	-	-	
	Poor coordination of water distribution	26	54.2	
	Water theft	5	10.4	
	I am tail-end irrigator, water does not reach	17	35.4	
	Total	48	100	

Source: Field survey (2017GC)

The study identified that the scheme has water committee. The water committee is responsible for coordinating the water distribution. The water committee nominates two individuals who are responsible to open the water gate as per the program of each of the groups (formed based on their farm location).No monthly salary of each gate keeper and their responsibility is, in addition is to open and close the gate with mud on canals, they are responsible for keeping turn and protecting water theft. Each group did not get water based on time limit (scheduling).

According to table 4.2.3, 93.3% of beneficiaries said that they get enough water when needed for their agricultural activities. The table also clearly shows a significant number of water users (6.7 percent) said that they have faced a problem of water shortage in the irrigation scheme; they said that they could not get enough water for their farm activities when they need. Of the 6.7 percent of irrigation water users who complained not to get enough water, 54.2 percent said that the shortage is due to Poor coordination of water distribution 10.4 percent said that the shortage is due to Water theft and 32.4 percent said that the shortage is due to being tail-end irrigator, water does not reach. This problem may be created due to the weakness of the management, negligence of the water committee in coordinating water distribution, beneficiaries use the water in the reservoir for their livestock consumption, and there are careless water users when to irrigate the farm in the study area for which excess water flow back to the river and they could not manage the job so it is means of water losses. These in turn result in water scarcity in the area. Moreover, Poor coordination of water distribution, being tail-end irrigator and water theft were the 1st, 2nd and 3rd most important problems that constrained the supply of adequate water in the operating command area of the irrigation scheme respectively.

Table 4.2.4: Farmers' response on major causes for water scarcity

If there is water scarcity, what are the most important causes for you?		Frequency N=48	Percent	Remark
Causes	Seepage loss	31	65.1	
	Increasing number of users	0	0	
	Declining level of water from the river	0	0	
	Poor scheduling of distribution	17	34.9	
	Total	48	100	

Source: Field Survey (2017GC)

According to table 4.2.4, 65.1 % of the respondents expressed that Seepage loss in a sense of water wastage was one of the factors responsible for water scarcity in the command area. This is due to poor coordination of water distribution and high water wastage in the study area. The other cause of water scarcity in the command area is poor scheduling of distribution (34.9%). This may be due to the fact that in the study area except small parts of the main conveyance canal made from cement (100 meter), the remaining main and secondary canals are earthen canals and malformed due to lack of timely and proper maintenance activities. As a result of this excessive seepage was observed during the study time. Moreover, poor coordination of scheduling and inadequate coordination of water distribution in the command area have had contribution for the problem of water scarcity in the study area.

Table 4.2.5: Water users' opinion about the performance of water committee in water distribution

What do you feel about the performance of the water committee in the management of water distribution		Frequency N=714	Perc ent
Opinions	Enough water is not received due to mis-utilization of water (adequacy)	576	80.7
	Water is not received when needed (timeliness)	42	5.9
	Water distribution is unfair (equity)	96	13.4
	Total	714	100

Source: Field survey (2017GC)

According to table 4.2.5, more than half of the water users 80.7 percent witnessed that they could not obtain enough water due to miss-utilization of water by some careless irrigators. The other 5.9% and 13.4% irrigators said that they could not receive water when they need and water distribution is unfair respectively. This is because according to the information obtained from the water committee chairperson, special emphasis is given to vegetables that are any farm covered with vegetables can irrigate whenever the plant required without following the rotation. As a result, farmers who have plot covered with crops and perennials may not get water when they need. The water committee consists of seven members to coordinate and control water distribution in the command area of the scheme. However, according to the most important performance indicators in the distribution of irrigation water designed by World Bank in 2000 include adequacy, timeliness and equity in the supply of water, the water committee was found to be inefficient in managing the water distribution in terms of the three performance indicators.

Table 4.2.6: Farmer's responses about socioeconomic groups that get more water in the irrigation scheme

If there is unfair distribution of water, which socioeconomic groups get more water in the irrigation Scheme?		Frequency N=96	Percent	Remark
Groups	Farmers with large family	3	3	
	Farmers with large farmland	93	97	
	Rich farmers who grow perennials	0	0	
	Total	96	100	

Source: Field survey (2017GC)

According to table 4.2.6, 97% of the beneficiaries said that farmers with large farmland obtained more water because they have large farm land and there is no time limit how long each farm has to irrigate. As a result of the above mentioned reasons, farmers having small farm land size are suffering from lack of irrigation water. 3% of beneficiaries also complained that farmers with large family received large volume of irrigation water. Moreover, during the focus group discussion the beneficiaries also indicated their satisfactory experience that the performance of the scheme has been raising over the past years to a level where it is more making a difference in their farming practices. This progress happened due to the better performance of the water committee in water distribution. The prevalence of unfair distribution of irrigation water that means certain socioeconomic groups obtains more water for their farm activities than others. As a result, the target community could not fully and equally benefit from the water as it had been anticipated.

Table 4.2.7: Users' opinion about major management problems related to water distribution

What are the major management problems related to water distribution?		Frequency N=714	Percent	Remark
Opinions	Sanctions not imposed against illegal water users	379	53.2	
	Rotation does not accomplish equality	111	15.5	
	Rotation is not strictly implemented	178	24.9	
	Poor coordination of water distribution by Water committee	46	6.4	
	Total	714	100	

Source: Field Survey (2017GC)

Table 4.2.7 presents users' perceptions about the major weaknesses of the water committee on water management. Of the total users, 53.2% reported that Sanctions are not imposed against illegal water users i.e. irrigators that extracted and used more water by abusing turns. Some of the illegal water users may be intimate friends or relatives of the water committee members. Hence, sanctions may not be imposed on them. 24.9% of the beneficiary farmers stated that they were not able to obtain water in a reliable manner because rotation is not strictly implemented. The research result also shows that 15.5% and 6.4% of irrigation users did not obtain the quantity of water that they need because, among others, rotation does not accomplish equality. This may be due to the fact that rotation is based on the type of crops and vegetables planted and the size of the farmland in the command area as a result of this rotations were not strictly implemented .

Moreover, the study shows that the general performance of the Water Users committee in terms of managing the scheme was offensively poor.

4.2.2. CONFLICT AND CONFLICT MANAGEMENT

With regard to Jemjem SSI scheme, water users, water committee members and key informants explained that conflicts arising from water allocation and distribution are a common phenomenon among irrigators within and between groups. Hence, according to Gashaye (2007) institutional arrangement on irrigation is required to overcome problems related to irrigation water as a common property resource, to provide incentives to disciplined members, disincentive to free riders/ violators.

Table 4.2.8: Beneficiary farmers' response to the presence and causes of conflict over irrigation water

Have you ever faced any conflict over irrigation water?		Frequency N=714	Percent	Remark
Responses	Yes	201	28.2	
	No	134	18.8	
	Total	-	-	
What are the causes for water conflict?				
Causes	Water theft	223	31.2	
	Water scarcity	-	-	
	Competition due to increasing number of water users	22	3	
	Lack of proper control of water distribution	134	18.8	
	Total	714	100	

Source: Field survey (2017GC)

Table 4.8 shows the results of household questionnaire that majority of beneficiaries, 28.2% acknowledged the presence of conflict arising from distribution and allocation of irrigation water. They mentioned water scarcity, water theft, lack of proper control of water distribution and competition due to increasing number of water users as the prominent factors for water conflict.

31.2% beneficiaries stated that water theft has also been one of the prime factors for water disputes within groups and between groups. Informants also expressed that lack of enforcement of regulations for water allocation has also been one of the most important constraints that led to unnecessary water disputes. They also expressed that '*the stated bylaws are good in written form* but when we see them in practice, they are not well applied. Some irrigators break the bylaws and commit water theft but there is no penalty that is proportional to the mistakes that they made. This is because the violators may build a strong relationship with the water committee members'.

The remaining 18.8% and 3% of irrigators said that the conflict arises due to lack of proper control of water distribution and competition (increasing number of water users') respectively. Furthermore, the beneficiaries ranked the causes of water conflict as water theft, lack of proper control of water distribution and competition (increasing number of water users') as the first, second and third respectively.

Table 4.2.9: Farmers' response on conflict over irrigation water by their farm location

-Have you ever faced any conflict over irrigation water?		Where is your farm location from the water source?			
		Upper catchment	Middle catchment	Lower catchment	Total
Responses	Yes	178	223	90	491
	No	112	21	90	223
	Total	290	244	180	714

Source: Field survey (2017GC)

Table 4.2.9 shows that water users in the Upper-catchment area of the irrigation scheme were faced disputes over irrigation water. From this we can understand that conflict over irrigation water is becoming severe at the middle catchment of the water source. As a result of this, most Lower-catchment beneficiaries responded that they faced conflict over irrigation water. When a farmer's farm location is far from the water source, the probability of getting enough irrigation water at the time required is low. This in turn results in water scarcity, the major cause for water conflict.

Table.4.2.10:Farmers' opinion about the performance of water committee in resolving conflicts in the irrigation system

How do you evaluate the performance of the water committee in resolving conflict?		Frequency N=714	Percent
Opinions	They take immediate actions on cases	89	12.5
	Conflict management has been improved	558	78.2
	They suspend cases	67	9.3
	Total	714	100%

Table 4.2.10 presents that a significant number of beneficiary farmers (12.5%) responded that the water committee takes immediate actions on cases to resolve conflicts when they arose. The rest 9.3% said that the water committee suspended cases. This may be due to the fact that whenever there are violators, the water committee rarely takes such perpetrators or committers to kebelle social court. Nevertheless, the court always demands witnesses for the offences done. Because of these procedural problems, cases may be suspended. Informants also indicated that when fellow farmers who had witnessed the wrong doing (the wrong doer in action) are asked to stand as witnesses; they decline from cooperating; in case the perpetrator might resent against them. Most beneficiaries of the scheme do not want to risk consequences from such feelings of resentment from any one endured legal actions for being found guilty. So, the committee often finds itself powerless to ensure observance of the regulations set for the irrigation water management.78.2% of beneficiaries said that conflict management has been improved in the irrigation system.

This is due to the presence of support from wereda irrigation authority experts and development agents on the issue of conflict management. The researcher also conducted an interview with the water committee chair person about the enforcement of the by-law on the guilty farmers. The interview revealed that for instance, if the person is guilty on water theft, he/she will be penalized based on the appearance of the plant. If the plant is endangered due to water scarcity and if the person is trying to save the life of the plant, he/she will be penalized less than the expected penalty. If the case is beyond the capacity of the water committee, it will be submitted to or sentenced at the kebele social court.

4.2.3. Operation and Maintenance of the Irrigation System

According to the information obtained from the water committee members, maintenance such as clearing canals by removing mud and grasses of the canals are undertaken by mass mobilization, on random in a year and according to their verbal by-law those beneficiaries who are absent in the maintenance work will not be penalized.

Moreover, farmers undertake canal cleaning and but not system maintenance activities under the leadership and coordination of the water committee and local development agents. The most important reason they suggested for the maintenance problem is financial shortage. Nevertheless, the irrigation beneficiaries defer major maintenance works that require input of expert skills and industrial product (e.g. cement, steel gate) to the government agencies to do it for them. In order to look after violators, the committee has assigned two guards without payment. Each of the irrigation beneficiaries owning a plot size of 0.5ha (half of a hectare) could have contributed some ETB per year for the salary and the use the remained money for maintenance.

Table 4.2.11: Beneficiaries opinion about the maintenance of the scheme

If your answer is poor or very poor, what are the causes?

Table 4.2.11: Beneficiaries opinion about the maintenance of the scheme			
How do you evaluate the maintenance of the scheme?		Frequency N=654	Percent
Opinions	Very good	-	-
	Good	79	12.08
	Acceptable	555	84.86
	Poor	-	-
	Very poor	20	3.06
	Total	654	100%
If your answer is poor or very poor, what are the causes?		Frequency N=60	Percent
Causes	Siltation	0	
	Poor imposition of sanctions on reluctant users	20	33.33
	Absenteeism of some members on maintenance days	20	33.33
	Breaching of canals by illegal water users	0	
	Poor coordination of maintenance activities	20	33.33
	Total	60	100

Source: Field survey (2017GC)

Jemjem small scale irrigation is furrow irrigation system which comprises some on and off-farm Infrastructure which perform several important functions like turning the flow to a field on and off, conveying and distributing the flow among the fields. The main canal with length of 200m is lined the remaining 3.05km earthen is not fully performing in a good condition, in addition it has no control gate instead mud and boulders are used. This canal feeds five secondary canals and one tertiary canal but two secondary canals and one tertiary canal are non functional as it broken down of main canal after the third secondary canal. Drops in the main canal are also in a good condition except the non functional or idle part of the canal system. But the secondary canal is not in a good condition. With reference to Table 4.2.11 insignificant number of beneficiaries (12.08%) responded that maintenance of the irrigation scheme is in a good condition. However, according to beneficiaries who said the maintenance of the scheme is very poor (3.06%), poor imposition of sanctions on reluctant users (33.33%), absenteeism of some members on maintenance days (33.33%), and poor coordination of maintenance activities (33.33%) were some of the major causes.

4.2.4. The Contribution of the Water Committee in the Irrigation Scheme

The water committee is to be formed through election by the irrigation beneficiary community members every year to manage the irrigation. The first of the water committee was formed through election by community members at the time of Jemjem project was completed in 2014G.C. The members of the committee are: Chairperson, Vice chairperson, Secretary, Treasury, Auditor and two operators. The system has no a by-law in the kebelle judiciary (social court) written and legalized. There is no written directive defines the roles and functional procedures of the water committee as well as the rights and obligations of the irrigation beneficiaries; along with the types of offences that are considered punishable and subsequent fines.

However, the water committee is responsible to manage the scheme and its main roles include protecting the infrastructure from being damaged (misuse or otherwise), facilitating scheduled water use by the irrigation beneficiaries and monitoring any attempt involving violation of verbal regulations by users such as defaulting agreed water access schedules and trying to divert water while it is not their turn. In addition to the above mentioned roles, the water committee is also responsible for resolving disputes related to water, land and maintenance based on the verbal by-law.

4.2.5. Constraints of users for self-management of the irrigation scheme

Key reflections captured during focus group discussion with irrigators, interview with key informants and interview with the water committee members on the constraints of users for self management of the irrigation are discussed below:

4.2.5.1 Capacity limitations in irrigation agronomy and water management

The limitation in the availability of water is due to lack of capacity for sustainable management and use of the available water. The extension supports in water management and irrigation agronomy are weak due to limitations in technical capacity. Research and extension support in farm management, irrigation water management, irrigation agronomy and even though the site is between Ginchi and olankomi towns marketing is poor or with inadequate coverage. Even if there is FTC nearby Jemjem, it does not provide satisfactory training about water management. Failure to give full support for the water committee is another drawback of the extension system.

4.2.5.2 Disfavoring market system and related constraints

One of the main challenge of farmers in relation to market is that they often sale their products at lower prices as decided by the merchants. This is mainly because of the marketing system and unbalanced bargaining power involved in the transaction process, which usually disfavors farmers. Despite the expressed constraints of community members regarding the inconveniences related to marketing of their products, the available services of FSC (Farmers' Service Cooperative) do not include marketing of agricultural products. The main reason that the FSC is not providing agricultural marketing services is because of its limited capacity.

4.2.5.3 Prevailing of dominant figures in the water committee

Since 2014 G.C (Jemjem weir was completed), there is an election of the water committee by the beneficiaries every year to manage the irrigation. Nevertheless, some of the initial members are still serving as the water committee members i.e. they have not been fully changed since the initial election except a few replacements of individual committee members who left the committee for different reasons. This reflects a sign of dominant figures prevailing in the committee.

4.2.5.4 Absence of a water users association (WUA)

Despite the existence of a water committee and its efforts to manage the SSI Scheme, it does not have the required strength to effectively manage and ensure realization of a sustainable livelihood for the beneficiaries as well as contributing to the socioeconomic development of the community in the area. In addition, the absence of a WUA presents a major gap in terms of having formal institutional arrangements for governing the irrigation scheme. Had the WUA existed, there would have been a creation of reasonable product price for the products produced.

4.2.5.5 Provision of fertilizer and improved seeds

Most of the focus group discussants and key informants have indicated the availability of fertilizers during both irrigated and rain fed cropping seasons despite their high prices. In addition, inadequate provision/ supply of improved seeds both in quality and quantity are one of the constraints farmers raised during the FGD (Farmers Group Discussion).

4.2.6. MAJOR CHALLENGES THAT HINDER THE SUSTAINABILITY OF THE IRRIGATION SCHEME

Numbers of factors hinder the sustainability of Jemjem Small scale irrigation scheme. Some of them are presented below based on the summary of the study result:

-Poor water distribution/scheduling and failure to get sufficient water at down streams according to design, occur mostly due to the wasteful use of head-end irrigators.

-Some farmers use water for their farm regardless of crop water requirement of each crop type. -Weak water committee that fails to effectively manage water distribution schedule.

-Water volume decrease in the catchment is also considered as a challenge, because of the prevalence of inadequate flow into the river, farmers could not get enough irrigation water for their farm activity.

-Relevant education and training, about the use of irrigation water together with the long term consequences, have great importance in smoothing the operation of the scheme under operation. However, irrigators are not sufficiently aware about the water requirement of different types of crops, and hence, frequent conflict arises among them.

-Lack of adequate external support (in water and conflict management, technical assistance and capacity building) by local development agents and the other concerned partners even though the regional institutional framework states that the management and operation of the irrigation system is a joint responsibility.

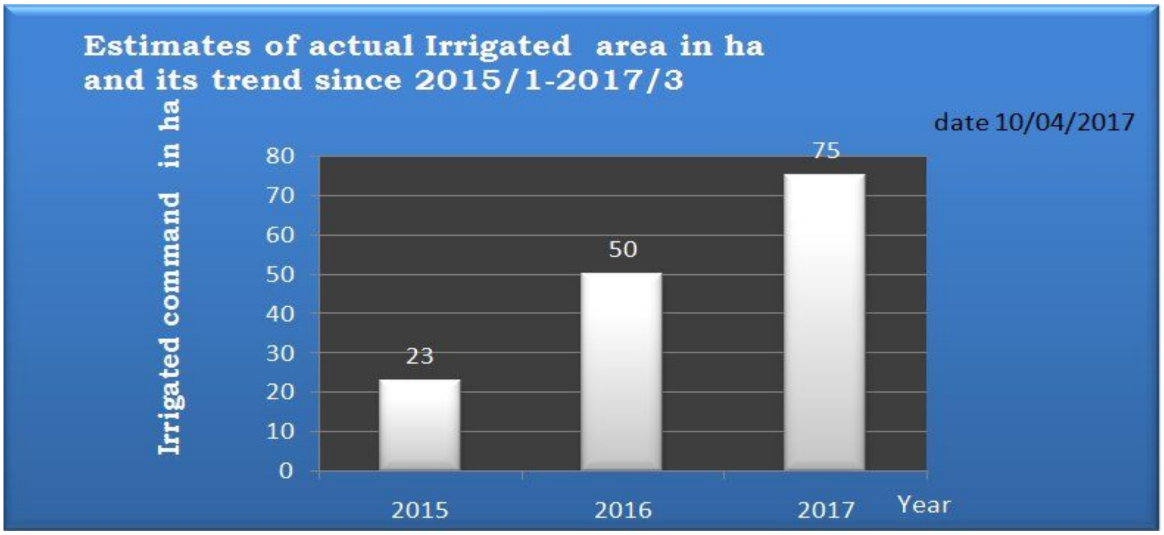
-Poor coordination of scheduling, inadequate coordination of water distribution and water theft in the command area has had contribution for the problem of water scarcity in the study area.

. Generally, the main challenges that hinder the sustainability of Jemjem Small Scale Scheme are
Inadequate river water, poor water management practices, excessive seepage.

4.2.7. IRRIGATION MANAGEMENT AND IRRIGATED AGRICULTURE IN THE IRRIGATION SCHEME

4.2.7.1. Irrigation management and utilization of the developed land

The farmland in jemjem small scale irrigation scheme is broadly categorized into rain fed and irrigable land. In the study area, the irrigable land is further classified into "*Shumo and Yubdo". Shumo* is the most fertile land and close to the water source. It is the first step to cultivate and irrigate all over the year even if the volume of water from the river is low. *Yubdo*, on the other hand, is fertile land and faraway from the water source. It is the second step to cultivate and it will be cultivated if and only if there is enough water in the river and failed part of the canal system is maintained and if not it will be kept uncultivated. Therefore, beneficiaries in the irrigation scheme have farmland both in the *Shumo and Yubdo* part of the farmland.
According to the Woreda Agricultural and Rural Development Office, the plot size planned to be allocated for beneficiaries in the irrigation scheme ranges between 0.25ha (1pair of oxen)-0.5ha (2pair of oxen), with visible substantial land fragmentation. The intended allocation was based on family size. Those who had large family size were scheduled to get up to 0.25ha including children under age of 18 and if family member with age greater than 18 existed 0.25ha of land is allocated for him. Based on the findings of the time series analysis (2015/2-2017/4), the actual irrigated area is small compared to the potential (130ha).



Source: some from Ejersa Lafo district Irrigation Authority office report

Figure 4.4: Data Estimates of actual Irrigated area in ha and its trend since 2015/1-2017/3

Table 4.2.12: Farmers' ranking of the reasons for under use of their irrigable land in 2008E.C				
Do you irrigate all of your irrigable Land in 2008 E.C.?		Frequency N=210	Percent	Rank
	Yes	12	5.71	
	No	198	94.29	
Responses	Total	210	100	
What are the major reasons for under use of your irrigable land?		Frequency N=504	Percent	Rank
	Water scarcity	12	2.38	
	Shortage of oxen	0	0	
	Unreliable access to water	0	0	
	Shortage of labor	246	48.81	
	The plot I possess is large	246	48.81	
Responses	Total	504	100%	

Source: Field survey (2017GC)

According to table 4.2.12, **94.29%** of beneficiaries in the irrigation scheme responded that they did not fully irrigate their farm land in 2008 E.C. The table also shows farmers ranking of the constraints that discouraged them from participation in irrigated farming and led to the under utilization of the irrigable farm land. The result obtained in Jemjem SSI mentioned also that **shortage of labor and the plot possessed and water scarcity** is large as the 1st, 2nd and 3rd most important factors responsible for under use of the potential irrigable land respectively.

4.2.7.2. Irrigation management and crop production

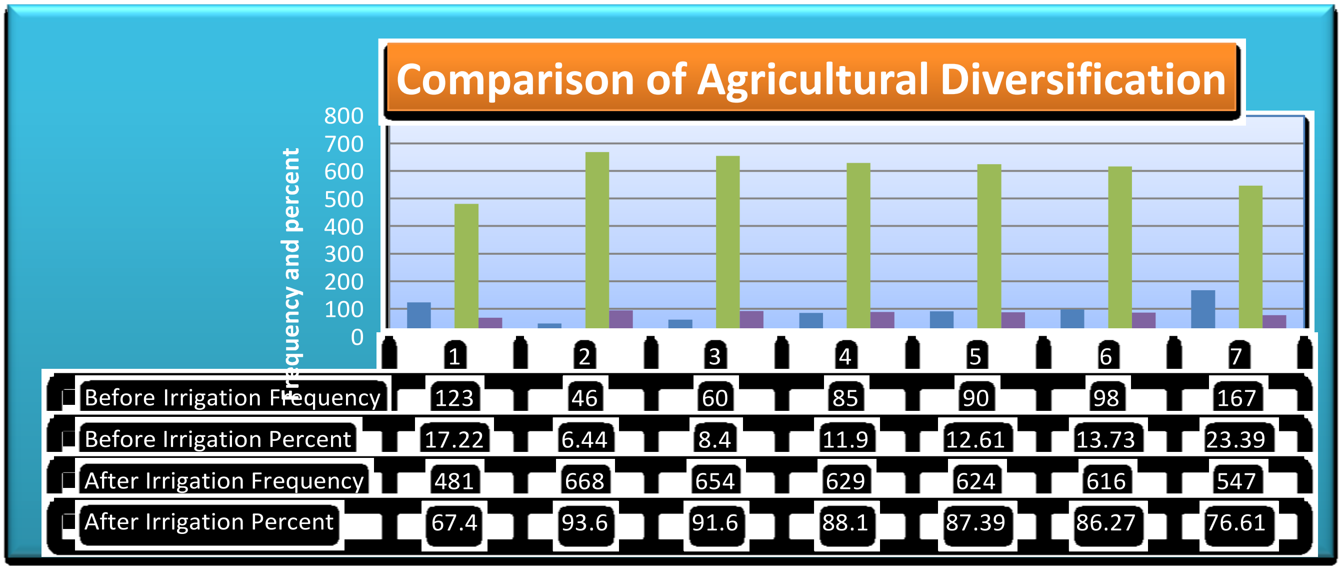
Irrigation is a key factor of success in increasing the overall agricultural productivity and crop diversification in Ethiopia. Irrigation increased crop diversification and intensification of land use practices such as double cropping. One of the most important social effects of the implemented irrigation project was increased diversification of production. One method to show the impact of the intervention on diversification is through comparison of crops and vegetables cultivated by farmers before and after irrigation. The finding (table 4.2.13 and fig.4.6) indicated that the types of crops and vegetables and the number of farmers who grew a wide range of crops and vegetables, including potato, tomato, maize, onion, cabbage and pepper have substantially increased after the introduction of irrigation. The production of cabbage and pepper was significantly different before and after the introduction of irrigation in Jemjem irrigation scheme

Table 4.2.13: Comparison of agricultural diversification before and after irrigation

Crops and vegetable	Before		After			
	Frequency	Percent	Frequency	Percent	Before	After
1.Maize	123	17.22	481	67.4	X^2=6.99	X^2=8.167
2.Potato	46	6.44	668	93.6		
3.Tomato	60	8.40	654	91.6		
4.Onion	85	11.9	629	88.10		
5.Garlic	90	12.61	624	87.39		
6.Cabbage	98	13.73	616	86.27		
7.Pepper	167	23.39	547	76.61		

Source: Field survey and design document (2017GC)

The second most important impact of the implemented Jemjem SSI project was increased intensification of land use practices (temporal diversification of production) in the irrigation system



Source, Field survey (2017GC)

Fig 4.5 Comparison of crop and vegetable diversification before and after irrigation

The above figure clearly shows that the production of potato, tomato, maize and onion insignificantly different before and after the introduction of irrigation in Jemjem irrigation scheme (see Table 4.2.13).

Table 4.2.14: Irrigation beneficiaries' response on the frequency of harvest in a year

How many times do you produce in a year by applying irrigation?		Frequency	Percent	Remark
Responses	Once	-		
	Twice	625	87.54	
	Thrice	89	12.46	
	Total	714	100	

Table 4.2.15: About support Farmers' response received from DAs			
Responses	**Do you receive support from DAs**	Frequency	Percent
	Yes	44	6.20
	No	670	93.80
	Total	714	100%
What are the supports you received?		Frequency	Percent
Supports	Advice		
	Training		
	Demonstration		
	Conflict resolution		
	Controlling water distribution		
	Total		

Source: Field survey (2017GC)

Table 4.2.16: farmers' responses on crop failure and perceptions on possible causes of crop failure				
Have you ever faced a problem of crop failure While you are using irrigation?		Frequency N=714	Percent	Remark
Responses	Yes	224	96.6	
	No	8	3.5	
	Total	232	100%	
What are the possible causes for crop failure?				
Causes	Water shortage	-		
	Damaged by disease	241	50	
	Poor adoption of varieties used	241	50	
	Total	482	100%	

Source: Field survey (2017GC)

Table 4.2.17: Farmers' response about credit service for their agricultural activities			
Do you get an access to credit?		Frequency N=714	Percent
Responses	Yes	-	-
	No	714	100
	Total	14	100
What are the sources of credit?		Frequency	Percent
Sources	Cooperatives		
	Local lenders		
	Neighbors and relatives		
	Microfinance		
	institutions		
	Total		

Source: Field survey (2017GC)

The researcher asked a question that 'how many times do you produce in a year by applying irrigation?' to the beneficiary farmers. According to the response, **(87.54%)** and **(12.46%)** (See table 4.2.14) of farmers responded that they can produce twice and thrice in a year respectively. This clearly shows that irrigation can facilitate agricultural production intensification that means irrigation schemes helps to increase agricultural productivity of a given land in the study area. And it also helps to diversify product types With reference to table 4.2.16, 96.6% of the beneficiary farmers responded that they were faced a problem of crop failure while they are using irrigation. The prevalence of crop and vegetable disease and poor adoption of varieties used were the most important constraints that dictate and brought about a change in cropping pattern in the irrigation scheme. Table 4.2.16 shows that 50% of beneficiary farmers responded that they have faced crop failure due to disease. During the study time, all farmers faced **tomato damage due to the prevalence of disease and also due to frost**. The rest 50% of beneficiary farmers faced Poor adoption of varieties

Table 4.2.15 clearly shows that a greater number (93.8%) of beneficiary farmers of Jemjem SSI Scheme didn't receive support from DAs. And among the services they received, untellable advice and training take the minor share. Supports from experts (DAs) should be a continuous process. A one-time support cannot bring about a desired effect on the production and productivity of irrigation agriculture. The remaining 6.2% of beneficiaries get support from experts. On the beneficiaries side, a few farmers may be aware about the essence of supports given by experts; they do not need of per diem because some of the trainings given at grass root level are free from per diem as a result a few irrigators opt to be present. On the experts' or development agents' side, in addition to absence of per diem payment, experts may require to pay the maintenance and fuel cost of the motor bicycles from their own pocket that will not be reimbursed.This condition may discourage them to carry out fieldwork many times that involves all beneficiaries.As it can be seen from table 4.2.17, none of the farmers was able to use credit for their agricultural activities. The reasons for their inability to use credit were, they were not interested, requirement of collateral, lack of access to credit supply and high cost of access to credit.

5. CONCLUSIONS AND RECOMMENDATION

5.1. CONCLUSIONS

The major findings of the study are summarized hereafter using the objectives and/or the research questions as guides. Canal Conveyance efficiency designed and the actual value obtained for the irrigation scheme showed great difference. It is found to work under its expectation. Therefore, this research was carried out to analysis participating party (water users, funding agent) and factors (hydraulic and hydrologic factors) on water management and conveyance efficiency of the schemes since the value used in the study or design stage is difficult to guess and moreover unlikely to meet the project conditions in their present and future state. For main canal after the 1st secondary canal, conveyance efficiency is much lower than for the canal before the 1st secondary canal due to high grass and silt deposition in addition to wastage of water.

Accordingly, **hydraulic** (conveyance characters like roughness coefficient, hydraulic radius and bed slope) showed great variation from the designed values and **hydrologic factors** (the variation in water depth which further increased the top width of water surface, seepage and evaporation losses which in turn due to increased top width of water surface) were made the (90%) conveyance efficiency taken at the design stage was fail to **meet (90%)** and in the current operation is **(34.9%).** Similarly, **(Adam T., 2013),** Hydraulic and Hydrologic Factors on Conveyance Efficiency: Case of Fentale and Tibila Irrigation Schemes was referred. The result of his study showed that efficiency calculated was 0.344, which is 34.4% for Fentale and this conveyance efficiency was much lower than the standard value 95% taken during the design. But for Tibila case, 89% was obtained since geo-membrane and cement concrete were used on main canal where there was doughty to excessive seepage and as it was at good condition up to date of research.

Moreover, the primary cause to the decrease of conveyance efficiency was high water wastage, grass grown in the canal and mud or silt deposition in the canal which made increase in water depth in the canal. Soil deposited and grass grown in the canal decreased flow velocity. Decrease in flow velocity made the scarcity of irrigation water in the command areas which will cause crop water stress which in turn result in low yield. The result obtained analyzing the flow of the river showed the sufficiency of water for planned command area but deficit in meeting an irrigation water demand observed in irrigation scheme from November to June.

In general, hydrologic factor (soil eroded that entered canal) caused hydraulic factor (decreased in conveyance characteristic) and in turn hydraulic factors such as increase in Mannings roughness coefficient and wetted perimeter caused hydrologic effects such as evaporation(3.01lit/sec) and seepage losses(0.321lit/sec). Discharge lost due to evaporation and seepage resulted in loss of command areas (5.64ha) and 0.6ha per month respectively. Therefore, the value of conveyance efficiency taken directly from standard recommendations has great effect on the **overall structural performance (57.07%)** of the irrigation scheme. Water users next to the broken main canal (after 2.02km from the weir) become chanceless to irrigate their plot. 3.63lit/sec loss as seepage and evaporation loss **23.07lit/sec** flow of the main canal was lost as wastage or as mismanagement. Similarly**,** different **IWMI** literatures such as water resources and irrigation development in Ethiopia, authored by Seleshi Bekele Awulachew, Aster Denekew Yilma, Makonnen Loulseged, Willibald Loiskandl, Mekonnen Ayana and Tena Alamirew was indicated or showed the wider impact of irrigation on poverty and environment project, provided information and database on the water resources of Ethiopia, potential of development and extent of existing development focusing on irrigation development, identifies existing irrigation development categorized by various river basins and regions and Identifications were also made on schemes that are non-operational or transferred to community and private sector and their implication on performance.

_ The water committee is responsible for water allocation and distribution, coordinating maintenance activities and conflict management in the irrigation scheme with support from development agents and extension workers. Nevertheless, the water committee in the irrigation scheme is found to be inefficient in managing water distribution in terms of adequacy, timeliness and equity in the supply of water. In this small scale irrigation scheme, 35% of households did not obtain the amount of water they needed, 52.5% beneficiaries witnessed that enough water is not received due to mis utilization of water and the rest 12.5% of water users acknowledged that there is also inequity in water distribution between locations and between socioeconomic groups. The result indicated that access to adequate irrigation water is more unlikely if the beneficiary farmers' irrigable plot is in the tail-end area because of poor water management and water scarcity.

_ A significant number of beneficiaries (61.7%) faced a problem of water shortage for their agricultural activities. Water scarcity, poor coordination of water distribution, water theft and far farm location from the water source were the most important reasons for not obtaining the required quantity of water for irrigation over the command area of the irrigation scheme. There are also technical problems that negatively affected water distribution in the planned irrigation scheme. There are some areas in the command area of the scheme that are not reached with water because of **canal breakage and aqueduct destruction**. Farmers, who become hopeless of irrigation water reaching their field, cultivated the canal and buried some head drop structures to expand their agricultural field.

_ The research result revealed that conflict over irrigation water persistently occurs among the irrigators. The interviewed households reported that water scarcity at downstream or at end users, water theft and lack of proper control of water distribution as the responsible factors. The different indicators and interview results revealed that conflict over irrigation water and farm location from the water source has a significant relationship.

_ Clearance of the canals is undertaken by mass mobilization once in two, three or more months. Nevertheless, the irrigation beneficiaries defer or postpone major maintenance works that require input of expert skills and industrial product (e.g. cement) to the government agencies to do it for them. In the study area, no better operation and maintenance of the irrigation system was observed.

_ Although the river discharge was meant to irrigate 130 hectares of the vast command area, it is irrigating about 75 hectares on average and that is small as compared to the potential. The study identified that water scarcity, shortage of labor and the large plot possessed were the most important factors responsible for underuse of the potential irrigable land. **Similarly, (Habtamu W. 2011)**, on irrigation management practices in Tigray (The case study of Qorir small scale irrigation schemes, Klite-Awlalo woreda, Eastern Zone of Tigray). The result of his study showed that different water users didn't get water as per their need due to management problems. Water scarcity, poor coordination of water distribution, water theft and farm location from the water source, water scarcity, shortage of labor and shortage of oxen, the types of crops and vegetables and the number of farmers who grew a wide range of crops and vegetables have substantially increased after the introduction of irrigation and others observed in his study

_ since irrigation has positively affected farmers' livelihood through its effect on increased diversification and intensification of production, the development of well managed small scale irrigation systems that involves improved on-farm water management, organizational and other infrastructural development is required. As the study revealed, the types of crops and vegetables and the number of farmers who grew crops and vegetables have increased after the introduction of irrigation.

_ However, in the study area farmers faced constraints that hinder the production diversification. Such factors include weakness in water management, prevalence of disease because farmers have not regularly been supplied with improved adaptable seeds of vegetables and crops that work under irrigation (57.7%) and continuous decline in the amount of water (from 364lit/sec to 41lit/sec) conveyed into the scheme.

5.2. Recommendations

To enhance sound irrigation management practices and to maximize the socioeconomic benefits of Jemjem Small Scale Irrigation Scheme, the following recommendations are proposed:-

As can be seen in the result of hydrologic analysis, the 80% dependable flow of Jemjem River in certain dry years near to unmeet the Crop Water Requirement. Therefore, to take care of the uncertainties, mechanisms such as increasing environmental protection in the catchment in a form of mass involvement and reduction of command area when demand is greater than the available discharge in the river and select crops having less water requirement and provision or encouraging night distribution are important.

If preventative measurement is not taken on the increased value of Manning′s roughness coefficient while releasing of the total design discharge during the critical crop season, it will over flow the canal bank exceeding the free board designed. **Therefore, maintenance of canal from time to time is required and control gate should be installed on every canal head to control water to use it properly**. Moreover, watershed management of the catchment is recommended in order to decrease the amount of silt that deposited in the canal. Agronomic and technological transfer factors were not analyzed in this study. Therefore, the two factors must also incorporate in the future study. High value conveyance efficiency as obtained from different guidelines must not be applied without considering these factors.

· The water committee in the irrigation scheme is found to be inefficient in managing water distribution in terms of adequacy, timeliness and equity in the supply of water. Hence, strong institutional setup which can manage the system has to be developed or strengthening the existing one i.e. the existing water committee has to be transformed to Water Users' Association (WUA) and Periodical training and frequent follow up has to be conducted to Water Users' Association.

· Lack of regular supply and high price of inputs were one of the constraints of users for self management of scheme. The regional government, therefore, should take prompt measure to benefit inputs regularly at an affordable price to the irrigators.

· The major factors for the underperformance of Jemjem Small Scale irrigation scheme is water loss as a form of seepage and wastage, Poor coordination of water distribution and water scarcity. To reduce water loss problems, the earth canal should be lined with concrete and structures such as canal, flume, division boxes which are broken and cracked should be maintained with skilled man. Therefore, the sustainability of the scheme should be secured by reducing the seepage water loss rate and evaporation rate through expansion of lined canal and beneficiaries should introduce technologies that minimize water scarcity like drip irrigation.

· Decline in the quantity of water conveyed in to the canal since constructed has been observed. This may lead to progressive deterioration and collapse of irrigation in the catchment area. Hence, the Government and Non-government actors involved in small scale irrigation development should design means of enduring the sustainability of the agricultural activities using motor pump that can suck water from the underground. To ensure this, the integration among all stakeholders (regional or zonal irrigation authority, Woreda irrigation authority, kebele development office and beneficiaries) has to be strengthened.

· In the study area, water scarcity, shortage of labor and large plot of land possessed by a farmer were the most important factors responsible for the underutilization of the potential irrigable land. Hence, beneficiaries should take loan from the nearby credit service institutions to overcome such problems. Strong regulatory mechanism should be designed to overcome problems related to irrigation water to provide incentives to committed and disciplined farmers whereas disincentives to defaulters.

· The transport of water from a weir to the farms needs an efficient canal networks to tackle problems such as water logging and water scarcity. Hence, training should be given to farmers in techniques of water management, irrigated agriculture, and conservation of resources.

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Annexes

Annexes A-1 Laboratory Soil analysis result (secondary data)

Pit code	Depth (cm)	Ph	E.C	O.M	T.N	Av. P	Clay (%)	Silt (%)	Sand (%)	Texture Class
P1	0 -100	6.72	0.26	1.55	0.13	2.28	69	17	14	CL
P2	0 70	6.54	0.09	1.51	0.13	3.33	71	15	14	"
P2	70 -120	7.79	0.23	0.32	0.03	3.33	71	15	14	"
P3	0 - 50	7.47	0.16	1.19	0.10	0.50	73	11	24	"
P3	50 -100	7.70	0.15	0.28	0.20	3.00	63	19	18	"
P3	100 - 150	7.81	0.17	0.20	0.02	0.50	77	9	14	"

Source is feasibility study (July, 2012)

Annexes A-2 Summary of Monthly Data: Mean monthly Flow of Jemjem River												
Station Number : 031034												
Time-Series Type : Flow (cumecs)												
year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1966	0.074	0.107	0.100	0.402	0.062	0.488	4.298	12.019	8.216	0.711	0.167	0.099
1967	0.058	0.088	0.054	0.425	0.831	0.495	4.136	9.596	5.288	1.913	1.246	0.206
1968	0.078	0.298	0.128	1.368	0.228	0.599	4.779	6.484	4.417	1.116	0.167	0.162
1969	0.251	0.294	0.612	0.308	0.497	1.369	6.418	13.025	7.050	0.667	0.413	0.200
1970	0.069	0.229	0.600	0.263	0.058	0.317	7.890	13.194	7.641	2.447	0.226	0.125
1971	0.130	0.077	0.049	0.174	0.479	2.705	10.299	14.041	9.480	1.162	0.212	0.324
1972	0.116	0.319	0.219	0.335	0.296	0.225	4.824	6.315	2.492	0.279	0.118	0.083
1973	0.146	0.052	0.023	0.009	0.094	0.360	3.273	10.008	7.822	1.440	0.210	0.132
1974	0.132	0.074	0.179	0.176	0.084	0.234	4.475	11.071	4.664	1.063	0.184	0.091
1975	0.087	0.073	0.043	0.122	0.054	0.486	8.208	9.327	12.285	1.510	0.159	0.091
1976	0.073	0.042	0.101	0.073	0.186	0.488	3.237	8.943	3.442	0.239	0.159	0.085
1977	0.193	0.109	0.051	0.097	0.127	0.512	5.632	8.671	4.331	2.159	3.143	0.182
1978	0.102	0.170	0.148	0.135	0.112	0.581	4.316	9.235	5.015	0.966	0.183	0.125
1979	0.134	0.178	0.231	0.177	0.260	0.373	3.817	6.989	2.778	0.614	0.192	0.115
1980	0.069	0.079	0.112	0.081	0.057	0.441	5.533	9.996	3.671	0.407	0.099	0.062
1981	0.068	0.053	0.199	0.516	0.148	0.167	4.528	9.000	8.091	0.892	0.190	0.144
1982	0.102	0.133	0.101	0.175	0.201	0.296	2.178	8.261	3.549	1.710	0.208	0.133
1983	0.074	0.111	0.179	0.323	0.837	0.849	2.783	10.070	6.375	0.566	0.176	0.114
1984	0.089	0.052	0.057	0.030	0.063	1.208	4.819	5.960	4.742	0.312	0.084	0.056
1985	0.037	0.026	0.028	0.071	0.132	1.082	4.217	11.095	4.629	0.402	0.098	0.062
1986	0.036	0.045	0.097	0.169	0.203	0.956	3.114	7.108	4.652	0.729	0.093	0.060
1987	0.044	0.063	0.304	0.759	0.577	1.102	2.165	6.154	1.791	0.291	0.095	0.062
1988	0.044	0.040	0.032	0.075	0.069	0.392	2.903	11.151	7.838	0.875	0.139	0.087
1989	0.095	0.145	0.112	0.271	0.076	0.269	4.862	6.844	5.763	0.481	0.131	0.100
1990	0.068	0.247	0.236	0.427	0.084	0.390	3.581	8.801	5.159	0.699	0.129	0.085
1991	0.071	0.076	0.235	0.053	0.048	0.307	4.282	9.480	6.338	0.342	0.095	0.087
1992	0.076	0.154	0.074	0.138	0.141	0.511	2.964	8.168	5.887	0.686	0.150	0.115
1993	0.096	0.138	0.065	0.438	0.502	1.258	4.793	12.356	7.787	1.451	0.235	0.136
1994	0.103	0.066	0.072	0.114	0.097	0.545	3.032	7.816	5.395	0.757	0.176	0.109

1995	0.078	0.068	0.051	0.277	0.226	0.415	2.995	8.002	5.807	0.314	0.119	0.075
1996	0.137	0.047	0.213	0.472	0.546	2.805	7.398	14.231	6.220	0.547	0.184	0.128
1997	0.113	0.074	0.050	0.143	0.099	0.425	3.155	6.144	1.401	0.325	0.258	0.107
1998	0.149	0.085	0.279	0.128	0.41	2.246	6.93	10.457	8.554	2.66	0.555	0.286
1999	0.201	0.11	0.132	0.078	0.36	1.255	4.048	10.111	5.504	5.033	0.35	0.183
2000	0.138	0.111	0.121	0.159	0.146	0.261	3.051	10.023	5.109	2.869	0.304	0.211
2001	0.081	0.08	0.168	0.17	0.232	5.165	7.434	9.002	3.018	0.37	0.134	0.07
2002	0.124	0.062	0.097	0.083	0.053	0.155	2.927	3.512	1.459	0.22	0.11	0.255
2003	0.103	0.071	0.243	0.294	0.181	0.518	9.825	4.238	4.258	0.588	0.236	0.199
2004	0.086	0.182	0.112	0.477	0.331	0.717	5.067	13.139	4.815	1.416	0.096	0.057
2005	0.069	0.032	0.08	0.206	0.866	0.658	11.797	12.991	5.129	1.048	0.267	0.221
2006	0.13	0.117	0.252	0.564	0.276	1.156	11.033	10.37	5.802	0.793	0.343	0.1265
2007	0.239	0.231	0.216	0.232	1.778	8.42	12.439	11.725	6.282	1.178	0.089	0.032
2008	0.029	0.017	0.003	0.005	0.107	1.529	15.935	17.613	8.041	0.728	0.326	0.146
2009	0.130	0.097	0.052	0.104	0.117	0.214	3.172	15.363	6.883	0.702	0.155	0.159
2010	0.089	0.238	0.363	0.709	0.557	1.931	9.399	11.274	8.634	0.649	0.200	0.147
2011	0.126	0.061	0.155	0.065	0.219	1.444	4.585	12.833	7.053	0.605	0.206	0.110

Mean annual flow is **2.03m^3/sec** after correlated with Melka kunture Gauging Station of Awash River flow

Annex A-3 Interview Questionnaires formats

Table .1: Sexes of Household Heads and Their Participation in the Affairs of the Scheme

Do you ParticiPate in the affairs of the scheme?		Sex of the household head		
		Male	Female	Total
ResPonses	Yes			
	No			
	Total			

Table 2: Age and Level of Education of the Household Head

ResPonses		Level of Education o-f the Household head					
		Illiterate (can't read and write)	Can only read and write	Grade 1-4	Grade 5-8	Grade 9-12	Total
Edge of the house Hold head	18-28						
	29-38						
	39-48						
	49-58						
	59-68						
	Above 68						
	Total						

Table .3: Responses related to getting enough irrigation water and reasons for not getting enough irrigation water

Do you get enough water?		Frequency=	Percent	Remark
ResPonses	Yes			
	No			
	Total			
What are the major reasons for not getting enough water?		Frequency=	Percent	Remark
ResPonses	Water scarcity			
	Poor coordination of water distribution			

	Water theft			
	I am tail-end irrigator, Water does not reach			
	Total			

Table 4: Farmers' Response on Major Causes for Water Scarcity

If there is water scarcity, what are the most important causes for you?		Frequency N=-----	Percent	Remark
Causes	Seepage loss			
	Increasing number of users			
	Declining level of water from the reservoir			
	Poor scheduling of distribution			
	Total			

Table 5: Water Users' Opinion about the Performance of Water Committee in Water Distribution

What do you feel about the performance of the water committee in the management of water distribution		Frequency N	Percent
Opinions	Enough water is not received due to miss utilization of water (adequacy)		
	Water is not received when needed (timeliness)		
	Water distribution is unfair (equity)		
	Total		

Table 6: Farmer's Responses about Socioeconomic Groups That Get More Water in the Irrigation Scheme

If there is unfair distribution of water, which socioeconomic groups get more water in the irrigation scheme?		Frequency N=-	Percent	Remark
GrouPs	Farmers with large family			
	Farmers with large farmland			
	Rich farmers who grow perennials			
Total				

Table .7: Users' Opinion about Major Management Problems Related to Water Distribution

What are the major management problems related to water distribution?	Frequency N=	Percent	Remark

Opinions	Sanctions not imposed against illegal water users			
	Rotation does not accomplish equality			
	Rotation is not strictly implemented			
	Poor coordination of water distribution by Water committee			
	Total			

Table .8: Beneficiary Farmers' Response to the Presence and Causes of Conflict over Irrigation Water

Have you ever faced any conflict over irrigation water?		Frequency N=--	Percent	Remark
Responses	Yes			
	No			
	Total			
What are the causes for water conflict?				
Causes	Water theft			
	Water scarcity			
	Competition due to increasing number of water users			
	Lack of proper control of water distribution			
	Total			

Table .9: Farmers' Response on Conflict over Irrigation Water by Their Farm Location						
Have you ever faced any conflict over irrigation water?		Where is your farm location from the water source?				
		Upper catchment	Middle catchment	Lower catchment	Total	
ResPonses	Yes					
	No					
	Total					

Table.10: Farmers' Opinion about the Performance of Water Committee in Resolving Conflicts in the Irrigation System

How do you evaluate the performance of the water committee in resolving conflict?		Frequency N=-	Percent
Opinions	They take immediate actions on cases		
	Conflict management has been improved		
	They suspend cases		
	Total		

Table .11: Beneficiaries Opinion about the Maintenance of the Scheme

How do you evaluate the maintenance of the scheme?		Frequency N=	Percent
Opinions	Very good		
	Good		
	Acceptable		
	Poor		
	Very poor		
	Total		
If your answer is poor or very poor, what are the causes?		Frequency N=	Percent
Causes	Siltation		
	Poor imposition of sanctions on reluctant users		
	Absenteeism of some members on maintenance		

	days		
	Breaching of canals by illegal water users		
	Poor coordination of maintenance activities		
	Total		

Table .12: Farmers' Ranking of the Reasons for Underuse of Their Irrigable Land in 2008E.C.

Do you irrigate all of your irrigable land in 2009 E.C.?		Frequency	Percent	Rank
Responses	Yes			
	No			
	Total			
What are the major reasons for under use of your irrigable land?		Frequency	Percent	Rank
Responses	Water scarcity			
	Shortage of oxen			
	Unreliable access to water			
	Shortage of labor			
	The plot I possess is large			
	Total			

Table 13: Comparison of Agricultural Diversification Before and After Irrigation

Crops and vegetable	**Before**		**After**		**Remark**	
	Frequency	Percent	equency	Percent	X2-value	
Maize						
Potato						
Tomato						
Onion						
Gurlic						
Cabbage						
Pepper						

Table 14: Irrigation Beneficiaries' Response on the Frequency of Harvest in a Year				
How many times do you produce in a year by applying irrigation?		Frequency	Percent	Remark
ResPonses	Once			
	Twice			
	Thrice			
	Total			

Table 15: Farmers' Responses on Crop Failure and Perceptions on Possible Causes of Crop Failure

Have you ever faced a problem of crop failure while you are using irrigation?		Frequency	Percent	Remark
Responses	Yes			
	No			
	Total			
What are the possible causes for crop failure?				
Causes	Water shortage			
	Damaged by disease			
	Poor adoption of varieties used			
	Total			

Table .16: Farmers' Response about Support Received From DAs			
Do you get support from DAs			
Responses	Yes	Frequency	Percent
	No		
	Total		
What are the supports you received?		Frequency	Percent
Supports	Advice		
	Training		
	Demonstration		
	Conflict resolution		

	Controlling water distribution		
	Total		

Table .17: Farmers' Response about Credit Service for Their Agricultural Activities

Do you get an access to credit?	Yes	Frequency	Percent
Responses			
	No		
	Total		
What are the sources of credit?		Frequency	Percent
Sources	Cooperatives		
	Local lenders		
	Neighbors and relatives		
	Microfinance		
	institutions		
	Total		

Annex -B Dated photos of observed field features

Figure B-1 Division box without gate or uncontrolled **water (Jemjem SSIP)**

Figure B-2 Main canal discharge measurement of Jemjem SSI

Figure B-3 **One of furrow irrigation of tomato Plant (Jemjem SSIP)**

Figure B-4 Veiw of demolished aqueduct in nonfunctional Part of **Jemjem SSIP seen during the study**

Figure B-5 **90 degree v- notch weir prepared for canal discharge measurement**

Figure B-6 canal flow before discharging over the weir during the measurement

Figure B-7 **One of pump irrigations on the opposite side of the Jemjem River**