# Performance Evaluation of Farmers Managed Small-Scale Irrigation: The Case of Fultino Small-Scale Irrigation Scheme in Ada'a District of East Shoa, Oromia

Desta Abera Shanko

A Thesis Submitted to

The Program of Water Resources Engineering

School of Civil Engineering and Architecture

Presented in Partial Fulfillment of the Requirement for Degree of Master`s in Irrigation Engineering

Office of Graduate studies

Adama Science and Technology University

March, 2018

Adama, Ethiopia

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## Declaration

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

Name: Desta Abera Shanko

Signature:_____________________

This MSc thesis has been submitted for examination with our approval as thesis advisors.

Name: Mengistu Sime (PhD)

Signature: __________________

Name: Mekonen Ayana (PhD)

Signature: __________________

Date of submission: ______________

## DEDICATION

This thesis manuscript is dedicated to my **beloved wife, KURI ABEBE AND MY SONS ABEL DESTA AND ALAZAR DESTA,** for their love and sacrifice in the success of my life.

## BIOGRAPHICAL SKETCH

The author was born in November 16, 1985 in Kembata Tembaro Zone, Doyogena District, Ancha Sedicho Kebele. He attended his elementary education in Minatofa elementary school, and senior secondary school at Ayer Tena Senior Secondary School, in Addis Ababa. In 2003, he completed his high school education and joined Haramaya University and graduated with BSc degree in Soil and Water Engineering and Management in July, 2006. He was firstly employed as a Soil and Water Conservation expert and worked for 7 months in Kembata Tembaro Zone, Doyogena District. From May, 2007 to July, 2013; he worked different sectors at head position in the Doyogena District.

From September 2012 to yet, he has been working in F.D.R.E Ministry of Science and Technology (MoST) as a Director, Policy Research and Future Planning. In October 2016, he was joined to the Program of Graduate Studies of Adama Science and Technology University for his M.Sc. study in Water Resources Engineering Program /Irrigation Engineering/.

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## Approval of Board of Examiners

We, the undersigned, members of the Board of Examiners of the final open defense by Desta Abera have read and evaluated his thesis entitled " Performance Evaluation of Farmers Managed Small-Scale Irrigation: The Case of Fultino Small-Scale Irrigation Scheme in Ada'a District of East Shoa, Oromia" and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirement of the Degree of Maser in Irrigation Engineering.

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# ABSTRACT

*The critical purpose of small-scale irrigation scheme performance evaluation is to determine overall performance or to determine the satisfaction level of the scheme or not and, if not, which and where different actions need to be taken in order to remedy the condition. It should offer understandings into the process of irrigation so that managers, farmers, and planners can do activities in new, more fruitful and efficient ways. The major objective of this study was to evaluate the overall performance of Fultino small scale irrigation scheme using selected IWMI performance evaluation indicators from February 2017 to November 2017. Primary data were collected from five water users' association field based at the upper, middle, and downstream of the main canal. Discharge measurements and soil sample analysis were conducted, and secondary data were collected from Ada`a Woreda Bureau of Agriculture, Water, Energy and Mine and Transport and Administration. CROPWAT 8.0 computer model was used to calculate the crop water requirements, rainfall and effective rainfall. From the analysis of data, the indicative values of the output per unit command area for Fultino were 12,600,000 Birr/ha. Similarly the output per unit cultivated area for the scheme was 9,521,897 Birr/ha obtained from the major crops, namely onion, tomato, pepper, maize and sugarcane. The output per unit water consumed was 12.8 Birr/$m^3$ and the results of application efficiency, distribution efficiency, conveyance efficiency and water productivity are 75%, 73.4%, 75.96% and 4.314 kg/$m^3$, respectively. Conferring to these findings, it can be concluded that expected results are not such a satisfactory in case of water distribution efficiency, conveyance efficiency and water allocation and equity. It is recommended that all activities in the irrigation system should be monitored and checked, technical requirements should be met, training and extension should be enhanced, evaluation should be performed on a seasonal basis and the results should be delivered to the important stakeholders and organizations with well-organized monitoring and evaluation system. Water users associations and cooperatives that embark on the operation and management of irrigation scheme should be authorized.*


Keywords*:* ***Small Scale Irrigation, Performance Indictors, Productivity Indictors***

# ACRONYMS

| | |
|---|---|
| AD | After Death of Christ |
| ADLI | Agricultural Development Lead Industrialization |
| AfDB | African Development Bank |
| AWM | Agricultural Water Management |
| BC | Before Birth of Christ |
| BCM | Billion Cubic Meters |
| CP | Collaborative Programme on Investment in Agricultural Water for Poverty Reduction and Economic Growth in Sub-Saharan Africa |
| CPM | Country Programme Manager |
| CSA | Central Statistical Agency |
| DAs | Development Agents |
| FAO | Food and Agriculture Organization of the United Nations |
| GDP | Gross Domestic Product |
| GTP | Growth and Transformation Plan |
| GoE | Government of Ethiopia |
| ICT | Information Communication Technology |
| IFAD | International Food and Agriculture Department |
| IWMI | International Water Management Institute |
| MoFED | Ministry of Finance and Economy Development |
| MoWIE | Ministry of Water, Irrigation and Electric |
| MoA | Ministry of Agriculture |
| NGO`s | None Governmental Organizations |
| PTA | Policy and Technical Advisory Division |
| RIMS | Results and Impact Management System |
| SPA | Special Programme for Sub-Saharan African Countries Affected by Drought and Desertification |
| SSA | Sub-Saharan Africa |
| SWC | Soil and Water Conservation |
| SSI | Small Scale Irrigation |

# Glossary of Local Terms

| | |
|---|---|
| Abba Ganda | Community Leader |
| Abba Affosha | Community associations leader |
| Malaqa | Community water association leader for water distribution |
| Fagee | Improved maize variety |
| Mangudo Bishaani | Committee of elders represent able for irrigation water |
| Bulchinsa fi Haqa | Administration and Justice the three justice committee |
| Kert | Local unit of measurement equivalent to 0.125 ha |

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# 1. INTRODUCTION

## 1.1 Background

In Sub-Saharan Africa, agriculture accounts for approximately 70% of the economically active population and it remains a very important social and economic sector. In this part of the world, rain-fed agriculture is largely dominant: food security and income of rural populations are vulnerable to rainfall variability, and food production is often less than the requirements of growing population (FAO, 2006). The Agriculture (crop production) system in Ethiopia is dominated by smallholders on highly fragmented pieces of lands. These smallholders agriculture is mainly based on rainfed farming depending on highly variable less predictable rainfall. The rainfall distribution is erratic in both its spatial and temporal distribution. Rainfed agriculture remained to be a risky production system which made productivity to be extremely low and left farmers highly vulnerable. Unreliable rainfall aggravated by the impacts of climate change among others has indeed been a key challenge of the Ethiopian agriculture (MoA, 2015).

The volatile rains and soil degradation partly explain the stagnation of agricultural yields, one cause of the chronic food deficit (FAO, 2006). Irrigation development has been identified as an important tool to stimulate economic growth and rural development, and is considered as a cornerstone of food security and poverty reduction (Awulachew, 2010).

Ethiopia has a long history of traditional irrigation systems. Simple river diversion still is the dominant irrigation system in Ethiopia. According to Gebremedhin and Peden (2002), the country's irrigation potential ranges from 3.5 to 5.1 million hectares but the recent studies indicate that the irrigation potential of the country is higher. Similarly, Tilahun and Paulos (2004) as cited by Awulachew *et al.* (2010) pointed, estimates of the irrigation potential of Ethiopia may be as large as 5.1 million hectares. Traditional irrigation schemes cover more than 138,000 hectares whereas modern small-scale irrigation covers about 48,000 hectares.

The main purpose of irrigation development in the 1960s in Ethiopia was to provide industrial crops to the growing agro-industries in the country. The irrigation potential of Ethiopia is estimated at 5.3 million ha including rainwater harvesting and groundwater irrigation (Awulachew, 2010 and MoWIE, 2015). The land and water resources of the country are little utilized for irrigation development and a lot remains to be done in terms of expansion. There is no adequate data for the small-scale irrigation (SSI) potential of the Ethiopia. However, about 2.4 million ha has been irrigated under small-scale irrigation including traditional schemes (MoA, 2015).

According to MoWIE (2015) the area irrigated under medium and large irrigation schemes is around 1.5 million ha, which indicates that from total irrigation potential of the country seven to eight percent of the total medium and large irrigation scale potential has been developed. Although the small-scale irrigation development seems increasing at a faster rate, a lot remains to be done in medium and large scale irrigation development.

Recently, the government of Ethiopia has put large emphasis to irrigation expansion which is well reflected in the development plans of the country. According to the five years plan of irrigation sector of Ethiopia(2016-2020). Additional medium and large scale irrigation schemes up to the end of Growth and Transformation Plan (GTP II) is more than 1.5 million ha (MoWIE, 2015). The area planned to be irrigated under small-scale irrigation schemes is also estimated to reach four million including river diversion, shallow groundwater and rainwater harvesting.

Classification of irrigation development in Ethiopia can be made based on scheme management and scale. According to Desalegn (1999) and MoWE (2002), irrigation schemes in Ethiopia are classified into four categories (typologies): i) Traditional SSI schemes: - these are generally initiated and implemented by the community, do not generally have permanent water acquisition structures, and are community-managed. ii) Modern communal irrigation schemes: - these are constructed by the government, NGO's, development partners, etc. and generally consist of permanent water control, structures. These are managed either by the community or dual-managed. iii) Modern private irrigation: these are mainly commercial Agricultural Water Management (AWM) projects by private investors. iv)Public irrigation: these are generally large-scale irrigation schemes growing industrial crops; and are implemented and managed by public enterprises. Based on scale (irrigated area), irrigation development in Ethiopia is classified into three (MoWE, 2002). These are small scale irrigation (less than 200 ha), medium scale irrigation (200-3,000 ha) and large scale irrigation (larger than 3,000 ha).

Surface irrigation is a major irrigation practice in the country in all scales. Pressurized irrigation (sprinkler and drip) is less practiced that accounts for less than 1% of the total irrigated area

(MoWIE, 2016).The small-scale irrigation users (irrigators) are not try to use modern types of irrigation types like sprinkler, drip and center pivoted irrigation methods.

In irrigation development more emphasis is given to the construction of infrastructure while the management aspect of irrigation (performance evaluation) is often neglected. According to Woldeab (2003) for the community based (farmers` managed) small scale irrigation systems to be successful, the interaction of both performance and physical aspects of irrigation is very important to evaluate the whole system of irrigation scheme.

This study, is therefore, aims at evaluating the performance of Fultino small-scale irrigation scheme in Ada'a district, which intends help to generate information and increase understanding to assist in future planning and development of farmers managed small-scale irrigation schemes.

## 1.2 Statement of the Problem

Even if Ethiopia has a substantial potential for irrigated agriculture assessed both from available land and water resources view point, the bulk of this potential is still not utilized (MoWR, 2010).The government of Ethiopia to expand irrigation of all categories including rain-water harvesting with the prime purpose of overcoming the problem of food insecurity, extreme rural poverty, and to promote economic dynamism (MoWR, 2010). In line with the development objective of the country also promoting irrigation sector by SSI development, to increase and stabilize food production in the country.

It was with this aim that Fultino small scale irrigation scheme was developed from traditional water use to modern scheme in Fultino, Kofitu, Godino Peasant association (PA), Ada`a District, East Shoa Zone of Oromia Region with the budget from Oromia regional government in 2007. The command area and beneficiaries are 85 ha and 475 household (HH) respectively (OIDA, 2007).

The main aim of irrigation scheme was to improve farmer welfare, if scheme are designed properly, constructed properly and managed according to specific set of key management objectives, which must be achieved within the context of effective organizational coordination and farmer participation (OIDA, 2007). But, the aforementioned farmer participation and effective organizational coordination is not practiced.

One of the main challenges of the intervention in SSI development made in Ethiopia in general and in Oromia in particular, focused only on improving and expansion of the physical structure of existing traditional small-scale irrigation schemes. That is why performance and sustainability of existing small scale irrigation scheme is not as anticipated as the planning and appraisal stages (Leliso, 2008). This is a dilemma for professionals in the water sector that the country's limited resources are allocated to reduce the chronic food security problem, but could not result in the desired change. Eventually, this is an area of concern regarding what should be done and what type of strategic plan to be developed in the future. Many researches have been done on performance evaluation of small scale irrigation project; but most of them were focus on physical and technical evaluation of the scheme. Since irrigation system varies depending on the prevailing practice, environmental and social conditions, factors affecting the continued use of irrigation projects in the background of limited resources are not adequately and systematically studied in the study area.

Hence, it is clear that there is a lot to be done in search for some set of performance, institutional and economical practices. Particularly whether the system will continue to exist and function, at least for the time intended during the planning stage of the project by understanding the past and current situation of the scheme.

Therefore, this specific research was designed to generate location specific data on performance of irrigation scheme in the study area.

### 1.3 Scope of the Study

This study has covered the performance evaluation of Fultino small-scale irrigation scheme which is found in the Ada`a District to evaluate and identify the gaps and performance of existing scheme by using field measurements on water use efficiency, water application efficiency, conveyance efficiency ,water resource availability ,irrigation intervals and irrigation scheduling ,and analysis the main irrigation performance using selected integrated water management institute (IWMI) indictors based on data availability by means of field measurement, interview ,observation and questioners in the district on small-scale irrigation.

## 1.4 Objectives of the Study

### 1.4.1 General objective

The major objective of this study was to evaluate the performance of Fultino farmers managed small-scale irrigation scheme using selected integrated water management institute (IWMI) indictors.

### 1.4.2 Specific objectives

The specific objectives of the study were to**:**

- identify the major performance gaps in the irrigation scheme;
- measure and evaluate the performance of the scheme using selected performance indicators (water application efficiency , conveyance efficiency, productivity and water equity),and
- propose performance improvement measures in the district.

## 1.5 Research Questions

Based on the above study purposes, the following research questions were formulated.

- What are the major performance gaps facing on small-scale irrigation scheme for the development/practices of small-scale irrigation at farmers' level in the study area?
- What is the level of the performance of the scheme as measured using selected indicators?
- Is there a way to further improve the performance of the scheme?

# 2. LITERATURE REVIEW

## 2.1 Irrigation Performance

Irrigation is defined as the artificial application of water onto cropland for the purpose of satisfying the water requirements necessary for growing different crops and plays a key role in stabilizing food production in a number of countries by either supplementing or replacing the need for natural precipitation for the purpose of food production (FAO, 2010).

Again, FAO (2010) defines irrigation modernization as a process of technical and managerial upgrading (as opposed to mere rehabilitation) of irrigation systems combined with institutional reforms, with the objective to improve resource utilization (labor, water, economic, environmental) and water delivery service to farmers (FAO, 2010 in FAO, 2010).

From the above discussions one can understand that, irrigation facility is the physical structure, performance of the whole system that brings social and environmental component together for bringing efficient development.

## 2.2 Performance Evaluation in Small-Scale Irrigation Scheme

### 2.2.1 Definition of performance evaluation

Small and Svendsen (1992) is represented performance by the outputs from the system as opposed to the performance achieved in managing available resources towards specified goals. The distinction could perhaps be better demonstrated by referring to operational performance and strategic performance. Operational performance is the degree of fulfillment of either a specific quantified output target, typified by such things as yield, water use efficiency, or cropping intensity, or a specific input target such as discharge, water level or timing of irrigation deliveries.

According to Abernethy (1989**)** performance evaluation is ratio of output to inputs. At any given location a time series analysis of real values may be the most useful measure of performance, but dimensionless ratios are more effective in comparing performance at different locations during the same time period. Strategic performance looks at the process by which available resources are utilized in order to fulfill the eventual outputs of the system, and involves assessment of the procedures by which, targets are set in relation to both available resources and the objective setting process. This means that it includes evaluation of performance of individuals in matching objectives and targets, in identifying and utilizing performance parameters that effectively reflect those objectives, and in responding to unexpected changes in resource availability. While assessments on managerial performances are less neutral and more individual than of output performance. It may more clearly identify ways in which performance can be improved.

### 2.2.2 Importance of performance evaluation

Performance evaluation importance in irrigation schemes are performance measure, observation, documentation and interpretation of activities related to irrigated agriculture with the objective of continuous improvement. Performance evaluation is an activity that supports the planning and implementation process. The ultimate purpose of performance evaluation is to achieve an efficient and effective use of resources by providing relevant feedback to the management at all levels. As such, it may assist the project management in determining whether the performance is satisfactory and, if not, which and where corrective or different actions need to be taken in order to remedy the situation. It should provide insights into the process of irrigation so that managers, farmers, and planners can do business in new, more productive and efficient ways (Murray-Rust and Snellen 1994).

Performance assessment can be used in a variety of ways, including operational performance evaluation by managers to determine how the operational processes are performing, strategic performance evaluation to understand how a system or organization is performing and using available resources; diagnostic performance assessment to understand the causes of low or high performance; as a prelude to design and implementation of interventions for system improvement and rehabilitation; comparative performance assessment and benchmarking to compare performance to set appropriate benchmark standards and identify processes that lead to higher performance, assessing impact of irrigation and supporting adaptive management. A systematic and timely flow of actual data on key aspects of a project is an essential condition for the monitoring of performance to become an effective management tool. This data should provide sufficient information for the managers to answer two simple questions (Murray-Rust &

Snellen 1994). The adoption of sustainable water management and irrigation development programs, as well as strong linkages with private sectors and markets with institutional support are essential; these could provide plenty of opportunities in terms of a coping strategy for climatic change, poverty reduction, wealth creation, growth of economy and reducing the environmental impact of agricultural expansion to marginal land under rapid population growth (Awulachew, 2005 and 2008, Mekonnen and Kidane, 2015). SSI development is one of the components of water resource development. Ethiopia has large water potentials that could be used for a wide range of irrigation development programs.

According to Molden et al. (1998), performance is assessed for a varieties of reasons to improve system operations, to assess progress against strategic goals, as an integral part of performance-oriented management, to assess the general health of a system, to assess impacts of interventions, to diagnose constraints, to better understand determinants of performance and to compare the performance of a system with others or with the same system over time. The type of performance measures chosen depends on the purpose of the performance assessment activity.

### 2.2.3 Development of small scale irrigation in Ethiopia

Modern irrigation was started in the early 1950's by the bilateral agreement between the government of Ethiopia and the Dutch company jointly known as HVA-Ethiopia sugar cane plantation (MoA, 2011a; Bekele et al., 2012). Most of the traditional irrigated lands in Ethiopia are dominantly supplied by surface water sources, while ground water uses has just been started on a pilot basis in the East Amhara region (MoA, 2011a). According to MoA, (2011a) pressurized sprinkler irrigation system was once practiced in Fincha State Farm, Eastern Amhara, Southern Tigray and on some private farms in the Rift Valley. The rift valley is a place where modern irrigation in Ethiopia starts especially in the Awash River Basin at which adoption of pump-irrigation commences. Surface irrigation methods predominantly furrow irrigation and basin irrigation methods were practiced for cotton and wheat productions and for commercial fruits such as bananas respectively.

Meanwhile, similar reports such as Awulachew et al. (2007) explained that irrigated agriculture was started in Ethiopia in the upper Awash Valley with the objective of producing industrial crops as sugarcane, cotton and horticultural crops on a large-scale basis, explained in a remarkable emergence of irrigation development and establishment of agro-industrial centers.

This was due to taking an advantage of the construction of Koka dam aimed as a reservoir irrigation water supply, flood control and hydropower generation. During the mid1970s, windmills and hand pumps were introduced to lift water from groundwater for drinking water supply, domestic and gardening purposes (MoA, 2011a). According to the Ministry of Agriculture, In Ethiopia, there were modern water storage and water management systems for irrigation purposes. This includes water diversion schemes, water storage dams, and micro irrigation systems, rainwater harvesting and shallow ground water harvesting techniques. These systems make use of different water drawing irrigation technologies for lifting, conveying and applying irrigation water for irrigation uses. Night water storage facilities, Treadle pumps for lifting water, smallholder drip systems and micro- sprinklers for irrigation application are used among others (MoA, 2011a).

Makombe et al. (2011) noted that irrigation development is a key for sustainable and reliable agricultural development which leads to overall development in Ethiopia. Irrigated agriculture is being practiced under smallholders, medium and large scale farming. Many authors such as Awlachew et al. (2007), Makomb et al., (2007), Hagos et al. (2009), Bacha et al. (2011) were used government based irrigation schemes classification systems for their description during their studies

### 2.2.4 Selected performance evaluation indicators

It is useful to consider an irrigation system in the context of nested systems to describe different types and uses of performance indicators (Small and Svendsen 1992). An irrigation system is nested within an irrigated agricultural system, which in turn can be considered part of an agricultural economic system. For each of the systems, process, output, and impact measures can be considered. Process measures refer to the processes internal to the system that measures describe the quality and quantity of the outputs where they become available to the next higher system.

Many authors have proposed indicators to measure irrigation system performance as summarized by Rao (1993) and have given examples of their use at particular irrigation systems (Bos and Nugteren 1974). Recent studies have attempted to standardize these indicators to allow for better comparison across systems (Bos et al., 1994).

Nine indicators are developed by International Water Management Institute (IWMI) related to the irrigation and irrigated agricultural system. The main output considered is crop production, while the major inputs are water, land, and finance. Output per unit of irrigation water supplied and output per unit of water consumed are derived from a general water accounting framework (Molden 1997). The water consumed, in this case is evapo-transpiration.

It is important to ensure that the indicators selected for a system will describe performance in respect of the objectives established for that system. It is this process that links the use of indicators to the overall performance assessment framework (Bos et al., 1993). Failure to take this into account may lead to managers being assessed in terms of activities that were not included in their initial brief. A good indicator can be used in two distinct ways. It tells a manager what current performance is in the system, and, in conjunction with other indicators, may help him to identify the correct course of action to improve performance within that system: in this sense the use of the same indicator over time is important because it assists in identifying trends that may need to be reversed before the remedial measures become too expensive or too complex.

2.2.4.1 Productivity indictors

Relative irrigated area is the total area under irrigation versus total designed command areas of already implemented irrigation projects during a particular year or averaged over years in the country or region.

*2*.2.4.2 Beneficiaries performance indictors

Beneficiaries target performance is the ratio of actual number of beneficiaries using irrigation schemes and planned or targeted number of beneficiaries. This is applicable mainly to community-owned schemes in the country or region. For capturing the potential of irrigation, we used secondary data sources based on master plan studies and review of literature. For the assessment of broad national performance, using database developed for this purpose according to Awulachew *et al.* (2007).

Analysis of causes of underperformance of small-scale irrigation performance indicators were 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.

Structural (hardware) performance are relates to the number of structurally functional schemes to total number of schemes implemented during the period. Social and institutional (management) performance is the ratio of number of managerially functional schemes to that of total schemes implemented (Robel, 2005 and Girma, 2006).

### 2.2.5 Water delivery indictors

Determined based on irrigation and water supply measurements being related to demands. This includes conveyance efficiency, Irrigation efficiency and Relative irrigation supply (RIS).

#### 2.2.5.1 Conveyance efficiency

Effective conveyance ratio (CE) represents the capability of a canal reached to carry water with loss, while the conveyance loss (L) is the amount of losses occurred in the specified length of canal reaches.

Conveyance efficiency is defined as the ratio of the amount of water delivered at the turnouts of the main irrigation conveyance network to the total amount of water diverted into the irrigation system or simply it is the ratio of outflow rate to inflow rate of a system. It is one of closely related and commonly used output measures of performance that focus on the physical efficiency of water conveyance by the irrigation system (Bos, 1997). Bos *et al*. (1994) stated that the change of the ratio is an indicator for the need of maintenance. Quantifying the outflow over inflow ratio for only one month gives information to the system manager provided that a target value of the ratio is known. A regular repetition of the measurement allows the assessment of the trend of an indicator in time. This assists the manager in identifying trends that may need to be reversed before the remedial measures become too expensive or too complex. Losses of irrigation water occur during convey of water from the head of a canal to the farm plot. In open canals, such losses take place primarily due to evaporation and seepage. About 10 to 15% of the water admitted in to a canal can get lost in this way (Mazumder, 1983).

2.2.5.2 Water delivery performance

The simplest, and yet probably the most important, hydraulic performance indicator is (Clemmens & Bos 1990; Bos et al. 1991):

$$\text{Water delivery performance} = \frac{\text{actually delivered volume of water}}{\text{intended volume of delivered water}} \qquad 2.1$$

This measure enables a manager to determine the extent to which water is delivered as intended during a selected period (may range from second to year) and at any location in the system. The primary utility of the water delivery performance ratio is that it allows for checking of whether the flow at any location in the system is more or less than intended. It is obvious that if the actually delivered volume of water is based on frequent flow measurements, the greater the likelihood that managers can match actual to intended flows. Over a sufficiently long time frame (e.g., monthly, or over three or four rotational time periods) it can be assumed that; if the water delivery performance ratio is close to unity, then the management inputs must be effective. If the water delivery performance ratios for different units within the considered command area have about the same value, the uniformity of water delivery must (because of the concept of conservation of mass of the available water resources) be good. The uniformity of actual water delivery may be quantified by calculating the standard deviation of the water delivery performance (WDP) values.

2.2.4.3 Irrigation efficiency

The ICID (1978) standard definition for the field application ratio (irrigation efficiency), Ra, is

Irrigation Efficiency = $Ra = Vf/Vm$ 2.2

Where, Vm = the volume of irrigation water needed, and made available, to avoid undesirable stress in the crops throughout (considered part of) the growing cycle.

Vf = the volume of irrigation water delivered to the fields during the considered period.

The value of Vm is difficult to establish on a real time basis because many complicated field measurements would be needed. The method which is used to quantify Vm, however, is not so very important provided that the same (realistic) method is used for all command areas (lateral or tertiary units) within the irrigated area. For practical purposes we may assume that Vm equals the evapo-transpiration by the irrigated crop minus the effective part.

### 2.2.6 External performance indictors

The four basic selected performance indicators relate output to unit land and water. These "external" indicators provide the basis for improvement of irrigated agriculture performance. Where water is a constraining resource, output per unit water may be more important, whereas if land is a constraint relative to water, output per unit land may be more important (Clemmens and Bos 1990; Bos et al., 1991):

i) Output per cropped area (birr/ha)

$$= \text{production}/_{\text{irrigated crop area}} \qquad 2.3$$

Output per unit command (birr/ha)= $production/command\ area$ 2.4

iii) Output per unit irrigation supply (birr/m$^3$)

$$= production/delivered\ irrigation\ supply \qquad 2.5$$

iv) Output per unit water consumed (birr/m$^3$) =

$$production/volume\ of\ water\ consumed\ by\ ET \qquad 2.6$$

Output per unit of irrigation water supplied and output per unit of water consumed are derived from a general water accounting framework (Molden 1997).

### 2.2.7 Internal performance indictors

It is valuable to consider an irrigation system in the situation of nested systems to describe different types and uses of performance indicators (Small and Svendsen 1992). An irrigation system is nested within an irrigated agricultural system, which in turn can be considered part of an agricultural economic system. For each of the systems, process, output, and impact measures can be considered. Process measures refer to the processes internal to the system that lead to the ultimate output, whereas output measures describe the quality and quantity of the outputs where they become available to the next higher system (Molden *et al.*, 1998). According to Molden et al. (1998) much of the work to date in irrigation performance assessment has been focused on internal processes of irrigation systems. Many internal process indicators relate performance to management targets such as timing, duration, and flow rate of water; area irrigated; and cropping patterns.

Kloezen and Garces (1998) had reviewed different literatures and summarizes that process indicators help system managers to monitor the quality of daily and seasonal operational performance but do not allow to assess the importance of irrigation in a given system, at different system levels, in a given season, and with a specific water source relative to other systems, levels, seasons, or irrigation sources. Numerous studies focus on the definition of a number of process indicators.

Common indicators defined in the literature include:-

- ❖ Conveyance, distribution, field and application, and schemes efficiencies;
- ❖ Reliability and dependability of water distribution;
- ❖ Equity or spatial uniformity of water distribution; and
- ❖ Adequacy and timeliness of irrigation delivery

A major purpose of this type of evaluation is to assist irrigation managers to improve water delivery service to users. Targets are set relative to objectives of system evaluation, and performance measures tell how well the system is performing relative to these targets. Generally, indicators are used to evaluate actual irrigation performance relative to scheme-specific management goals and operational targets.

# 3. MATERIALS AND METHODS

## 3.1 Description of the Study Area

### 3.1.1 Location and demography

The study was conducted in Ada`a district on Fultino small scale irrigation scheme, which is found in Oromia National Regional State of East Shoa Zone, Ethiopia. During irrigation season from February 2017 to November 2017. The catchment covers a total area of 185 ha. The dominant soil type in this area is clay and clay loam soil. The area starting from the lower right end of the catchment and up to the central periphery is dominated by clay and clay loam, with average dominant soil depth of less than 30cm.

Geographically, the study area is located at $8^{0}35`$N and $38^{0}55`$E and having an altitude ranges from1500 to over 2000 meters above sea level. The water bodies of the district include five crater lakes namely; Lake Bishoftu, lake Hora, Lake Bishoftu Guda, Lake Koriftu and the seasonal Lake Chelalaka, and important forests including government protected Dirre-Garbicha, Tedecha and community forests. The land uses in this district shows that about 51% was arable or cultivated, 6.4% pasture,7.4% in community, regional and national forests and the remaining 34.8% is considered degraded or others uses, unusable. The main crops grown in the district were legumes, cereals (mainly teff and wheat), sugar cane, different fruits and vegetables, etc.

Ada`a District is part of the former Ada`a Chukala district that was divided between current Ada`a district. The Ada`a district is bordered on the south by Dugda Bora, on the West by West Shoa Zone, on the northwest by Akaki, on the northeast by Gimbichu and on the East by Lome. The 2007 National Census a total population for this district was 130,321 of whom 67,869 were men and 62,452 were women, none of its population was urban dwellers. On the other hand, based on figures published by the Central Statistical Agency (CSA, 2005) Ada`a Chukala had an estimated total population of 355,343 of whom 175,788 were men and 179,555 were women,142,866 or 40.21% of its population were urban dwellers, which is greater than the Zone average of 32.1% with an estimated area of 1,635.16 square kilometers.

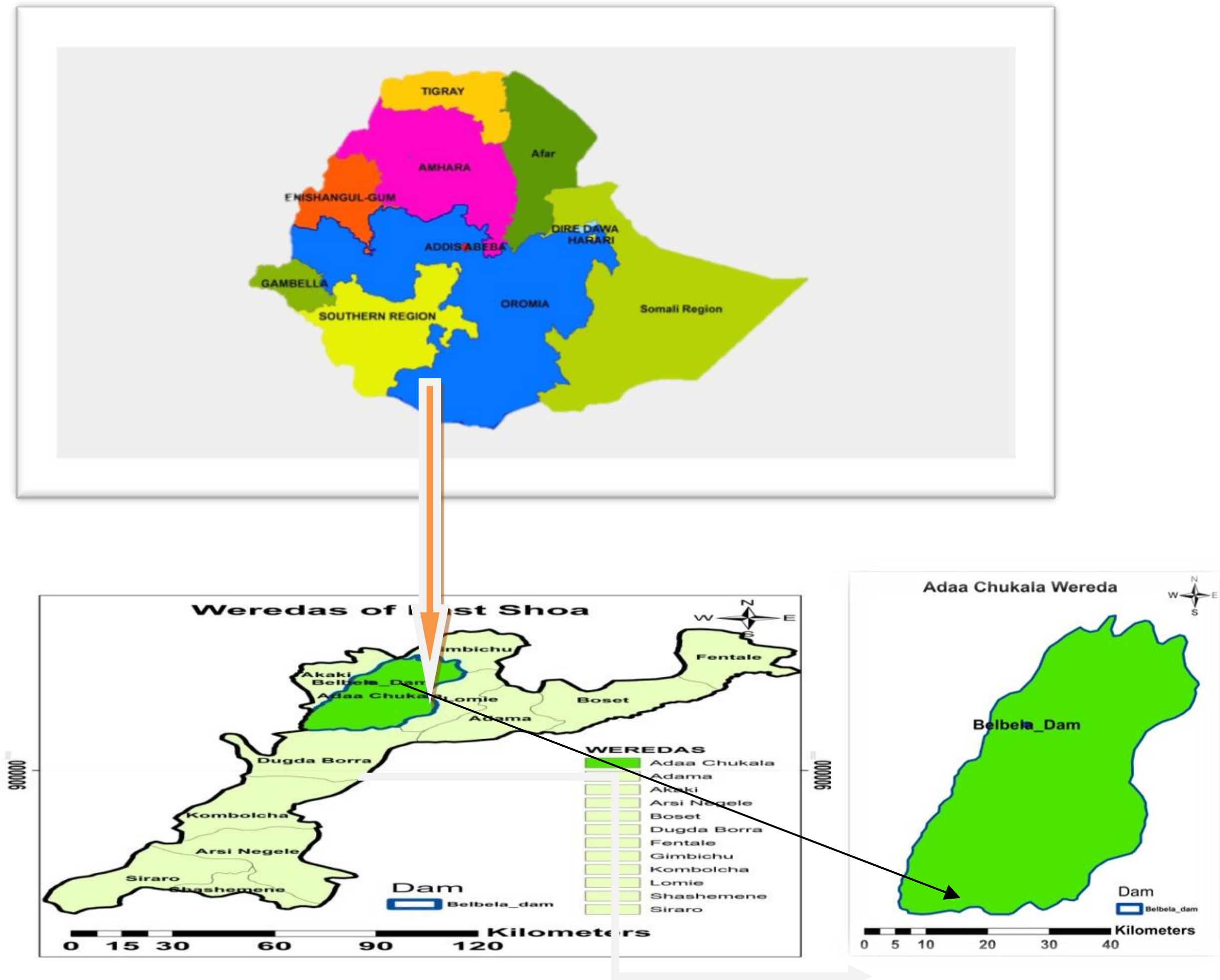
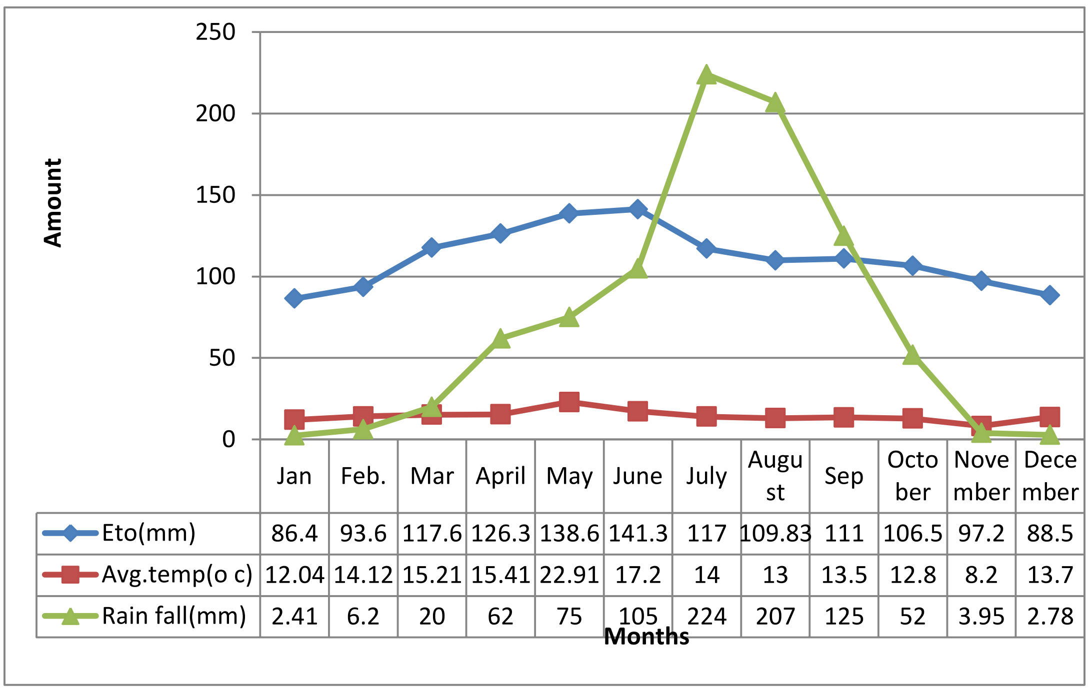



Fig 3.1 Location map of the study area

### 3.1.2 Climate Condition of the Study Area

The Ada'a Woreda is divided into three climatic and topographic variations: the highlands (including Tulu Dimto, Kajima, Gerbicha, and the northern quarters of Liben and Zukala), the rift valley area (covering the southern sub-districts of Zukala and Liben), and the mountain zones (Zukala and Yerer). The villages of Sirba and Godeti are located in the highlands which comprise of Ada'a Woreda with an area of 1,000 km$^2$. In the highlands, elevation varies between 1,800 and 2,000 meters with alternating temperatures of between 8 and 23 degrees centigrade. The average annual rainfall of this area as recorded in Bishoftu is 1,100 mm and there was a slight occurrence of frost every 3 or 4 years. The area of the rift valley section is about 600 km. The elevation of the rift valley area varies from 1,500 to 1,800 meters with a corresponding reduction in rainfall that average fluctuates between 700 mm and 1,000 mm per year. The two major mountain peaks (Zukala and Yerer) reach heights of 3,000 to 3,500 meters. A third minor hill lies south of Bishoftu. Frost is a common occurrence in these parts of Ada'a. The altitude of the village ranges from 1,800 to 1,900 meters with an average monthly temperature of 17 degrees centigrade and an annual average rainfall of about 740 mm. Part of the village (Koftu and Fultino) are vulnerable to flooding during the rainy season, but there are no serious incidents of flooding in district which disrupt the normal activities of life. There was no time in the past when the village was isolated from the nearest towns or villages due to the impact of rain. Since the area generally falls within the climatic zone called Woina Dega, it does not get very cold. However, it may get relatively colder in October and November as compared to other months of the year.




| | Jan | Feb. | Mar | April | May | June | July | August | Sep | October | November | December |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Eto(mm) | 86.4 | 93.6 | 117.6 | 126.3 | 138.6 | 141.3 | 117 | 109.83 | 111 | 106.5 | 97.2 | 88.5 |
| Avg.temp(o c) | 12.04 | 14.12 | 15.21 | 15.41 | 22.91 | 17.2 | 14 | 13 | 13.5 | 12.8 | 8.2 | 13.7 |
| Rain fall(mm) | 2.41 | 6.2 | 20 | 62 | 75 | 105 | 224 | 207 | 125 | 52 | 3.95 | 2.78 |

Source: Debre Zeit Agricultural Research Centre Weather Station

Fig 3.2 Evapotranspiration rate, mean monthly rainfall and average temperature in the study site

### 3.1.3 Soil characteristics of the study area

The soil of the study area is dominated by clay and clay loam which the type of clay mineral that assumed greater importance with respect to soil water storage. The physical assessment of soils of the study area shows dominated by clay soil. The average soil depth is about 0.65 to 1.05m with medium infiltration rate and medium water holding capacity (OIDA, 2002).

Table 3.1 The textural classification of soil of the Fultino SSI scheme.

| S.no | Soil type | Textural class in % |
|---|---|---|
| 1 | Sand and Silt | 3.0 |
| 2 | Clay | 88.0 |
| 3 | Clay loam | 9.0 |

### 3.1.4 Physical characteristics of the Storage Dam

The storage dam at Belbela is one of supplementing (recharging) other through hydrological catchment transfer which was constructed in 1980 by a Cuban Civil Mission in collaboration with Ethiopian Water Resources Authority (WRDA). The protection works, canals, and on farm structures were later constructed by the Ethiopian Water Works Construction Authority (EWWCA) with an objective of irrigating land area to be used by State Farms. The volume of the reservoir system is 25.5 million $m^3$ with dead storage of 1.6 million $m^3$ (OIDA, 2000).

## 3.2 Research Methods

### 3.2.1 Research Design

As this study was performance evaluation of small-scale irrigation of Fultino scheme at district level starting from February 2017 to November; 2017 of the irrigation season. In this study quantitative and qualitative research style were conducted. Primary and secondary data were collected and engaged for the study purpose. For field data collection and measurement purposes; Current Meter, Double ring Infiltro-Meter, Auger, Tape Meter, Cutthroat Flumes, Garmin GPS and

Sensitive Balance were used during the study period and influence on collective and economic values on farmers (irrigators). This were included water application efficiency, irrigation efficiencies, equity and productivity indicators (land productivity - qt/ha or Birr/ha or water productivity (kg/$m^3$ of water or Birr/$m^3$ of water.

The methodological structure of this study were descriptive survey and field measurement the targets were on Fultino small-scale irrigation scheme and irrigator farmers, development agents (DAs), irrigation and water experts, Woreda agricultural office heads, Woreda administration heads, Woreda water, irrigation and mine staff. From upstream water users, middle water users or irrigators and from downstream irrigators and five water users association were selected using distance, location topography, irrigation structure and practice availability, irrigation types and utilization and population. Descriptive survey was preferred over other methods as it enables to make investigations with narration of events comparisons, and drawing conclusion based on the information obtained from relatively large and representative samples of the target population. Parkash (2005) described that survey research is important to collect detailed descriptions of existing phenomena with the intents of employing the data to justify current condition and practice. The field measurements also important to deal with the application performance, distribution and relationships performance in small-scale irrigation scheme were variables in their natural setting and structural design.

### 3.2. 2.Data sources

#### 3.2.2.1 Primary sources of data

Sample was selected from small-scale irrigation scheme at Fultino, farmers and their irrigation practices, water conveyance system of the scheme, water application efficiency ,water transport data, water use efficiency ,water amount (storage capacity of reservoir ),conveyance efficiency, by using interview DAs, experts, data taken from upper stream and from downstream of irrigators, farmers selected for this purpose (where irrigation scheme found ) was served as primary source of data through self-administered questionnaire and field measurements . Woreda high level experts of agriculture and water, irrigation and mine office heads, and Woreda administration were used as primary source of data through semi-structured interview and observation checklist though secrete follow up by the researcher about performance evaluation of irrigation in small-scale irrigation scheme, data handling, leading style, measuring mechanisms, protection of structure, water distribution, etc.

3.2.2.2 Secondary sources of data

Secondary data gathered from annual reports of Woreda agricultural, water, irrigation and mine and road transport offices, irrigation development work process, upstream and downstream irrigator farmers ,scheme design capacity as well as from NGOs which worked on irrigation, and from selected water users association.

## 3.3 Sampling Techniques and Sample Size Determination

### 3.3.1 Target Population

The selected Fultino small-scale irrigation scheme in terms of water use, infrastructure, available resources water application efficiency, irrigation efficiencies (application, conveyance adequacy), equity and productivity indicators and the total population of the subjects of the study were five water users associations and there were 50 male and 20 female irrigators and none irrigator farmers from five selected water users associations including chairpersons of that associations by considering the homogeneity of the target population to furnish reliable data for the study. The envisaged sample size allocated among water users associations of each 50 was taken, 10 experts from Woreda and 4 work process heads were deliberately included in the sample as source of data.

### 3.3.2 Sample Size

The selected Fultino small-scale irrigation scheme and all selected water users associations, DAs, experts of irrigation and natural resources management, water users association ` chairpersons were totally, included in the sample. Among total selected associations ` DAs, six (four males and two females), all were included in the sampling, from users association chairpersons, five (four males and one female) for interview purpose only, all were included. From selected irrigator farmers out of 70 (50 males and 20 females) all were included for interview purpose but for field measurement only three farmers field were selected with eight replications , and from total Woreda higher experts out of 10 (7 males and 3 females) were selected for interview purpose , all were included.

### 3.3.3 Sampling Techniques

Stratified sampling technique were employed for all selected water users (irrigator) farmers, DAs, irrigation and natural resources experts, model farmers, and other farmers were randomly selected for interview and focus group discussions . The Fultino small-scale irrigation scheme fields' measurements (water resources, water utilization, irrigation interval, infrastructures, water application efficiency ,application uniformity and water use committees, by laws, by community, internal and external performance evaluation indictors) were carried out. Also from Woreda agricultural and water, irrigation and mine offices work process heads were purposefully included in the sampling to get additional information.

Table 3.2 Total population and sample size (interview purpose only)

| S/N | Types of Respondents | Population size | | Sample size | | | Collected interview | | | | Av. Percentage (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M | F | M | F | % | M | F | M | F | |
| 1. | Irrigator farmers | 50 | 20 | 4 | 1 | 100 | 41 | 13 | 3 | 1 | 80 |
| **2.** | DAs | 5 | 1 | 5 | 1 | 100 | 4 | 1 | 4 | 1 | 90 |
| 3. | Selected water users association chairman | 5 | 1 | 5 | 1 | 100 | 5 | 1 | 5 | 1 | 100 |
| 4. | Woreda higher experts | 7 | 3 | 7 | 3 | 100 | 7 | 3 | 7 | 7 | 100 |

Table 3.3 purposefully selected supporting data (for external indictors)

| S/N | Source | Location of Data | Total no. of Respondents | Total no. of Responded | Percentage |
|---|---|---|---|---|---|
| 1. | Woreda agricultural, irrigation, water and mine and transport offices work process heads | Woreda Agricultural, Water, Irrigation and Mine and Transport Offices | 7 | 6 | 86 |
| 2. | Woreda agriculture development ,water irrigation and mine and transport office head | Woreda Agriculture & Natural Resources Office | 3 | 2 | 67 |
| 3. | Woreda administrative head | Woreda Administration Office | 1 | 1 | 100 |

### 3.4. Data Collection Techniques

The research was employed four types of data gathering tools (questionnaire, interview observation and field measurements). The data from the primary source of information was collected through questionnaire, semi-structured interview, and observation and field measurements. The secondary data were gathered from yearly report of Woreda agriculture and natural resources development office, water and irrigation office, meteorological records of the area, upper and downstream irrigators' farmers in the irrigation scheme.

### 3.4.1 Questionnaire to check productivity indictors

Based on the objective of the study both close-ended and open-ended questionnaires were prepared and administered to Woreda agriculture, water, irrigation and mine and transport offices, upstream and downstream irrigators farmers and administrative heads, Woreda work process heads, Woreda agricultural, water, irrigation and mine and transport office higher experts, DAs and farmers to elicit information concerning performance evaluation of small-scale irrigation in farmers managed irrigation scheme, appropriate structure for soil types, gradient, irrigation types and efficiency, water utilization methods that have been taken to improve and give appropriate solution to current irrigation performance evaluation challenges of small-scale irrigation scheme of such acts and its impact on towards social, economic and environmental stress and decreases of agricultural productivity. The questionnaire was prepared in English and translated into Amharic to reduce communication barriers with respondents (especially in case of farmers also translated to Afan Oromo`). The prepared questionnaires was pre-tested before distributing to respondents of sample farmers selecting five in each water users association, two DAs and two irrigation and natural resources expert, who were later not participated in the study, the selection was randomly. And then, based on the result of pre –tested questionnaires the necessary reliability and validity modification made on the questionnaires.

### 3.4.2. Interview

Semi-structured interview was employed with Woreda agriculture and natural resources development, water, irrigation and mine and transport offices higher experts, work unit heads, agriculture, water, irrigation and mine and transport offices heads, Woreda administrative head and upstream and downstream (irrigators) farmers that were directly responsible for handling irrigation schemes, water and infrastructure development activities in the district. Pre-determined semi-structured interview was made about types, effects, challenges, methods, and water resource availability, road access, market access, etc.

Performance evaluation of irrigation in small-scale irrigation scheme acts to forward suggested solution to irrigation management and utilization in order to handle such as irrigation opportunities evaluation failure in different farms, irrigation types and methods, soil types, land use practices, vegetation cover and different irrigation structures.

Interview guide prepared in English, and translated into Amharic during the interview to obtain the necessary in-depth information also into Afan Oromo and avoid communication barrier.

### 3.4.3 Observations

To support the data obtained through the questionnaire and semi-structured interview, five consecutive observation was carried out, the Fultino irrigation scheme and 5 selected water users association around field transect walk where irrigation in small land and irrigation structures were done and water shed management processes in addition to this the market access and road access were observed.

### 3.4.4 Field measurements

3.4.4.1 Water application efficiency, (Ea)

Determining the amount of water released from reservoir (storage dam) by flow meter, inlet measurement and amount of water applied into field by measuring the crop water requirement of the field .using CROPWAT 8.0 and measuring the distribution efficiency (uniformity) by measuring the total accumulation of water in one fourth of the smallest depth by dividing the value obtained to total area in irrigated field by using

$$Ea = water\ sored/\ water\ diveroted\ to\ the\ ploit \tag{3.1}$$

Where, Ea , is application efficiency

Measure the evaporation rate by using Penman-Monteith evaporation measuring method and measuring infiltration rate of field.

#### 3.4.4.2 Conveyance efficiency

Water distribution is the central importance of any managing of irrigation systems. Conveyance system diverts water from its source, transports and distributes water to the point of use. As water is conveyed from the diversion site to the irrigation field, some amount of water is lost in different ways such as seepage and evaporation. Well-organized irrigation system transports water with minimum losses and hence has high conveyance efficiency.

The command to determine the effectiveness of conveyance system in the main canal, the amount of flow rate that enters to the main canal and amount of flow rate that leaves the main canal was measured. Water transport efficiency from the source to the field is measured by conveyance efficiency. The conveyance efficiency is used to evaluate the efficiency of the systems to carrying water.

$$CE = Q_{in} / Q_{out} \tag{3.2}$$

$$L = Q_{in} - Q_{out} \tag{3.3}$$

Where L = Conveyance loss

CE= Conveyance efficiency

$Q_{in}$ and $Q_{out}$ $=$ are the inflow and outflow in specified canal reached length

Water flow amount measurement is an applicable data for irrigation scheme performance evaluation activities, computation of conveyance efficiency and losses. There are different methods to measure the flow of water in the rivers/canals. For this study Current Meter and Cutthroat Flume water flow rate measurement equipment were used.

Repeated flow measurements have been taken starting from intake to referenced point of main and secondary canals; through using Current Meter .Through Current Meter; at straight and regular reach of intake, main canals and secondary canals flow rate measurements were taken in weekly bases to capture temporal and spatial fluctuates of irrigation water flows along the scheme for first three months, starting from February to April 2017 and for second two months May to June irrigation season.

From the main canal (head of major secondary canals) 4 measuring points, were bench marked to capture the amount of inflow before entering to the secondary canals and out flow used to calculate lost amounts comparative to the diverted amounts. The main canal and secondary canal of irrigation scheme is constructed in lined masonry and grass way (earthen canal).

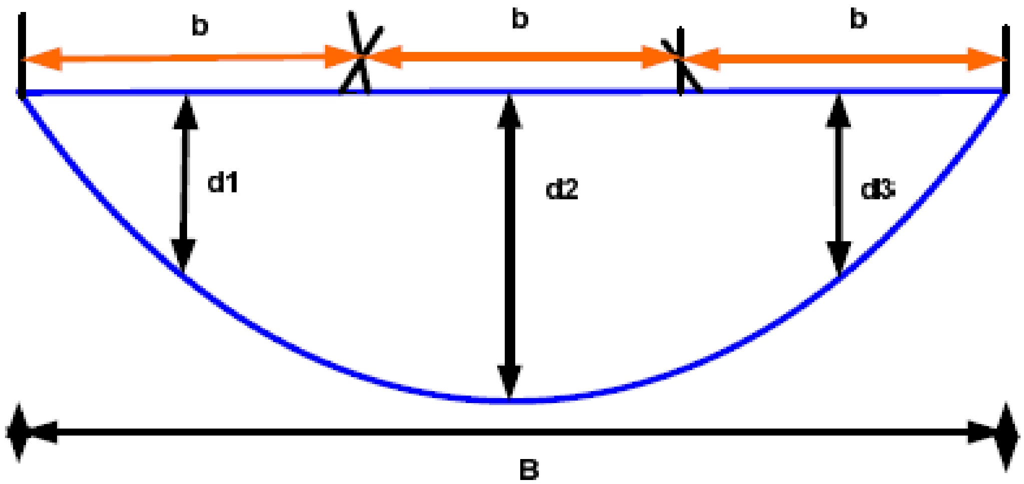



Figure 3.3: Canal flow cross section

The cross sectional arrangement scheme is rectangular. The discharge amount would be equal to the result of the average velocity (Va) and the area of the cross-section (A). The wetted width of the canal was divided into three equal cross sections (at right edge, left edge and center) and the flow depth was measured at each division. The average flow velocity was calculated at a depth of (0.6*d) from the water surfaces at each vertical; where'd' is the respective depths of each division.

The discharge (q), in each sub section of the canal could be determined by applying the area of the sub section by the average flow velocity in that section. The total discharge would be the summation of individual discharges in the specified cross section.

$$q = b * (d1 + d2)/2 \qquad + (v1 + v2)/2 \qquad 3.4$$

$$Q = \sum_{n=1}^{n} q \qquad 3.5$$

Where;

B= bottom width (m)

b= wetted width of the cross section (m)

d1, d2, d3= flow depth at each cross section (m)

q= individual flow rate at each cross section ($m^3/s$)

V= velocity (m/s)

Two measuring points have been fixed in 50m length at main and secondary canals, to capture the amount of losses and to compute the conveyance efficiencies. The computation was carried out in similar procedure like main canal. Flow rates were measured at two secondary canals of 1 and 2 in 100m length (for each at 50m).

To determine the flow rate at farm inlets measurements were taken by Flumes from sampled irrigator farmers. Totally six farmer plots were selected purposively from farmers that has been selected for questionnaire survey at each canal reaches (head, middle and tail) at scheme. The Flumes that used for this study work has a maximum capability to measure up to 6 l/s flow rate, from the graduated wall can read depth of flow in (m) and discharge rate in (l/s).

#### 3.4.4.3. Irrigation interval

Computing the soil moisture content of soil using the available water moisture content to water need to field formula and by direct interviewing the irrigators farmers (water users associations ) ,senior water and irrigation experts in the woreda , was calculated the irrigation interval and irrigation schedules,

#### 3.4.4.4 Irrigation efficiency

According to Reddy et al., (2013), water requirement efficiency is given by general considerations

$$Irrigation\ efficiency\ (IE) = volume\ of\ water\ stored\ \ /Volume\ of\ water\ required\ \ in\ the\ root\ zone \qquad 3.6$$

Determining relative water supply which was developed as a water supply indicator by (Levine,1982). Relative water supply (RWS) indicates the efficiency of water applied to the amount of water demanded by the crop. It is the ratio of total water supplied by irrigation (I) and rainfall (P) to total water demanded by crop (i.e. actual crop evapotranspiration ($ETc$).

RWS = Total water supply / Total crop water demand 3.7

Where;

Total water supply= surface diversion + effective rainfall $m^3$,

Crop water demand= potential ET, or the ET under well-water conditions for each crop $m^3$.

And to determined potential ET, CROPWAT 8.0 computer program was used to estimate the total water requirements of foremost grown crops in the irrigation scheme. FAO (1992) Penman-Monteith method was selected to calculate the reference crop evaporation (ETo).The model needs climatic, crop and soil data for the determination of crop water and irrigation requirements. To determine ETo values the model requires climatic data; mean monthly minimum and maximum temperature (0c), relative humidity (%), wind speed (km/day) and sunshine hours (hr).

The amount of water required to compensate the evapo-transpiration loss from the cropped field is defined as crop water requirement. Although the values for crop evapotranspiration under standard conditions (ETc) and crop water requirement are identical, crop water requirement refers to the amount of water that needs to be supplied, while crop evapo-transpiration refers to the amount of water that is lost through evapotranspiration. The program estimates (ETc) based on equation:

$$ETc = ET_o * K_c \qquad 3.8$$

Where; Kc= crop coefficients, varies with a crop growing stages

The value of Kc of each major crops were taken from FAO I & D 24 (1992) and 56 (1998) papers. The determination of irrigation requirement was made after estimation of effective rainfall by USDA Soil Conservation Service Method (Clarke *et al.,* 1998). Irrigation is required when rainfall is insufficient to compensate for the water lost by evapo-transpiration. The primary objective of irrigation is to apply water at the right period and in the right amount. By calculating the soil water balance/budget of the root zone on a daily basis, the timing and the depth of future irrigations can be planned. In order to compute the irrigation water requirement, CROPWAT 8.0 computes a daily water balance of the root zone. Computed as;

$$IWR = ETc - Rf_{eff} \qquad 3.9$$

Where,

ETc = Evapotranspiration

IWR= Irrigation water requirement

$Rf_{eff}$ =Effective rainfall

And to estimate the total crop water requirement at scheme level input data of actual irrigated area by crop type was included and used to calculate the relative irrigation supply and it is useful to assess the degree of irrigation water stress/abundance/ in relation to irrigation demand (Molden et al., 1998).

$$RIS = \text{Irrigation supply} / \text{Irrigation demand} \qquad 3.10$$

Where;

RIS= Relative irrigation supply

Irrigation supply= only the surface diversion for irrigation $m^3$,

Irrigation demand= the crop ET less effective rainfall $m^3$

3.4.4.5 Productivity indicators

Productivity indictors (land productivity-qt/ha or Birr/ha or water productivity ($kg/m^3$ of water or $Birr/m^3$ of water and irrigation practices).Agricultural output indicators (water-land productivity). A number of indicators were developed regard to irrigated agricultural systems. Water, land and finance are the main inputs for output of crop production. Five of them are relating to output to land and water were selected, i.e., two from land productivity and three from water productivity. These external indicators provide the basis for the comparison of irrigated agricultural performances. Where water is a limiting resource, output per unit water may be more significant, whereas if land is a limitation relative to water, output per component land may be more important.

**Output per unit irrigated cropped area (OPUIA) (birr/ha):**

It is calculated as the total value of production per harvested area in the irrigation seasons.
The harvested /Irrigated / area includes the areas that were irrigated in the irrigation seasons.

$$OPUIA = \text{value of production} / \text{Harvested cropped area (birr/ha)} \qquad 3.11$$

**Output per unit command area (birr/ha):**

The calculated value shows the level of application or number of cropping frequency of the given command area in the production year and the productivity of the command area. High value result shows there is good concentrated irrigation. Meanwhile small values are not pertinent from land productivity point of view; less intensity of irrigation could not increase the production amount per unit of land. Furthermore this is more relevant for land is the major constraint factor for production. Command area is the nominal or design area to be irrigated.

OPUCA = value of production / production command (nominal) area (birr/ha) 3.12

**Output per unit irrigation water diverted (birr/m3):**

Calculated as the total value of production per unit water diverted from the headwork to the command area throughout the irrigation seasons; it includes the conveyance losses in the irrigation systems. It illustrates the productivity of diverted water from the source. It is an important parameter where water is a scarce resource. Diverted/supplied irrigation water is the volume of surface irrigation water diverted to the command area.

OPUIS = value of production / diverted irrigation water (birr/$m^3$) 3.13

**Output per unit irrigation water delivered (birr/$m^3$):**

It quantifies the value of production per unit delivered irrigation water to the head of farm inlets in the irrigation seasons. It is the net irrigation water delivered to the farm and it does not include losses in conveyance systems. It is a useful comparative indicator because it addresses output per drop of irrigation water actually delivered to the user. A lower value of this indicator indicates there is inefficient water use in the irrigation system or specifically at farm level.

OPUID = value of production / diverted irrigation water (birr/$m^3$) 3.14

**Output per unit consumed water (birr/$m^3$)**

This indicator derived from the general water accounting frame work (Molden, 1998). Consumed water is the actual evapotranspiration or process consumption from only irrigated crops (ET); it excludes other losses and water depletion from the hydrological cycle. The computed value does not affected by water losses through the system but only affected by the climatic feature of the area. It used to observe water consumption of crops at scheme level through evapotranspiration relative to the diverted and delivered amount of irrigation water. It has a contribution for irrigation management aspects; to take measurements those minimize evapotranspiration losses.

$$\text{OPUDC} = \text{value of production / volume of water consumed by ET (birr/m}^3\text{)} \qquad 3.15$$

**Value of Production** is the output of the irrigated area in terms of gross or net value of production measured at local or world prices. In this study production from irrigated agriculture is the principal issue to compare systems. However there are difficulties when comparing different crops across a system, say Wheat and Potato, as 1kg of wheat is not readily comparable with 1kg of potato. When only one irrigation system is considered, or irrigation systems in a region where prices are similar, production can be measured as net value of production and gross value of production using local values. As a result agricultural output production values were determined through local.

### 3.4.5 Scheme Documents

Documents on irrigation scheme (Filtino scheme), types and size of small dam, water source and irrigation practices, related disciplinary case and measures that have taken on irrigation, infrastructure development, irrigation efficiency, agricultural productivity index, reports acts are source of secondary data in the study.

## 3.5 Methods of Data Analysis

The data generated though questionnaires, key informants interview, formal and informal discussions, from secondary and primary sources, from field measurements were analyzed and interpreted qualitatively and quantitatively. Extensive data analysis relevant to each variable was employed to interpret both quantitative and qualitative data by identifying the common explanations and understandings in respondents though open-ended questionnaire and interview and the field measurement was incorporated with data sources. Data from documents were incorporated to substantiate qualitative information from elders (aged around sampled area) and triangulate the response gained through the questionnaire. Based on the nature of basic question and the data collected statistical measurements like central tendency methods were employed.

The researcher was used to analysis the data collected by different methods by using SPSS statically software package, CROPWAT 8.2 based on data collected to check the association between data and validity of the analyzed data.

# 4. RESULTS AND DISCUSSIONS

## 4.1. Status of Irrigation Scheme and Irrigation Practices

Fultino SSI scheme was constructed in mid-1980`s by Cuban`s civil engineers with collaboration of Ethiopian water resource authority and gave a service around for last 40 years operational period. The initial command area of Fultino SSI scheme was 85ha, however due to erosion problem in the area about 10ha land became out of production. Therefore, the total command area of the scheme is declined to 75ha. From the total command area irrigable land covers 72ha. The land holding of beneficiaries ranges from 0.01ha to 0.75ha. The command area was classified in three blocks and in eight clustered farm blocks. Additionally for operation and management purpose the area was categorized into five water user association groups. The main canal length is about 2.5km and from this 1.5 km was constructed in lined masonry and 1km was grassed water way(earthen).

The secondary canal is not fully lined masonry and each secondary canal has an average length of 400m. Hydraulically the structure was not under good condition, because it was covered by weeds, silt and soils. The tertiary canal was constructed with earthen materiel .

In the irrigation scheme, there was cut-off drain structure constructed to divert Wedecha River. This structure is currently not fully functional. As a result, the river over-flows into the farmland during the rainy season. In the irrigation scheme flow control gates (metal sheets) were installed in the whole irrigation system at division boxes or turnouts, but more than half of them became out of function. The design document categorized the scheme under moderately vulnerable to soil erosion. The irrigation scheme was constructed to provide as a demonstration site for fruit and vegetable productions. During design period fruits (orange, banana, mango, avocado and sugar cane) and vegetables (tomato, pepper and onion) were recommended for production in the irrigation scheme. Farmers practice different irrigation methods. Flooding type of irrigation is widely practiced for the main crops, while at initial stage of growing period farmers have tried to practice furrow irrigation method for maize, pepper, onion and cabbage crops. For sugar cane cultivation they use furrow irrigation and for fruit trees they use basin irrigation. Rigid rotational irrigation schedule has been practiced in the irrigation scheme.

## 4.2 Rainfall Data Analysis

The rain fall distributions in study areas (Fultino irrigation scheme) showed a unimodal rainfall pattern. The minimum and maximum rainfall amount occurs in months of January 2.78 mm and July 224 mm, respectively. Conversely the average total annual effective rainfall amount of study area was found to a 740 mm.

In Fultino SSI scheme 91.43 mm and 130.73 mm average total effective rainfall was available in the first irrigation season (February-April) and in the second irrigation season (March-June) respectively. From the respondents 80% and 20% revealed that, rainfall was insufficient in amount for crop production for the last three years. Despite the variability of rainfall distribution in time and space; the amount of rainfall received in 'Belg' season (February-June) has significant impact for crop production in the irrigation season. As well it has an advantage to minimize conflicts that may arise due to water shortage at critical irrigation months. Hence this effective rainfall contributed to support the crop water demand in the irrigation seasons. Furthermore, the detailed advantage of this amount of rainfall is discussed in water delivery and water productivity performance indicators section.

## 4.3. Reference Evapo-transpiration (ETo)

Based on the procedure described in the methodology part, ETo values of Fultino SSI
Scheme was computed. Summary of meteorological data and computed values are listed (Figure 4.1)

The minimum and maximum daily ETo values of Fultino irrigation scheme were 3.12 mm/day in January and 3.43 mm/day in June. The estimated average daily ETo values of Fultino SSI scheme was 3.56 mm/day. As a result extra water is required to full fill the evapotranspiration demands of the area. However, to increase water productivity in irrigated agriculture, it needs to select crops which have low evapotranspiration demand and irrigation methods with minimum evaporation losses.

## 4.4 Soil and Soil Water Holding Capacity Analysis

### 4.4.1 Soil Sampling and Water Holding Capacity

Soil samples were taken at depth of 0-30 and 30-60cm to investigate the physical and chemical properties of the irrigation scheme. From the sampled soil texture, field capacity (FC), permanent wilting point (PWP), organic matter content (OM) and macro nutrients (N and P) were analyzed.. Based on the percentage of composition, the soil textural class was determined by USDA soil textural triangle method (Bouyoucos, 1951), as attached on the appendix (appendix figure 1).

Computed soil moisture characteristics values of field capacity (FC), permanent wilting point (PWP) and total available water content (TAW) are indicated in table 4.8. The total available moisture content values in Fultino irrigation scheme ranges from 125.9 to 147.01 mm/m for clay and clay loam soils, respectively. In Average the moisture holding capacity of scheme is good.

However, the total available water or water holding capacity of the soil at irrigation scheme was poor. In general, the relative magnitude of water holding capacity of the soil depends on its textures and structures. As a result, the low water holding capacity of the soil can affect crop water productivity of the irrigation scheme. Thus it needs to improve the soil structures at irrigation scheme through proper managements include addition of organic matter, adopting of suitable tillage, soil conservation and cropping practices /rotations/.

Table 4.1 Soil FC, PWP and TAM of the irrigation scheme

| Canal reaches | Soil depth(cm) | FC (%) | PWP (%) | bulk density(g/cm$^3$ ) | TAW (%) | TAW(mm/m |
|---|---|---|---|---|---|---|
| Head | 0-30 | 32.64 | 20.59 | 1.22 | 14.701 | 147.01 |
| | 30-60 | 35.2 | 23.22 | 1.22 | 14.62 | 146.2 |
| Middle | 0-30 | 38.65 | 27.50 | 1.21 | 13.49 | 134.9 |
| | 30-60 | 38.55 | 28.23 | 1.22 | 12.59 | 125.9 |
| Tail | 0-30 | 36.24 | 20.45 | 1.23 | 19.42 | 194.2 |
| | 30-60 | 39.28 | 28.60 | 1.23 | 13.136 | 131.36 |
| Average | | | | | | 146.595 |

Where; FC= field capacity, PWP= permanent wilting point, TAW= total available water

### 4.4.2 Soil textural class and nutrient contents

The soil textural class of the irrigation scheme was determined based on the particle size distribution through using USDA SCS Soil Textural Triangle method. As indicated in table 4.2 the soil texture distribution was slightly varied at study area. Clay and Clay Loam soil type was found in the head and tail of the scheme; while the dominant soil type in the middle of the scheme was clay loam soil type.

Table 4.2 Soil textural classes of the irrigation scheme

| canal | Soil depth (cm) | Particle size distribution (%) | | | Textural class |
|---|---|---|---|---|---|
| | | Clay | silt | Sand | |
| Head | 0-30 | 35 | 37 | 31 | Clay loam |
| | 30-60 | 41 | 33 | 30 | Clay loam |
| Middle | 0-30 | 48 | 39 | 25 | Clay |
| | 30-60 | 52 | 36 | 18 | clay |
| Tail | 0-30 | 39 | 38 | 27 | Clay loam |
| | 30-60 | 48 | 30 | 23 | Clay |

## 4.5 Crop Water Requirements and Irrigation Requirements

CROPWAT 8.0 model computed the crop water requirements based ETo values obtained from evapo-transpiration of scheme.

It was determined for the main crops grown in the irrigation scheme based on crop water requirement equation. The main crops grown in the irrigation seasons have been identified for the scheme.

Description of crop characteristics; i.e., planting date and length of growing period (LGP) were collected from household survey results and 80% data collected and 90 interviewed irrigator farmers described they used crop water requirement by using the cultural methods by which inserting their finger in to soil and observe the amount of moisture available. The field measurement result varies from 0.25 to 0.56 depending on crop types with their water consumption rate and growth period. Furthermore, the allowable soil moisture depletion fraction for each crops at each growing stage were adopted from FAO paper 24 and 56, and research documents. Allowable moisture depletion fraction is a critical soil moisture level where the first drought stress occur affecting evapotranspiration and crop production. The fraction normally varies from 0.2-0.6 with the lower value being for sensitive crops with limited rooting systems. The Fultino SSI scheme result also showed the similar trends i.e. average allowable soil moisture depletion fraction was 0.56 and the lower limit for tomato was 0.25.

Through the above input data the total crop water and irrigation water requirements were computed for the estimation of total water demands at the irrigation scheme in the growing seasons. .

### 4.6 Irrigation Interval

Water application depth and interval in days are the important elements in irrigation scheduling. However, there was a problem in irrigation scheme applying the required depth of water at the proper time to optimize crop yield. The irrigation interval in Fultino SSI scheme is depends on condition of plant and availability of water the interval varies between 10-12 days. At present, the crops grown in the scheme suffer from moisture stress problems as a result yield of crops is reduced. Moreover, it was difficult to grow crops that need frequent irrigations.

Volume of water applied during irrigation events was determined through multiplying the average flow rate by duration of flow in that particular event. Average depth of water entered into the farmers' field during irrigation events were determined by dividing volume of water applied by their respective area. Based on field measurements, mean irrigation water applied to the fields' was 33.29 mm .There was a problem in delivering irrigation water in the right amount (size, frequency, and duration).

### 4.7 Performance evaluation

#### 4. 7.1 Performance of scheme relation to irrigation from farmers' perspective

According to the survey, 80% of the respondents believe that the benefit of the irrigation scheme is in good performance condition based on their agricultural productivity and 20% respondents said that the performance of Fultino irrigation scheme is not in good performance condition. They (20% respondent) believes that the construction quality of the canals, unequal water distribution, the communication of government bodies and farmers were very low is the main reasons that decrease the performance of the scheme.

And the discharge amount (record) has been made to confirm the survey that has been done in the scheme. Similar research was done by Garry et.al (2005) and contrasted result was recorded to this research finding as 85% of interview respondents believe that less efficiency was because of unequal water distribution.

The record has been disturbed for one week and water was not unconfined in the canal due to the occurrence of rainfall in (12/4/2017 and 14/4/20017). Off course the flow difference was slight and decreasing trend in the irrigation season. In this irrigation scheme a maximum flow 0.17 l/s was recorded in 14/4/2017 immediately after the end of rainfall. Despite farmers have not used the first irrigation season; from the respondents 80% of them pronounced that irrigation water is more accessible up to 7 months, starting from November to May. To synthesize the situation and to show the water accessibility; a monthly discharge and demand was generated through farmer's local experience and knowledge about the discharge variability in the canal. Similar result was found as the water distribution varies temporal and spatial by Tebebal and Ayana (2015).

Data was taken the date from take-off on main canal at head, middle and tail show at below table is that almost the performance is satisfactory

Table 4.3 Average required (QR) and (QD) discharge on the main canal to measure the performance of the scheme

| Month | Head ($m^3/s$ ) | | | | | | Middle ($m^3/s$) | | | | | | Tail ($m^3/s$) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $Q_{R1}$ | $Q_{D1}$ | $Q_{R2}$ | $Q_{D2}$ | $Q_{R3}$ | $Q_{D3}$ | $Q_{R4}$ | $Q_{D4}$ | $Q_{R5}$ | $Q_{D5}$ | $Q_{R6}$ | $Q_{D6}$ | $Q_{R7}$ | $Q_{D7}$ | $Q_{R8}$ | $Q_{D8}$ |
| March | 0.12 | 0.12 | 0.1 | 0.09 | 0.18 | 0.16 | 0.17 | 0.1 | 0.1 | 0.09 | 0.12 | 0.1 | 0.08 | 0.06 | 0.06 | 0.06 |
| April | 0.12 | 0.12 | 0.1 | 0.09 | 0.18 | 0.14 | 0.15 | 0.1 | 0.1 | 0.08 | 0.12 | 0.09 | 0.08 | 0.05 | 0.06 | 0.06 |
| May | 0.11 | 0.12 | 0.1 | 0.095 | 0.18 | 0.14 | 0.13 | 0.09 | 0.1 | 0.08 | 0.12 | 0.1 | 0.08 | 0.05 | 0.06 | 0.06 |

Where $Q_{R1}$, $Q_{R2}$….. $Q_{R8}$ and $Q_{D1}$, $Q_{D2}$….. $Q_{D8}$ required and delivered discharge at 1, 2, 3….8 of supply canal incoming across the off-taking canal.

The discharge records of discharge required at head, middle and tail shows almost minor decreasing particularly at head the discharge level was nearly similar , but in case of middle and tail there were shows small decreasing trend .

Table 4.4 Average irrigation efficiency

| Month | Head | | | Middle | | Tail | | | Spatial Av. Efficiency | Total average distribution efficiency is 75% |
|---|---|---|---|---|---|---|---|---|---|---|
| | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | | |
| Feb | 0.65 | 0.55 | 0.68 | 0.78 | 0.70 | 0.9 | 0.82 | 0.8 | 0.74 | |
| March | 0.6 | 0.60 | 0.67 | 0.8 | 0.68 | 1 | 0.75 | 0.88 | 0.75 | |
| Apr | 0.62 | 0.62 | 0.68 | 0.78 | 0.69 | 0.88 | 0.91 | 0.8 | 0.75 | |
| Average | 0.62 | 0.59 | 0.67 | 0.79 | 0.69 | 0.93 | 0.83 | 0.82 | 0.75 | |

The distribution efficiency of irrigation water at Fultino irrigation scheme was average performance values of 0.74, 0.75 and 0.75 at head, middle and tail reach of the system, respectively (Table 4.5). From these results over all average distribution efficiency of the scheme was 0.75or 75%.

Similarly, 72% of the sample respondent said that, the irrigation scheme construction was not participatory and farmer centered, 20% said it was fair whereas 8% of the respondents said that, the scheme was good in construction and participatory with them. Most of the Head and middle user use irrigation water and land to generate cash crops which is 70% of the respondents 20% from head, middle and tail were benefited from scheme and 10% of the respondent did not want to use irrigation scheme. At the same time the respondent's insight on land size under irrigation as indicated above illustrate that the strengthening of the agricultural activities is the only way to improve the livelihood of the community.

The similar result was fund by Tebebal and Ayana (2015) as the canal ineffectiveness decreases the conveyance and irrigation efficiency.

Simplicity of constructed structure to operate, maintain and management also increases the performance of the scheme to the community. In link with this, 80% of the respondents said that, the structures are simple to operate, maintain and manage. In general, the performance of scheme indicates influence of the system to affected system. That is the existing traditional systems. As a result, from focused group discussion held with five traditional water leaders, three water users committee, one woman and one youth in Kofitu village and key informant discussion (DA of the area), the performance of the scheme for the farmers is perceived in different ways across the canals with respect to the location of the field from the head works.

Most of the middle user which is found on the right canals produces vegetables like onions, tomatoes and carrots. About 70% of respondents are those who use irrigation to harvest cash crops and belong to this right canals middle user. An elderly at Kofitu village of Fultino small scale irrigation scheme, for example, termed the performance of scheme in terms of the change of the production systems as:

He has a big farm land here in Fultino village out of this irrigation project but under traditional Irrigation from upstream diversion. But under this scheme they learn production onion, tomato and even Fogge(improved seed of maize with straight rows) Likewise, one of the beneficiaries that interviewed during direct observation when he and his friends were around intake gate and explained

The right canal head user which is found up to 500m specifically complain the project by saying after the involvement, we lost the traditional irrigation systems, which come from another diversion point from upstream. Because the new waterways developed by intervention give benefits for them before the head work was silted up. But, particularly after 2013, since the weir was completely silted up and it is above our capability to maintain it, it becomes load on them to desilt it. Now all are trying to desilt only from the gate and nobody work together with you to do this but only those who want the water.

From the above argument, it can be concluded that, the performance of irrigation scheme for the farmers is perceived in different ways across the canals with respect to the location of the field from the head works and community had awareness about advantages of irrigation.

Hence, 80% of the respondent said that their life was improved after irrigator farmers' habited using modern irrigation and indicators life change after they start to use modern irrigation.

### 4.7.2 Irrigation water application efficiency

Irrigation efficiency is an exceptional case of the water use efficiency. It is the portion of efficiency for irrigation given specified boundaries. There are several ways of calculating efficiency, some of which are conventional and well-known, others which are new and attempt to capture efficiency for the entire system and the time-based elements of efficiency. Unlike productivity, however, efficiency is expressed as a %, being a measure of net to gross water use or net days of irrigation to gross days of irrigation. The same approach and result was obtained by (Yusuf and Tena, 2007).

And the field data was taken from head, middle and tail of irrigation scheme as follows

Table 4.5 Calculated irrigation application efficiencies

| S.no | Field | Depth applied (mm) | Depth stored in the root zone (mm) | Application efficiency (%) |
|---|---|---|---|---|
| 1 | Field 1(head) | 11 | 7.1 | 71 |
| 2 | Field 2 (middle) | 9.5 | 7.12 | 75 |
| 3 | Field 3(tail) | 9.2 | 7.23 | 79 |

Efficiency and effectiveness of Irrigation refers to application of water and its welfares received from irrigation by the target communities or beneficiaries in a wider sense that can be described in terms of the productivity of water to crop grown and at the end of the day change in quality of life, in turn, can be described by better living style, increased number of meal in quantity and quality, asset possession. The similar results were obtained by Dejen et al at (2012 and 2013). However, 71% of the water application was efficient at head, 75% water application or irrigation efficiency was record at the middle of scheme and 75% water application or irrigation efficiency was recorded at the tail and at head, middle and tail .The average efficiency was 75%, so general scheme system in case of water application was not such an efficient. The East Shoa zone and Ada`a district water, mine and energy officials and experts also approves this during our group discussion and the progressive yearly plan reports.

### 4.7.3 Conveyance efficiency

The average efficiency of scheme at head, middle and tail was recorded 79.56%, 74.92%, and 73.4%, respectively. According to Brouwer and Prins, (1989), cited in Leliso,(2007), the conveyance efficiency for long unlined canals (>2000 m), have been reported as 60, 70, 80% for sand, loam, and clay soil respectively; for medium length unlined canals (200-2000) as 70, 75, 85% for sand, loam and clay soil respectively; and for short canals (<200 m) as 80, 85 and 90% for sand, loam and clay soil respectively. The efficiency of lined canals has been reported in the order of 95% for all canal length. Finally overall Fultino small scale irrigation scheme conveyance efficiency was the average of three fields of total 75.96%. With this respect, 75.96% for lined canal are lower than 95%. So the scheme with respect conveyance is not efficient

Table 4.6 Conveyance efficiency of the scheme

| S/no | Head average at 500 m | | | Middle average at 500m | | | Tail average at 500m | | |
|---|---|---|---|---|---|---|---|---|---|
| | Left canal (l/sec) | Right canal (l/sec) | Ave. efficiency (%) | Left canal (l/sec) | Right canal (l/sec) | Average efficiency (%) | Left canal (l/sec) | Right canal(l/sec) | Av. efficiency (%) |
| 1 | 25.2 | 27.6 | 82.5 | 24.3 | 29.6 | 82 | 22.9 | 28.3 | 80.1 |
| 2 | 21.2 | 22.34 | 75.5 | 20.9 | 30.2 | 69.2 | 18.5 | 27.3 | 68 |
| 3 | 22.75 | 28.06 | 81 | 21.6 | 28.2 | 76.6 | 21.6 | 28.9 | 74 |
| 4 | 19.2 | 23.22 | 83.8 | 20.6 | 27.7 | 74.4 | 19.7 | 26.8 | 73.5 |
| 5 | 20.32 | 27.08 | 75 | 20.5 | 28.3 | 72.4 | 20.3 | 28.4 | 71.4 |

Likewise, to see distribution efficiency and field application efficiency there must be extension of service including secondary and tertiary canals system. But in this case secondary and tertiary canals systems were used the traditional systems.

From this, the main and secondary canals conveyance efficiencies were lower than the designed for scheme amount by Oromia Water Work and Construction Authority, but the problem was vast in the scheme. As a result the canals of the irrigation scheme have been found under poor performance conditions; couldn't deliver the amount of inflow rate to the required place. Furthermore, at irrigation scheme the losses at secondary canals were higher than the main canal.

In general at Fultino SSI scheme the major constraints for higher conveyance losses were due to improper construction, siltation of canals with weeds and soils, cracking and breakage of canals, small cross sectional area of canals that led to overflow, insufficient inflow controlling structures and seepage problem.

### 4.7.4 Irrigation water delivery measurements (IWD)

In the study, the irrigation water in the canal was measured by calibrated flume which was made from local material. The flow amounts were taken from eight off-take canals which were situated at head; middle and tail reach of the irrigation system. The discharge of canal resulting from the depth-flow relationship in flumes was calculated in free flow conditions. The measurements were taken at the branch off-take canals just after abstraction points along the distribution canals. Based on the settled water delivery plan, the measurement of actual discharges in each branch off-take canals were taken on 12 days per three months (four days/month) and then converted into an average Monthly rate.

## 4.8. Water Allocation and Equity of Distribution

In the case of Fultino SSI scheme, 92% of the control gates of turn out were not efficient even if the construction of masonry are there, the community still use old-style turn out to the field and to secondary canal too. The standards for determining when to irrigate is not according to design document and there is no any operation and maintenance manual.

At the scheme level water delivery is fixed rotational system according to the table 4.6 mentioned above. But at village level since every village have their own water user association leader( malaqa), mode of water distribution differ depending on his experience and the dominant cropping pattern of the village. From table 4.8, 30 % of the respondent said that, judgment of Malaqa water user association leader (malaqa), govern who get water in the area, where as 60 % of the respondents agree that style of water distribution depends on the crop type and land size. Which mean, dependent on the condition of the crops and land size, the water user association leader (malaqa), know the time required to irrigate the field from his accumulated traditional skill.

Concerning availability of water during the interviewed, 80% of the respondents said that irrigation water is enough for the project. Whereas 20% said that, it depends on the condition of the rain. But when the respondents were asked the extent of water availability at plot level, 40% of the respondents said „yes" it is available, whereas 60% respond „no".

And More than 40% of the respondents approve that unfunctionality of the conveyance structure was the main reason of shortage of water at farm land levels. Similar result was found by research conducted by ministry of Water, Irrigation and Electric (MoWIE, 2013).The mode of irrigation water distribution of the Fultino irrigation scheme were still under the traditional water user association leaders called (Malaqa *)* in which decision of Malaqa accounts for more than 30 percent of water distribution. On the subject of equity of water distribution, about 80% of the respondent feels that they did not share equally; where as 20% of the users feel as they share equal quantity of water with every user of the scheme.

From the below table we can conclude that the three village was not got water equally .even with in the same water users association of Kofitu from 109 farmers only 66 farmers got the irrigation water on their own schedule. The same trends in Godino water users association. But in case of Fultino there is better water distribution like from total of 99 farmers 88 farmers got irrigation water based on their irrigation schedule.

Table 4.7 Traditional and current irrigation scheduling at scheme level which is rotational system

| Name of village | Number of users(HH) | | Total | Water distribution according to villages | Block | Satisfaction level | | |
|---|---|---|---|---|---|---|---|---|
| | Male | Female | | | | M ale | Female | Total |
| Kofitu | 92 | 17 | 109 | From Monday-Wednesday before noon and Saturday and Sunday | Head and middle user | 56 | 10 | 66 |
| Fultino | 84 | 15 | 99 | From Saturday-Sunday always after noon | Right canal tail users Left canals head and middle user | 76 | 12 | 88 |
| Godino | 14 | 8 | 22 | Except Monday and Friday always at the morning | Middle and tail users | 11 | 2 | 13 |

Table below and the interview respondent results shows that, water thefts and unplanned water use (Investment) play a great role in getting water. In the same way, 80% of the respondent said that, people found at headwork and middle user get more water than people found at tail or end user and the flower investment project use more than irrigator famers. This shows that, there was in-equality in water distribution which hinders issue of collective action toward sustainability of the scheme.

But, when water scarcity is high, the Malaqa decided water distribution on negotiated request. Thus, from focus group discussion and key informant interview held on the site, traditional leader which are elected by local community is the man in charge to distribute water but every village has its own Malaqa and there are no any coordination among them. When the respondent asked the extent of water availability at farm land level, 40% of the respondents said yes, whereas, 60% responded there is shortage. The factors that contribute for insufficiency of water for irrigation also represented problem of conveyance systems evaluate more.

Table 4.8 Reason of inequality in water distribution

| Reason of inequality | Frequency | Percent |
|---|---|---|
| Inability to control water | 25 | 36 |
| Water theft and unplanned water uses (Investment) | 42 | 60 |
| Lack of proper scheduling and allocation | 3 | 4 |
| Total | 70 | 100. |

## 4.9 Productivity indictors

### 4.9.1 Land productivity indictor

According to the design document and Key Informant interviewed during the study time, irrigated agriculture is the main means of income generating for actuality of life at the area due to shortage of rainfall for 7-9 months per year. That is why 90% of the respondents endorse that, the crop yield from rainfall is not adequate for them. Thus, application and introduction of intensive agricultural system by increasing cropping intensity per year is the only way out to ensure food security of the area and the data collected from the household interview of selected scheme shows that 80% are able to produce two times per year, 10% three times and 10% produce one times per years. Even if the design document was propose 150% per year as cropping intensity and under improved irrigation system, still the dominant existing cropping pattern were vegetables and tomato's and this was what they said two times per year.

Table 4.9 proposed crops and cropping calendar for Fultino SSI scheme during

Scheme design by Oromia Water Works Design and Construction Enterprise

| Crop under full irrigation | Ha | Month | Crop proposed under supplementary irrigation | Ha | Month | Proposed perennials under improved irrigation system | Ha |
|---|---|---|---|---|---|---|---|
| Onion | 17 | Oct-Feb | Maize | 7 | Feb-June | Papaya | 4 |
| Potato | 12 | Oct-Feb | Haricot bean | 10 | March-June | Sugarcane | 12.8 |
| Maize | 10 | Sept-Jan | Onion | 6 | March-June | Mango | 25.4 |
| Tomato | 5 | Sept-Jan | Potato | 7 | March-June | Sugarcane | 2.8 |
| Pepper | 7 | Sept-Jan | Cabbage | 6 | Feb-April | | |
| Carrot | 20 | Sept-Jan | | | | | |
| potato | 10 | Sept-Jan | | | | | |

However, the above cropping pattern was proposed during the scheme design, by now the dominant crops of the head users are onion, tomato sugarcane, and maize while onion and tomato were produced on the land of downstream users and middle user in the valley according to the user's discussion during focused group discussion held on Kofitu Village of Fultino farmers association. To confirm the above statement, 60% of the respondents said that they follow proposed cropping calendar, 30% said not followed whereas 10% said that they follow the proposed cropping calendar sometime. But 90% of the respondents said that their annual crop productions were increased and 10% said not increased which is due to introduction of fertilizers and improved seeds. This result is consistent with the findings of Mulugeta (2002), Ayalew (2003), Abebaw (2003) and Yilma (2005).

Table 4.10 Average improvement of crops production after irrigation development

| Type of crop | Agricultural land(In Ha) | Previous production/ kert | New production/ kert |
|---|---|---|---|
| Maize(supplementary) | 1.43 | 3 Quintal (qt) | 5-10 Quintal (qt) |
| tomato | 0.25 | Not practiced | 600 Birr |
| Onion | 0.25 | Not practiced | 550 Birr |
| Sugar cane | 0.2 | high | Low due to flooding (May-June) |
| Banana | 0.2 | high | Low due to flooding |
| Mango | 1 | 3000(Birr) | 4000Birr (depend on the condition of the time. |

90% of the interviewed households approve that, maize, teff, wheat; potato and sorghum are cultivated using rainfall. Concerning grain crops teff and maize is the dominant crops, and 50% of the command area was employed by onion and tomato, but within the boundary of this scheme. Taking 50 percent the lowest limit and 100 percent the largest limit productivity rated scale using different indictors the productivity average of the scheme were 3.58 which shows performance condition in most aspect but intensification activities is good but it lack the crop rotation in the scheme

Table 4.11 Productivity rated scale

| Category | Indictors of productivity | Expertise response in percent | Rated scale | Remark |
|---|---|---|---|---|
| Productivity | a. Generate sufficient income for the households | 80 | 3.8 | Good |
| | b. Improvement of the life style of the farmer | 80 | 3.8 | Yes |
| | c. Intensification (onion and potatoes rotation were dominant in the area) | 80 | 2.5 | Fair |
| | d. Increasing of annual production after modernization | 80 | 3.8 | Good |
| | e. Availability of farm labor | 90 | 4 | Very good |

Here, the key point of this is to see the financial sustainability of the scheme by discussing the financial feasibility of the member irrigator farmers. Even if the scheme is significance and productive for the farmers, absence of commitment feeling towards maintaining and sustaining the scheme, brings lack of condition which ensure financial viability of the scheme. Because of this, 50% of the sampled irrigator farmers are not paid and ready to pay operation and maintenance costs, water fee costs and project recovery costs, which show poor financial viability of the scheme.

Table 4.12 Crop yields and output production values for Fultino SSI scheme.

| Season I (February 2017-April 2017) | | | | | | Season II (May 2017-November 2017) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Crop | Area (ha) | Yield (Ql/ha) | Yield (ql) | Ave. price (Birr/ql) | Total income (birr) | Area (ha) | Yield (ql/ha) | Yield (ha) | Ave. price(birr/ha) | Total income (birr) |
| | (1) | (2) | (3)=(1*2) | (4) | (5)=(3*4) | (1) | (2) | (3)=(1*2) | (4) | (5)=(3*4) |
| Tomato | 15 | 200 | 3000 | 1000 | 3,000,000 | | | | | |
| Onion | 10 | 180 | 1800 | 1200 | 2,160,000 | | | | | |
| Cabbage | 5 | 103 | 515 | 450 | 231,750 | | | | | |
| Sugar cane | 7 | 98 | 686 | 5000 | 3,430,000 | | | | | |
| Maize | 12 | 45 | 540 | 700 | 378,000 | 27 | 50 | 1350 | 700 | 945,000 |
| Pepper | 11 | 17 | 187 | 500 | 93,000 | 10 | 17 | 170 | 500 | 85,000 |
| Chick pea | 10 | 27 | 270 | 950 | 256,000 | | | | | |
| Banana | 5 | 120 | 600 | 1350 | 810,000 | | | | | |
| Total | 75 | | | | | 37 | | | | |
| Sub total | Season I | | | | 10,358,750 | Season II | | | | 1,030,000 |
| Grand total | Season I + season II 10,358,750 +1,030,000 = 11,388,750 ETB OR 419,320 US$ | | | | | | | | | |

Table 4.14 General the Fultino SSI scheme agricultural productivity

| Command irrigable area (ha) | Area harvested (ha) | Production value (birr) | Irrigation water diverted ($m^3$) | Irrigation water delivered (m3**)** | Crop water consumed ($m^3$) |
|---|---|---|---|---|---|
| 85 | 75 | 5,651,520 | 12,600,000 | 9,521,897 | 7,217,236 |

### 4.9.2. Water productivity indicator

Water productivity performance was evaluated at Fultino irrigation scheme taking output per unit irrigation water supplied/diverted/, output per unit irrigation water delivered to the command area in the irrigation period and output per unit water consumed. As indicated in table 4.14 at the irrigation scheme the output per unit irrigation water delivered was higher than the output per unit water diverted and output per unit water consumed. This understood that the delivered amount of irrigation water was more productive than relative to the diverted irrigation water and consumed water and there was investment which consume more water before reaching to the command land or irrigation farm land. Furthermore, output per unit consumed water was relatively more productive than the diverted amount of irrigation water. From the total diverted water at the head, 40.2% was unproductive relative to the delivered amount; which means excess irrigation water was diverted to the command area with respect to delivered irrigation water. The output per unit irrigation water supplied of 12.80 birr/$m^3$. This revealed that a unit amount of diverted water was more productive, 125% higher in Fultino comparable results were also investigated in different countries in the word values of 10.04 birr/m3 in Burkinafaso (Molden et al., 1998).

The productivity per unit irrigation water delivered values of 24birr/m3 was recorded in Fultino scheme. Even though the lower water distribution efficiency was a critical issue at Fultino irrigation scheme, the yield values of unit irrigation water delivered at farm inlet was better than other findings. Molden et al. (1998) reported that the output production value per cubic meter of irrigation water tends to be higher in regions where rainfall partially contributes for crop water demands in the irrigation seasons. But it depends on the capability of farmers and system managements to use rainfall successfully. At the irrigation scheme rainfall contributes about half of the total crop water demand but the variability of occurrence and distribution make less dependable.

Generally the values of water efficiency indicators computed from Fultino SSI had shown higher performance. Even if there was unequal water distribution and crop selection experiences. Despite the water distribution inefficiency, the water efficiency values were satisfactory.

## 4.10 Performance improvement measures

### 4.10.1 Water user Association Establishment at Fultino SSI scheme (WUAs)

Government transferred the scheme to the community in a mode of joint management by both the government and the community, to carry out their respective responsibilities. But the whole water management style did not show this truth depending on interview and focused group discussion .The government has the responsibility for undertaking main maintenance or recovery works which could be beyond the ability of the user cooperatives /associations/. On the other hand, the operation and other minor maintenance activities are the responsibilities of the irrigation user cooperatives /associations/. Nowadays the main management responsibilities of the water user association committees are; allocate water and controls water distribution, ensure the safety of the scheme through organizing operation and maintenance works, and mobilizing resources for these works and resolve disputes related to water and maintenances based on their bylaws. Based on the context of SSI scheme frame work; Fultino SSI scheme WUAs were established around 1995. From the respondents, 80% were member of the WUAs. The finding by (Awulachew .et.al, 2006) was disused the similar trend concerning the water users association. Currently Fultino SSI scheme the association was initially formed in cooperative forms as a multi-functional local institution with three main objectives, which were operation and maintenance of the scheme; input and credit supply and marketing of out puts, but these objectives were not functional yet in the scheme. However, both parties have not been able to translate their responsibilities into reality on the ground. Currently the association only has been trying to practice the water allocation issues with minimum achievements.

The WUAs at irrigation scheme have developed their own management structures that suit for management of the irrigation scheme. Woldeab (2003) stated that one of the social requirements for successful irrigation is organization and management structure that suit the irrigation infrastructure.

Generally the WUAs have decision-making committee, sub-committee and water user teams for better achievement of operation and maintenance activities at irrigation system and distribution levels. A decision-making Committee consisting of seven members in each irrigation system is responsible for operation and maintenance of the irrigation systems. The composition of the WUA committee members has, chairman and vice chairman, a secretary, control and monitoring committee, cashier and two members.

The general assembly is the highest body in which all members of the irrigation systems jointly discuss the highest level issues and make the final decisions based on the bylaw. Water allocation and arrangement of irrigation timetables are the responsibility of the general assembly. Controlling and monitoring committee which supervises and controls the implementation process, and determines whether it is in line with the direction given by the general assembly and with the stated bylaws. The bylaw was developed by the initiation of Agricultural and Rural Development Office with the main objective to sustain the irrigation infrastructure and to assure fair distribution of water among beneficiaries Organizational set up and management functions of the committees are further decentralized depending on layout of the scheme. All water users in the irrigation systems constitute the water users teams (WUTs) 'Ketena', contains a number of water user groups 'Yewuha Budin'. Sub-committees are in charge of control of water distribution and coordination of maintenance activities in the respective territory units, water user teams. As a rule, they are accountable to the executive committee and expected to report to the board when regulations in the water distribution by-laws are violated. However, they did not effectively discharge this responsibility as stipulated in the bylaws, because of organizational weakness. Generally Fultino SSI scheme has three (3) water users teams(WUTs) and eight (8) water users groups (WUGs) which each WUG contains 25-60 users.

### 4. 10.2 Water user association bylaw

Effective and sustainable management of SSI scheme requires well-established internal bylaws which contains detailed rules and regulations developed and approved by beneficiaries, which ensure the interest of all irrigators.

Establishment gap created problem on the productivity and sustainability of the scheme. Meanwhile at Fultino WUA was established in 1995, the organization has a bylaw, but it is not fully implemented. Most of the time, beneficiaries had been ruled by their religious and cultural rules. Due to the poor functionality of WUAs at organizational levels and reluctance of committee members, rules written in the bylaws have not yet fully implemented. Offenders who were found guilty of turn abuses, breaching canals, power abuse to use water out of their turn and failure to respect decisions of the WUA committee members have not been fully charged.

In Kofitu village there was high illegal water abstractions and breaching of canals, but none of them were charged in accordance with the bylaw. Illegal water users contributed for unfair water distribution at SSI scheme. Additionally during group discussion, the water user association committees confirmed that they had not been got any information and awareness about the new internal water users associations (IWUAs) declarations yet.

### 4.10.3 Regular maintenance and canal cleaning

For the period of planning and construction period had a positive contribution to create sense of ownership and to assure sustainability. However 80% of the key informant interviewed result shown that the beneficiaries were not shared both at planning and construction stages in irrigation scheme. The effect of not participating beneficiaries was clearly visible in scheme.

As a result, beneficiaries were not concerned to efficiently use the irrigation infrastructure constructed to them. Even though the government gave the operation and other minor maintenance responsibilities to users, they didn’t carry out any operation and maintenance activities at both schemes yet.

However, beneficiaries annually clean canals by removing sediments and weeds in scattered manner. Participation varied among the different villages in the scheme for maintenance and canal cleaning. Most of the time farmers prefer to clean the nearby canals from their farm plots. According to the bylaw in irrigation scheme beneficiaries were expected to maintain twice per year in September and February. However, 80% of the respondents were participated once in the production season. The reflection depends on their farm plot proximity to the infrastructure.

#### 4.10.4 To improve irrigation efficiency

To improve the water application of the overall scheme, watershed management system of Fultino area must take as the priority agenda and tillage practice should be experienced in the scheme. In addition to these integrated water management institute (IWMI) SSI scheme performance evaluation indictors should be used like water productivity indictors, financial feasibility indictor, especially internal or management performance measurement should be the best scenario to Fultino SSI scheme.

# 5. CONCLUSIONS AND RECOMMENDATIONS

## 5.1. Conclusions

From this performance evaluation study of Fultino SSI scheme can be concluded that, beneficiary or farmer associations' involvement at the irrigation scheme in canal clearing, during construction and regular maintenance was very low. The majority parts of canals were covered by weeds, debris and soils. Because of the government or (responsible bodies) and water users association`s (WUA's) organizational function and legal enforcement of bylaws was weak even if they have by laws which was ratified on 1995. This weak enforcement also attributed to illegal water abstractions and unfair water distributions in the irrigation scheme and at end of the day decreases overall the scheme irrigation efficiency. In addition to this, in the SSI scheme non-functionality of majority flow control gates broken and cracked canal have contributed to high water losses. As a result the SSI scheme overall water distribution efficiencies was very low and nearly half of the diverted amount of water was unproductive which means water was lost by seepage, infiltration and overflow .

However, the scheme was better than irrigation and conveyance efficiencies in land and water productivity issues. The reasons were farmers have been used the rain fall support, land and crop intensively and grown high value crops. But in Fultino SSI scheme crop selection problems, intense cropping pattern, low irrigation concentrations were contributed to low gross return on investment values. Additionally, the rigid rotational schedule, low practices of irrigation interval and concentrated cropping pattern arrangements were highly affected the allocation of water distributions in the scheme.

Fulton's SSI scheme water user associations (WUAs) have a detailed and written internal bylaw. However it has not been enforced remarks incase illegal water abstraction that make guilty. As a result it reduces the legal enforcement of the bylaws to protect illegal water abstractions and canal breaching, which disturb the fair water distribution system. Furthermore in scheme there is on ground practice of water allocations for beneficiaries; however it has not been supported by technical approaches from water and agronomy experts, DAs and district irrigation experts.

Generally, in all selected minimum performance indicators, Fultino SSI scheme was perform better in agricultural productivity indicator. But less performance in irrigation water conveyance efficiency (averagely 75.96%), irrigation efficiency (average 71.3%) and water equity (unsatisfied water use trends).

Finally, the performance gaps that were identified and to take measurements for better improvement and sustainability of the Fultino SSI scheme for future were coordination between responsible bodies, water user association legal frame amendment, regular canal cleaning or the whole system maintenance of water conveyance distribution system and improve water application of the scheme.

### 5.2. Recommendations

- Irrigation efficiency, conveyance efficiency and water distribution equality of scheme were low. Therefore, the conveyance systems should be improved through regular canal cleaning and maintenance of broken irrigation infrastructures and regular check-up of flow control gates, while irrigation efficiency of the system also should be improved by providing the water conveyance distribution design improvement, irrigation and water resource expert ,farmers and stakeholders participation from grass root level and protecting the water shed management as per recommended by different research finding to the scheme.
- Secondary canals and lining of main canals (earthen canal part) is required to improve water conveyance efficiency in the scheme. So development of secondary and tertiary canal concrete line must take priority. As result water loss by seepage, overflow, broken canal and infiltration would be decreased.
- Even if the agricultural productivity of scheme was efficient announcing agricultural intensification and crop rotation increases land and water productivity more through integrated management and increasing irrigation intensities are very relevant to increase the productivity value of production per unit irrigated area and command area.
- To use the limited water resources at the irrigation scheme efficiently, water allocation shall be carried out based on programmed and designed cropping pattern with irrigation scheduling.
- Introducing updated legal frame or make amendment on the existing by law with consultation with water user farmer associations and stakeholders, by adopting the others

SSI scheme achievement trends with in the region or at country level for beneficiaries or to increases the overall efficiency of the Fultino SSI scheme.

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## Appendix of Tables

Appendix 1 Mean monthly m Temperature Of the Fulitino SSI scheme

Monthly ETo Penman-Monteith - C:\ProgramData\CROPWAT\data\climate...

Country: ethiopia — Station: fulitino SSI scheme.

Altitude: 1750 m. — Latitude: 8.35 °N — Longitude: 38.50 °E

| Month | Min Temp | Max Temp | Humidity | Wind | Sun | Rad | ETo |
|---|---|---|---|---|---|---|---|
| | °C | °C | % | km/day | hours | MJ/m²/day | mm/day |
| January | 11.5 | 13.9 | 59 | 145 | 7.5 | 18.8 | 3.12 |
| February | 14.8 | 15.0 | 58 | 174 | 8.0 | 20.7 | 3.70 |
| March | 14.8 | 15.5 | 60 | 174 | 7.0 | 20.1 | 3.74 |
| April | 14.8 | 15.6 | 57 | 164 | 8.0 | 21.8 | 3.87 |
| May | 22.0 | 24.9 | 52 | 182 | 7.8 | 21.0 | 5.02 |
| June | 15.2 | 17.8 | 50 | 188 | 7.0 | 19.3 | 4.26 |
| July | 13.0 | 15.0 | 58 | 195 | 5.0 | 16.5 | 3.43 |
| August | 11.0 | 15.0 | 59 | 147 | 5.5 | 17.7 | 3.25 |
| September | 13.2 | 14.8 | 70 | 125 | 5.5 | 17.7 | 3.11 |
| October | 7.0 | 14.2 | 62 | 122 | 7.5 | 20.1 | 3.20 |
| November | 7.0 | 10.0 | 58 | 122 | 9.0 | 21.1 | 2.87 |
| December | 11.2 | 15.8 | 60 | 157 | 7.5 | 18.3 | 3.11 |
| **Average** | **13.0** | **15.6** | **59** | **158** | **7.1** | **19.4** | **3.56** |

Appendix 2 Mean monthly meteorological data of rain fall and effective rain fall

Of the Fulitino SSI scheme

Monthly rain - untitled

Station: fultion SSI scheme

Eff. rain method: USDA S.C. Method

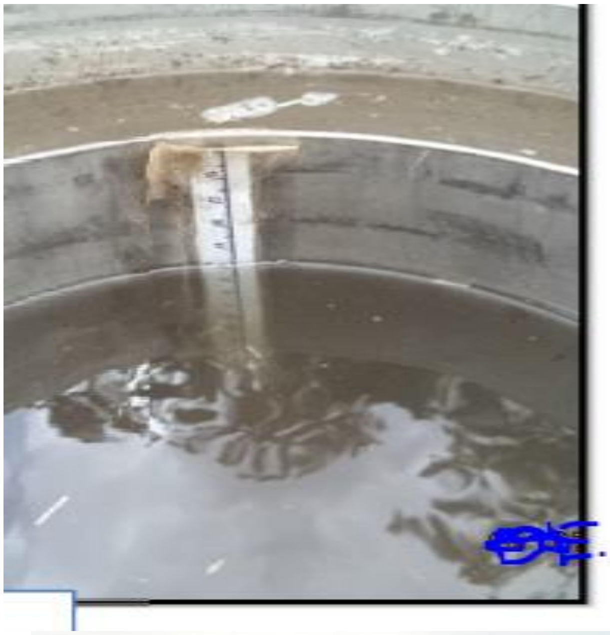
| | Rain | Eff rain |
|---|---|---|
| | mm | mm |
| January | 2.4 | 2.4 |
| February | 6.3 | 6.2 |
| March | 20.0 | 19.4 |
| April | 62.0 | 55.8 |
| May | 75.0 | 66.0 |
| June | 105.0 | 87.4 |
| July | 224.0 | 143.7 |
| August | 207.0 | 138.4 |
| September | 125.0 | 100.0 |
| October | 52.0 | 47.7 |
| November | 4.0 | 3.9 |
| December | 2.8 | 2.8 |
| **Total** | **885.4** | **673.7** |

Appendix 3 onion crop irrigation scheduling at Fultino SSI

| Date | Day | Stage | Rain mm | Ks fract. | Eta % | Depl % | Net Irr mm | Deficit mm | Loss mm | Gr. Irr mm | Flow l/s/ha |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2-Mar | 2 | Init | 0 | 0.54 | 58 | 63 | 17.6 | 0 | 0 | 39 | 2.26 |
| 4-Mar | 4 | Init | 0 | 1 | 100 | 21 | 6.3 | 0 | 0 | 14 | 0.81 |
| 6-Mar | 6 | Init | 0 | 1 | 100 | 20 | 6.3 | 0 | 0 | 14 | 0.81 |
| 8-Mar | 8 | Init | 0 | 1 | 100 | 18 | 6.1 | 0 | 0 | 13.6 | 0.79 |
| 10-Mar | 10 | Init | 0 | 1 | 100 | 17 | 6.1 | 0 | 0 | 13.6 | 0.79 |
| 12-Mar | 12 | Init | 0 | 1 | 100 | 17 | 6.5 | 0 | 0 | 14.5 | 0.84 |
| 14-Mar | 14 | Init | 0 | 1 | 100 | 16 | 6.5 | 0 | 0 | 14.5 | 0.84 |
| 18-Mar | 18 | Dev | 0 | 1 | 100 | 15 | 6.5 | 0 | 0 | 14.5 | 0.42 |
| 22-Mar | 22 | Dev | 0 | 1 | 100 | 30 | 14.3 | 0 | 0 | 31.9 | 0.92 |
| 26-Mar | 26 | Dev | 0 | 1 | 100 | 30 | 15.6 | 0 | 0 | 34.7 | 1 |
| 30-Mar | 30 | Dev | 0 | 1 | 100 | 28 | 15.6 | 0 | 0 | 34.7 | 1 |
| 3-Apr | 34 | Dev | 17.5 | 1 | 100 | 8 | 4.6 | 0 | 0 | 10.3 | 0.3 |
| 7-Apr | 38 | Dev | 17.5 | 1 | 100 | 7 | 4.6 | 0 | 0 | 10.3 | 0.3 |
| 11-Apr | 42 | Mid | 0 | 1 | 100 | 29 | 18.7 | 0 | 0 | 41.6 | 1.2 |
| 15-Apr | 46 | Mid | 0 | 1 | 100 | 23 | 14.7 | 0 | 0 | 32.6 | 0.94 |
| 19-Apr | 50 | Mid | 0 | 1 | 100 | 23 | 14.7 | 0 | 0 | 32.6 | 0.94 |
| 23-Apr | 54 | Mid | 14.8 | 1 | 100 | 8 | 5.5 | 0 | 0 | 12.2 | 0.35 |
| 27-Apr | 58 | Mid | 14.8 | 1 | 100 | 9 | 5.8 | 0 | 0 | 12.8 | 0.37 |
| 1-May | 62 | Mid | 0 | 1 | 100 | 32 | 20.8 | 0 | 0 | 46.2 | 1.34 |
| 5-May | 66 | Mid | 0 | 1 | 100 | 25 | 16.2 | 0 | 0 | 35.9 | 1.04 |
| 9-May | 70 | Mid | 0 | 1 | 100 | 25 | 16.2 | 0 | 0 | 35.9 | 1.04 |
| 13-May | 74 | Mid | 10 | 1 | 100 | 19 | 12.3 | 0 | 0 | 27.4 | 0.79 |
| 17-May | 78 | Mid | 10 | 1 | 100 | 19 | 12.6 | 0 | 0 | 27.9 | 0.81 |
| 21-May | 82 | Mid | 0 | 1 | 100 | 34 | 22.4 | 0 | 0 | 49.8 | 1.44 |
| 26-May | 87 | End | 0 | 1 | 100 | 34 | 22 | 0 | 0 | 48.9 | 1.13 |
| 31-May | 92 | End | 0 | 0.94 | 99 | 42 | 27.2 | 0 | 0 | 60.5 | 1.4 |

**List of Appendix Figures**

Appendix 1 field water discharge measurement and site visit with course advisor (Dr.Mengistu Sime).



Appendix 2 Concrete line canal and control gate


Appendix 3 Site visit and Belbela Dam site and its buffer zone

Appendix 4 Main canal concrete line and grass way

**Appendix 3: Questionnaire for collecting data on performance evaluation of Fultino small scale irrigation scheme on different performance indictors**

This questionnaire is designed to collect information on performance of evaluation of small scale irrigation scheme in relation between performance and productivity. It is used to collect the desired information from farmers; woreda different experts, government officials, irrigation water users and non-irrigation water users and the collected information will be used in the research thesis as partial fulfillment for obtaining Master Degree in Irrigation Engineering.

The desired information is organized into the respondent's personal data and perception that respectively refers to the respondent's personal information (A) and specific information (B, C & D) as shown in this questionnaire. Please note that each and every piece of the requested information is very important and needs to be fully replied. The information received from the respondents will also be treated ethically and confidentially.

Therefore, I politely request the respondents to patiently read and fill this questionnaire; and send the completed questionnaire back to the researcher (Desta Abera; mobile: 0912183844).

**(A) The respondent's Personal Information( for government officials, different level of experts)**

(1) Sex (put 'x' in the box as appropriate)

Male ☐

Female ☐

(2) Age _______ years

(3) Marital status (put 'x' in the box as appropriate)

Married ☐

Single ☐

Divorced ☐

(4) Level of education (put ‘x’ in the box for the highest level):

Less than diploma ☐

Diploma ☐

1st degree ☐

2nd degree ☐

3rd degree ☐

(5) Name of the current organization ___________________________________

(6) Department ______________________________________________________________

(7) Position of work _________________________________________________________

(8) Experience: (a) _________ years. (b) in other organization(s)_________ years.

**(B) Specific Information on performance of small scale irrigation with relation to productivity**

This questionnaire is designed to obtain the respondents’ perception on performance evaluation of small scale irrigation on productivity stated in the following table. You are requested to indicate the extent to which you agree or disagree with each statement. So, indicate your best choice (only one answer) by selecting from the five choices given on 1–5 numbered columns; and put the sign ‘**x**’ under the number of your best choice for each statement in the table.

1 = strongly disagree; 2 = disagree; 3 = indifferent (neither agree nor disagree); 4 = agree; 5 = strongly agree

| statement | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1. Filitino Small scale irrigation has impact on productivity increments | | | | | |
| 2. Filitino Small scale irrigation scheme has positive impacts on productivity | | | | | |
| 3. Filitino Small scale irrigation scheme has negative impacts on productivity | | | | | |
| 4. Tedicha dam water resource for irrigation user is enough and continuous | | | | | |
| 5. The performance of filition irrigation scheme is in good condition for maximum productivity plan . | | | | | |
| 6. All five irrigation water users got enough water for their irrigation scheduled program | | | | | |
| 7. Filitino small scale irrigation scheme changes the livelihood of irrigation water users | | | | | |
| 8. Irrigation water users satisfied by water application, irrigation interval and water management . | | | | | |
| 9. Community cultures in irrigation water application efficiency and performance of scheme with relation to productivity is strong | | | | | |
| 10. Community cultures in irrigation water application efficiency and performance of scheme with relation to productivity is weak | | | | | |
| 11. Cost-benefit analysis trends show positive for irrigation water users | | | | | |

**(C) Specific Information on Filitino Small scale Irrigation Scheme Performance of irrigation efficiencies**

This questionnaire is designed to obtain the respondents' perception on Filitino small scale irrigation scheme performance stated in the following table. You are requested to indicate the extent to which you agree or disagree with each statement. So, indicate your best choice (only one answer) by selecting from the five choices given on 1–5 numbered columns; and put the sign '**x**' under the number of your best choice for each statement in the table.

1 = strongly disagree; 2 = disagree; 3 = indifferent (neither agree nor disagree); 4 = agree; 5 = strongly agree

| **statement** | **1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|---|
| 1. The quality of scheme or the quality of results of the efficiency is used to measure the success of irrigation scheme | | | | | |
| 2. The quantity construction of primary ,secondary and tertiary canal is very good | | | | | |
| 3. The quality of construction of primary ,secondary and tertiary canal is very poor and inefficient | | | | | |
| 4. The irrigation water user applied their farm as per scheduled time or use irrigation or water experts advise | | | | | |
| 5. All canals performs effectively along the scheme and has attain the goal | | | | | |
| 6. During dry time all five irrigation water users association have got proportional water | | | | | |
| 7. There is no complain on irrigation scheduling from irrigation water users and the cost the are paying | | | | | |

**(D) Specific Information on performance of Fulitino small scale irrigation scheme on conveyance efficiencies**

This questionnaire is designed to obtain the respondents' perception on agricultural performance stated in the following table. You are requested to indicate the extent to which you agree or disagree with each statement. So, indicate your best choice (only one answer) by selecting from the five choices given on 1–5 numbered columns; and put the sign '**x**' under the number of your best choice for each statement in the table.

1 = strongly disagree; 2 = disagree; 3 = indifferent (neither agree nor disagree); 4 = agree; 5 = strongly agree

| **statement** | **1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|---|
| 1. Irrigation improves yields through reduced crop loss due to erratic, unreliable or insufficient rainwater supply | | | | | |
| 2. Irrigation allows for the possibility of multiple-cropping, and so an increase in annual output | | | | | |
| 3. Irrigation allows a greater area of land to be used for crops in areas where rain fed production is impossible or marginal. | | | | | |
| 4. Intensify cultivation, leading to increased productivity, overall higher production, and greater returns from farming | | | | | |