JIMMA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
JIMMA INSTITUTE OF TECHNOLOGY
FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING
HYDRAULIC AND WATER RESOURCES ENGINEERING
MASTER OF SCIENCE PROGRAM IN HYDRAULIC ENGINEERING

Performance Evaluation of Sembeta Small Scale Irrigation Scheme in Kachebira District Kembata Tembaro Zone in Southern Ethiopia).

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

By: Bizunesh Achamo

July, 2023
Jimma, Ethiopia

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July, 2023

Jimma, Ethiopia

DECLARATIONS

I, the undersigned person, hereby declare that this thesis is my original work and all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, all sources of materials that are not original to this work have been duly acknowledged.

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Jimma University School of Graduate Studies

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As member of the Board of Examiners of the Masters of Science thesis open defense examination, we Certify that we have read and evaluated the thesis prepared by Bizunes Achamo and examined the Candidate. We recommended that the thesis be accepted as fulfilling the Thesis requirement for the degree of Masters of Science in Hydraulic Engineering.

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LIST OF ACRONOMY/ABBREVATION

AGPs	Agricultural Growth program
A	Cross sectional area of the scheme
Bd	Bulk Density
CROPWAT.8	Crop Water requirement Estimation Model Window8
CWR	Crop Water requirement
GIR	Gross irrigation requirement
NIR	Net irrigation requirement
DAS	Developmental agents
DPR	Deep percolation ratio
Rz	Root zone depth
Ea	Application Efficiency
Ec	Conveyance Efficiency
Es	Storage Efficiency
ETc	Crop Evapotranspiration
ETo	Reference evapotranspiration
FAO	Food and Agriculture Organization of United Nation
Fc	Field Capacity
FSS	Financial Self Sufficiency
H1,H2,andH3	Fields Selected from Head Users
Ha	Hectare
IDD	Irrigation Development Department
IWMI	International Water Management Institute
Kc	Crop Coefficient
LMC	Lower Main Canal

m.a.s.l	meter above sea level
M1.M2 and M3	Fields Selected from Middle Users
MAD	Maximum Allowable Deficit
MoA	Ministry of Agriculture
MoAFS	Ministry of Agriculture and Food Security
MoWR	Ministry of Water Resource
NGOs	Non- Governmental Organizations
PWP	Permanent Wilting Point
Q	Water Discharge in Canal
Qi	Amount of Water at inlet point
Qo	Amount of Water at outlet point
RAW	Readily Available Water
RR	Runoff Ratio
SNNPR	Southern Nation Nationalities and Peoples Region
SSI	Small-scale Irrigation
T1, T2 and T3	Fields Selected from Tail Users
TAW	Total Available Water
UMC	Upper Main Canal
V	Velocity of Water in Canal
W	Width of Canal
Wd	Wight of oven dry soil
Wn	Water Desired to be Store at the Root Zone
Ww	Weight of Wet Soil

ABSTRACT

Ethiopia's agriculture is dominated by small-scale rain-fed production whose performance is subject to, among others, irregular rainfall pattern. Small-scale irrigation is believed in helping. To address this problem thereby reducing rural poverty, food insecurity as well as improving the overall contribution of agriculture to the national economy. The purpose of this study was to assess the effect of small scale irrigation on household food security in Kachebira Woreda. Evaluation of the performance of irrigation schemes helps to know the present status of the scheme and to apply possible measures for improvement. Sembeta small scale irrigation scheme was found in Kachabira District Southern Ethiopia and had a service of fifteen years. It is constructed by World Vision Ethiopia. The beneficiaries of this irrigation scheme are 228 households from this 170 are male households and 58 are female households. The performance of Sembeta Small Scale Irrigation Scheme had not been evaluated before this study. Therefore, this study was conducted to evaluate the scheme by considering water delivery performance, on field water management performance and organizational setups and their performance for irrigation water management and maintenance. Primary data collected through field measurements and household field survey, and secondary data from different sources were used. Water delivery was evaluated by internal indicators. Both internal and external indicators were used for evaluating on field water management performance. The internal indicators were application efficiency, storage efficiency, distribution uniformity and deep percolation ratio. The external indicators like agricultural out puts, physical and financial indicators were used. The result of conveyance efficiency, application efficiency, storage efficiency, distribution efficiency and deep percolation ratio, were 62.3%, 64.2%, 91.6%, 80.76% & 35.8% respectively. The *value of relative water supply and relative irrigation supply were 1.6 and 1.2 respectively. The result of output per unit command area, output per unit irrigated area, output per unit water supply and output per unit water consumed were 23.2Birr/Ha, 1.28Birr/Ha and .28, respectively. Unfair distribution of water was due to water scarcity and illegal water users as the beneficiaries responded. Generally, the scheme requires improvement measures.*

Keywords*: efficiency, external indicators, internal indicators, irrigation, performance, SSIS*

1. INTRODUCTION

1.1. Background

In the 21st century, agriculture continues to be a fundamental instrument for sustainable development and poverty reduction. Agriculture alone will not be enough to massively reduce poverty, but it has proven to be uniquely powerful for that task. In the agriculture-based countries, which include most of Sub-Saharan Africa, agriculture and its associated industries are essential to growth and to reducing mass poverty and food insecurity. As is known, Agriculture is by far the largest user of water, contributing to water scarcity.

Increasing the productivity of water in Agriculture will play a vital role in easing competition for scarce resources, prevention of environmental degradation and provision of food security: by growing more food with less water, more water will be available for other natural and human uses. It was identified that globally 60% of the diverted fresh water for agriculture does not contribute directly to food production. This amount of water is discharged because of poor water control, inefficient irrigation systems with leaky conveyance and distribution, poor on-farm water management practices, etc. (World Agriculture Forum, 2009). It depicts that only about 40% global fresh water abstracted for irrigation is being effectively used for consumptive use in agriculture. Part of the amount of the discharged water of these systems is lost to saline groundwater or to poor quality drainage water. Performance based management is a principal approach to improve the scheme performances. Ethiopia has presently embarked to an accelerated irrigation development plan, in which the irrigated land is planned to be increased to three folds in five years (Dejen, 2014).

Ethiopia is an agrarian nation where 80 to 85% of the population is engaged in subsistent agriculture such as crop and livestock production (Abraham, 2009) .The agricultural practice is mainly rain fed systems (Kortenhorst, L.F,et al, 1989). (Ngigi, 2003).With traditional tillage using animals and hand tools. However, rain fed agriculture greatly suffers from uneven and erratic rainfall distribution resulting in crop failure and production loss (. Abiyu, 2016); (Boke, A.S., et al)). Irrigation has contributed significantly to poverty reduction, food security, and improving the quality of life especially for the rural population (Alemu, M.M.,, Agricultural

Extension for Enhancing Production and Productivity: T). (Gebregziabher, G., et al, 2009) 2009). In Ethiopia, irrigation projects have been built to boost dry season food production through government interventions from surface water sources. Small-scale irrigation (SSI) has been promoted in Ethiopia to solve the problem of food shortage and improve the livelihood of smallholder farmers with various capacities and scales (Adela, 2019); (Amede) . (Zeweld, W., et al, 2015) (. Asmamaw, 2015); (Tesfaye, A., Bogale,et al, 2008)According to (Hagos, F., et al, 2011), around 4.5% of the agricultural gross domestic product (GDP) and 2% of the total overall GDP of the nation was gained through irrigated agriculture with more than twice the income generation for the smallholder farmers. Beyond the wide benefit of SSI, leakage problems in the main canals, quality of scheme design, lack of institutional support for regular maintenance of scheme, lack of market access, poor agronomic and water management practices, and excessive siltation along the canals, all together, constrained the performance of irrigation schemes (Awulachew, S.B., et al, 2011).

The Agriculture (crop production) system in Ethiopia is dominated by smallholders on highly fragmented pieces of lands. These stallholders' agriculture is mainly based on rain fed farming depending on highly variable less predictable rainfall. The rainfall distribution is erratic in both its spatial and temporal distribution. Rain fed 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 (MoAFS, 2002).

Performance can be simply defined as the level of achievement of desired objectives. (Awulachew, 2010) Stated that in many irrigation schemes in Ethiopia issues like water fees, water rights, water conflict resolution, incentives for collaboration between the local, regional, and federal levels of government and incentives for accurate reporting of current projects. Public investment in irrigation in Ethiopia has largely focused on infrastructural development, with very little attention given to operation and maintenance and long-term sustainability issues (Yami, 2012).Irrigation is one means by which agricultural production can be increased to meet the growing demands in Ethiopia (Awulachew, 2010). *A* study also indicated that one of the best alternatives to consider for reliable and sustainable food security development is expanding irrigation development on various scales, through river diversion, constructing micro dams, water harvesting structures, etc. (Lambiso.R., 2005). This technique is used in farming to enable plants to grow when there is not enough rain, particularly in arid areas. It is also used in less arid regions to provide plants with the water they need when seed setting. Irrigation improves the quality of life by increasing food security. One major effect (Awulachew, 2010)is the increase in prosperity which may improve the nutrition intake and resistance of the people against disease. The problem of food security is intensified by growth of population. In fact; the prices of food stuffs in the world market have recently begun to rise.

Many civilizations have risen on irrigated agriculture. Irrigated agriculture increases food production and food security of the societies as (FAO, 1989).Despite the positive contribution of irrigation development for food security and poverty reduction; many irrigation schemes have been unsuccessful and even have had negative impacts (Dawit Z.et al., 1997).

Food production needs can also be met through performance improvement in existing irrigation systems, as well as the expansion in irrigated areas, which have so far posed constraint on the early development irrigation. Irrigation has greatly expanded the amount of arable land and the production of food throughout the world. Irrigated land represents about 15 percent of all land under cultivation but often produces over twice the yield of non-irrigated fields (FAO, 1995).

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The traditional small-scale schemes are, in general, simple river diversions. Modern irrigation was started at the beginning of the 1960's by private investors in the Middle Awash valley where big sugar estates, fruit and cotton farms are found.

The total potential irrigable land in Ethiopia is estimated to be around 3.7 million ha (Awulachew, 2010). Hence, the main aim of modern irrigation development must be to make the best use of water in conjunction with land and human resources to enhance and sustain crop production. Many countries are expected to face insufficient water resources satisfy their current agricultural, domestic, industrial and environmental water demands within the next two decades. The world population is forecasted to grow by about 30% by the year 2025, reaching 8billion people. As a results of improved communications, globalization and more urbanization, the living standards of the people are expected to increase. This means competition among the agricultural, industrial, domestic and other users will increase in unprecedented levels (Food and agricultural Organization, 2011)Irrigation is an agricultural activity that delivers water to fill the soil moisture deficit. For the farmers, it is a component of successful crop husbandry particularly in a dry climate. A consistent and appropriate irrigation water supply can result in enhancements in agricultural production and assure the economic vitality. Many civilizations have risen on irrigated agriculture. These provide basis for their society and enhance food security of their people. Some have estimated that as little as 15-20% of the worldwide total cultivated area is irrigated (FAO, 1989)Irrigation can be defined as the science of artificial application of water to the land in accordance with the crop requirement through the cropping period for full-fledge nourishment of the crops (Eticha, 2011).

The utilization of important resources in irrigated agriculture is very important for sustainable production of irrigated agricultures. The potential efficiency of the system evaluated by on-farm operations. Performance assessment has been an essential part of irrigation since man first started harnessing water to improve crop production. Evaluation involves measuring conditions at one or more points in a field selected to be typical or representative for the irrigation projects (Pereira and Trout, 1999). Ethiopia is one of few African countries endowed with abundant water resources.

The World Bank, various development agencies and numerous countries have invested in large irrigation projects, but there is disagreement on whether investing in new irrigation projects is appropriate because of the less than satisfactory performance of existing projects(Burt and Styles, 1999). Most of the government initiated and community-managed projects are confronted with multifaceted technical and socio economic problems, which have resulted in low land, water and labor productivity. Agriculture is regarded as the backbone of Ethiopian economy and a key driver of its long term growth and food security. Agriculture directly supports 85% of the population constitutes. Of which 43% of gross domestic product, and 80% of export value (Awulachew, 2010)Agriculture employs 80% of the labor force while 85% of the population, which currently is above one hundred million, depends on agriculture for a living and live in rural areas (Awulachew, et al., 2007)

The volatile rains and soil degradation partly explain the stagnation of agricultural yields, one cause of the chronic food deficit (Water report, 8. FAO, Rome., 2007/2008(2000E.C)).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).As the world's inhabitant increase, the water use also increases everywhere. Agriculture is the sector that uses most water worldwide.

Currently, on a global basis, 69% of all water withdraw for human use on an annual basis is consumed by agriculture (mostly in the form of irrigation); industry accounts for 23% and domestic use (household, drinking water, sanitation) accounts for about 8%. These global averages vary with considered regions. In Africa, for example, agriculture consumes 88% of all water withdrawn for human use, while domestic use accounts for 7% and industry for 5% (*UN WWDR*, *2003*). The same situation is true for Ethiopia.

Adequate institutionalization and organizational development are crucial to enhance management and sustainability of the irrigation systems. Generally, IWMI developed two types of indicators to evaluate irrigation systems: internal and external indicators.

To achieve sustainable production from irrigated agriculture, it is obvious that the utilization of the important resources in irrigated agriculture; water and land must be improved. Comparative (external) irrigation performance indicators are useful tools for improving irrigation management and making optimization possible. They are capable to examine performance both across irrigation systems and within a system. They are preferred for analyzing the performance of various aspects of irrigation systems as they relate outputs from irrigated agriculture to the major inputs of water, land, and finance unlike the commonly used process indicators which focused management targets such as duration, flow rate of water, area irrigated; and cropping patterns in a system.

The aim of applying comparative indicators in this study is to evaluate outputs and impacts of irrigation management practices, interventions across different systems and system levels, as well as to compare various irrigation seasons and technologies with one another while process indicators are used to assess actual irrigation performance relative to system specific management goals and operational target (Kloezen, 1988). International Water Management Institute (IWMI) has prepared different "comparative" indicators that are helpful for comparing irrigated agriculture between countries and regions, between different infrastructures and management types, and between different environments and for assessment over time of the trend in performance of specific project. The set of indicators is small, yet reveals sufficient information about the output of the system.

Therefore, performance of irrigation scheme has to be evaluated periodically, both at system and at farm levels against the performance of some other similar scheme so that operational experiences are shared to improve for future use. Hence, this study was undertaken with the objective of evaluating the performance of Sembeta small irrigation scheme.

1.2 Statement of problem

In Ethiopia, the problem is exacerbated by low production and crop loss mainly caused by low and irregular rainfall among others. Agricultural production is predominantly dependent on rainfall. This has made the country's agricultural-based economy extremely fragile and vulnerable to the impacts of climatic variability which often results in partial or total crop failure and subsequent food shortages and famines. To alleviate the deep rooted food insecurity at household level, the Government of Ethiopia (GoE) has recently introduced and begun implementation of policies to minimize risk through full or supplementary irrigation ((Ministry of Finance and Economic Development), 2010).The main reason for the underperformance of the most small-scale irrigation schemes in Ethiopia is poor irrigation water management due to water scarcity (Bos, et al, 2004) (FAO, 1989) (Fissahaye et al, 2017).

Poor irrigation water management associated with water scarcity is the major reason for underperformance of most small-scale irrigation schemes in Ethiopia (Fissahaye et al, 2017).Particularly in Kembata Tembaro zone little or no attention is given to the monitoring and evaluation of the performance of already established irrigation schemes. Kechabira District is one of the areas in Kembata Tembaro Zone, where erratic rainfall and moisture stress problems are frequently observed. To solve this problem 8 small scale irrigation schemes were constructed in different years in this area.

Evaluating and improving the performance of existing schemes is an attractive way for sustainable development and used as a bench mark or point of entry for further irrigation development. The Irrigation schemes are being under low productivity due to absence of experience in design, operation, maintenance and limitation on modern irrigation water management, (irrigation scheduling techniques, water saving irrigation technologies, water measurement techniques), and low irrigation performance of schemes (MoA(Ministry of Agriculture, 2011). Sembeta small irrigation is one of these irrigation schemes which is area of 75ha.It is constructed in 2000 E.C by world vision Ethiopia. Moreover, losses of irrigation water in the conveyance system can be major component of the overall water losses particularly for farms located at significant distance from diversion points of the main canal. However, the most pressing challenge is the poor water management practice, which is very common in many small-scale irrigation schemes. The major cause for such poor performance of irrigation scheme include: poor land preparation and leveling, absence of water level measuring device, poor maintenance of main canal, limited know-how, inadequate practical skills of farmers on crop water needs, soil types and climatic conditions which are instrumental in choosing the more appropriate irrigation methods. Performance evaluation in this study is needed to identify problems in Sembeta small scale irrigation scheme from the diversion point to the farmers' field.

1.3 Objectives

1.3.1 General objective

The main objective of the study was to evaluate the performance of Sembeta small scale irrigation scheme using internal and productivity indicators.

1.3.2. Specific objectives

1. To quantify the efficiencies of the irrigation scheme.
2. To evaluate amount of actual water delivery to the farmers' field and selected crop wheat productivity in the system level
3. To evaluate the on-farm water management performance of irrigation scheme.
4. To identify and recommend sustainable irrigation water management practice to improve crop production.

1.4. Research question

1. Why distribution of water among users (farmers) is not uniform and conflicts are rampant from time to time and what is the current state of scheme efficiency of Sembeta irrigation scheme?
2. Does the quantity of water provided meet the growth needs of the crops planted in a given season?
3. What is the distribution of available water at different location of the irrigation scheme?

4. Does the timing of the water deliveries match the growth needs of the crops and the expectation of farmers?

1.5 Scope of the Study

The study was conducted on Sembeta small scale irrigation scheme of Kachebira district at farm level. One of the main problems was inaccessibility of respondents because they engaged in different social duties and marketing activities. Moreover, inaccessibility of roads in the community has constrained the transportation facilities and I was enforced to walk longer distance on foot. This made the data collection process longer than it was planned.

2. LITERATURE REVIEW

2.1. Irrigation

General Irrigation is the supply of water to crops by artificial means, designed to permit farming in arid regions and to offset the effect of drought in semi- arid regions. Even in areas where total seasonal rainfall is adequate on average, it may be poorly distributed during the year and variable from year to year. Where traditional rain- fed farming is a high- risk enterprise, irrigation can help to ensure stable agricultural production.

2.2 Perspectives and Objectives of Irrigation

A reliable and suitable irrigation water supply can result in vast improvements in agricultural production and assure the economic vitality of the region. Many civilizations have been dependent on irrigated agriculture to provide the basis of their society and enhance the security of their people. Some have estimated that as little as 15-20 percent of the worldwide total cultivated area is irrigated. Judging from irrigated and non-irrigated yields in some areas, this relatively small fraction of agriculture may be contributing as much as 30- 40% of gross agricultural output (FAO., 1989).According to (Jureims, et al., 2001), many countries depend on surface irrigation to grow crops for food and fiber. Without surface irrigation, their agricultural production would be drastically lower and problems of unreliable food supply, insufficient rural income, and unemployment would be widespread.

The method, frequency, and duration of irrigations have significant effects on crop yield and farm productivity. For instance, annual crops may not germinate when the surface is inundated causing a crust over the seedbed. After emergence, inadequate soil moisture can often reduce yields, particularly if the stress occurs during critical periods. Even though the most important objective of irrigation is to maintain the soil moisture reservoir, how this is accomplished is an important consideration. The technology of irrigation is more complex than many appreciate. It is important that the scope of irrigation science is not limited to diversion and conveyance systems, nor solely to the irrigated field, or only to the drainage pathways. Irrigation is a system extending across many technical and non-technical disciplines. One of the major concerns is the generally poor efficiency with which water resources have been used for irrigation.

Irrigation in arid areas of the world provides two essential agricultural requirements: A moisture supply for plant growth which also transports essential nutrients; and a flow of water to leach or dilute salts in the soil.

2.3 Irrigation and Water Resource in Ethiopia

Ethiopia covers a land area of 1.13 million km^2, of which 99.3 percent is a land area and the remaining 0.7 percent is covered with water bodies of lakes (MoWR, 2002). It has an arable land area of 10.01 percent and permanent crops covered 0.65 percent while others covered 89.34 percent. Though agriculture is the dominant sector, most of Ethiopia's cultivated land is under rain fed agriculture. Due to lack of water storage and large spatial and temporal variations in rainfall, there is no enough water for most farmers to produce more than one crop per year and hence there are frequent crop failures due to dry spells and droughts, which have resulted in a chronic food shortage currently facing the country (Awulachew, 2010).

2.4 Irrigation Potential in Ethiopia

Ethiopia has an important opportunity in water-led development, but it needs to address critical challenges in the planning, design, delivery, and maintenance of its irrigation systems if it is to capture its full potential (Awulachew, 2010).If the problem is failure of production because of natural causes, such as dry-spells and drought, agricultural production can be stabilized and increased by providing irrigation and retaining more rainwater for in situ utilization by plants (Awulachew, et al., 2007). *As* (Awulachew, et al., 2007)stated, in 1990 the total estimated irrigated agriculture of the country is 161,000 ha as a whole, of which 64,000 ha was in small-scale schemes.

Expansion of the area under cultivation is a finite option, especially in view of the marginal and vulnerable characteristic of large parts of the country's land. Increasing yields in both rains fed and irrigated agriculture and cropping intensity in irrigated areas through various methods and technologies are the most viable options for achieving food security in Ethiopia.

2.5. Irrigation development in Ethiopia

According to (Fekadu et al,, 2000), development of small scale irrigation was encouraged to be effected by the local farmers to cope with recurrent droughts. The attempt by the government to enhance the participation of individual peasants in small scale irrigation development had been considered earlier throughout the 1970 and 1980; but the results were below expectations.

Though the government has been providing irrigation infrastructure free of charge and the infrastructure development progressed well, but putting the schemes into production at optimum level was very disappointing, and in some instances only 10% of the developed areas were put into production. The need of developing irrigation for crop production is acquiring more and more attention in Ethiopia in response to the growing demand for agricultural produce. However, the distribution of rain varies from region to region. Much of the eastern part of the country receives very little rain while the western areas receive adequate rainfall. Production of sustainable and reliable food supply is almost impossible due to the temporal and spatial imbalance in the distribution of rainfall and the consequential non-availability of water at the required period. Sometimes, even the western highlands of the country suffer from food shortage owing to the discrepancies in the rainfall distribution (MoWR, 2001). Attempts have been made by the government to address the food security problems through preparation of relevant agricultural development policies and programs. However, low level of water use efficiencies are among the major constraints for development as well as operation of all water sectors including irrigation (MoWR, 2002).

A better policy environment for the agricultural sector exists since March 1990: the liberalization of the economy; the encouragement of private commercial farms; the drastic reduction in public investment in state farms; the restoration of free grain trade; improvement in the role of extension agents, etc. However, the land holding of individual farmers is increasingly becoming fragmented because of the growing population. About six million private farms in Ethiopia register an average size of 0.8 hectares of arable land compared to 1.5hectares in 1979/80. Irrigation is one means by which agricultural production can be increased to meet the growing demands in Ethiopia (Awulachew et al., 2005). A study also indicated that one of the best alternatives to consider for reliable and sustainable food security development is expanding irrigation development on various scales, through river diversion, constructing micro dams, water harvesting structures, etc. (Robel 2005). Irrigation is practiced in Ethiopia since ancient times producing subsistence food crops. However, modern irrigation systems were started in the 1960 with the objective of producing industrial crops in Awash Valley.

Private concessionaires who operated farms for growing commercial crops such as cotton, sugarcane and horticultural crops started the first formal irrigation schemes in the late 1950 in the upper and lower Awash Valley. In the 1960, irrigated agriculture was expanded in all parts of the Awash Valley and in the Lower Rift Valley. In addition, the construction of the tarmac Addis Assab road opened the Awash Valley to ready markets in the hinterland as well as for export. Although, certain aspects of the development during the pre-Derg era have wrong doings in terms of property and land rights, there has been a remarkable emergence of irrigation development and establishment of agro-industrial centers. Currently, the government is giving more emphasis to the sub-sector by way of enhancing the food security situation in the country.

Efforts are being made to involve farmers progressively in various aspects of management of small-scale irrigation systems, starting from planning, implementation and management aspects, particularly, in water distribution and operation and maintenance to improve the performance of irrigated agriculture. The country has developed irrigation schemes in many parts of the country at different scales. Data and information are not uniformly available to accurately know the existing irrigation schemes. While it is possible to capture the medium and large schemes data accurately, it is difficult to account for the small-scale irrigation development, particularly, the traditional irrigation development and the privately developed household-based irrigation schemes which use traditional diversions, water harvesting and ground water development(Awulachew et al., 2007). Irrigation scheme classification Based on the Ministry of Water Resources (MoWR) classification, irrigation projects in Ethiopia are identified as large-scale irrigation if the size of command area is greater than 3,000 hectares, medium-scale if it falls in the range of 200 to 3,000 hectares and small-scale if it is covering less than 200 hectares (Awulachew et al., 2007). Evaluating irrigation system and practices Solomon (2006),

Pereira and Trout (1999), describe information used to advice irrigators how to make better their system design and operation, improving design, model validation and updating, developing real time irrigation management decisions and optimization programming. According to Walker and Skogerboe (1987), the principal objective of evaluating an irrigation system is to identify alternatives that may be both effective and feasible in improving the system's performance. For instance, the evaluation may reveal that the application efficiency could be improved by limiting the duration of a given irrigation. It can also be discovered that the field length and slope requires modification for the existing system to operate more efficiently. Evaluations of surface irrigated fields yield not only data which can be used to detect problems but also information essential to achieving high levels of management and control. As described by Merriam et al., (1983), performance assessment practices are extremely important because of their central role in effective management. Dawit et al., (1997), defined performance as a measure of “how close an irrigation event (scenario) is to the reference irrigation”.

Performance assessments in irrigation and drainage can be defined as the systematic observation, documentation and interpretation of activities related to irrigated agriculture with the objective of continuous improvement. The ultimate purpose of performance assessment is to achieve an efficient and effective use of resource by providing relevant feedback to the project management at all level (Molden et al., 2004). Bos et al., (2000),described the objectives of performance assessment are: to upgrade management capabilities in both public and private sector irrigation and drainage projects with a view to improving the efficiency with which available resources are used. As such, the assessment should become part of the routine management procedures of the irrigation institution. Four different purposes of performance assessment: operational, accountability, intervention and sustainability (Small and Svendsen, 1992). Operational performance assessment relates: To the day-to-day, season-to-season monitoring and evaluation of system or scheme performance. Accountability performance assessment: Is carried out to assess the performance of those responsible for managing a system or scheme.

Performance assessment associated with sustainability: Looks at the longer term resource use and scheme or system impacts. According to (Yashima, 1997)the following responsibilities of irrigation managers in irrigation performance assessment include:

1. Evaluating the existing situation of irrigation performance in their system
2. Identifying constraints to proper performance if the performance is not satisfactory and
3. Implementing management interventions to improve the performance

2.5.1. Concept of performance

Performance is the degree to which a system achieves its objectives. The performance of a system represented by its measurable levels of achievements in terms of one or several parameters (Abernethy, 1986).The performance of any irrigation system is defined as the degree of measurements to which it achieves its expected objectivity, therefore it is essential to measure and evaluate their success or failure of objectively and identifies specific areas in need of improvement (Cakmak, et al., 2004). Performance of a system as encompassing the totality of both its activity inputs and the transformation of the inputs into intermediate and final outputs, and the effect of these activities on the system itself and on its external environment (Murray-Rust, 1993).

2.5.2. The need for performance assessment

Performance assessment for any irrigation system is essential to assess how far the goals and objectives set forth at the time of project formulation of the system have been achieved. This is a useful tool to provide necessary feedback for improving the systems management by initiating remedial measures (Raghuwanshi, 2001). Performance assessment of irrigation can be defined as the systematic observation, documentation and interpretation of activities related to irrigated agriculture with the objective of continuous improvement (Bos, et al., 2007). *The* ultimate purpose of performance assessment is to attain an efficient and effective use of resources by providing relevant responses to management at all levels. Therefore, it contributes the system management in determining whether the performance is satisfactory and, if not, which and where remedial actions need to be taken in order to remedy the situation.

For sustainability of an irrigated agriculture, the effective operation and management for small scale irrigation system plays a significant role. Hence, irrigation project performance studies are being used with increasing frequency to encourage this objective. Additionally, performance analysis is an important part of management, it is needed to target and monitor actual achievements in the operation and take appropriate actions if required. Performance of an irrigation system could be assessed for a number of reasons, some of needs are; to assess development against strategic goals of a system, to improve operations, to evaluate impact of water delivery service on the whole performance of the agricultural sector, to recognize cost effectiveness and financial viability of the system, and for comparison of one with other irrigation systems (Molden, et al., 1998).

Many researchers emphasized the importance of performance evaluation for an irrigation system. Much of the work to date in irrigation performance assessment has been focused on both external and internal processes of irrigation systems. These process indicators relate performance to management targets such as timing, duration, and flow rate of water, area irrigated and cropping patterns. (Kloezen, 1988), stated that effective irrigation management requires reliable performance assessment. Evaluation of farm irrigation systems specially plays a fundamental role in improving surface irrigation, a system which is usually considered inefficient in terms of water use. Evaluation of the system provide information used to advise irrigators on how to improve their system design and/or operation, as well as information on improving design, and developing real time irrigation management decisions.

According to (FAO, 1989)the principal objective of evaluating surface irrigation systems is to identify management practices and system configurations that can be feasibly and effectively implemented to improve the irrigation efficiency. An evaluation may show that higher efficiencies are possible by reducing the duration of the inflow to an interval required to apply the depth that would refill the root zone soil moisture deficit. The evaluation may also show opportunities for improving performance through changes in the field size and topography.

Evaluations are useful in a number of analyses and operations, particularly those that are essential to improve management and control. Evaluation data can be collected periodically from the system to refine management practices and identify the changes in the field that occur over the irrigation season or from year to year. The surface irrigation system is a complex and dynamic hydrologic system and, thus, the evaluation processes are important to optimize the use of water resources in this system (Walker R., 1987).

2.5.3. Goals of performance assessment

Performance studies are being used increasing frequency to promote the objective of sustainability, thereby helping to improve the system operation, assess the general health of the system, evaluate the impact of intervention, diagnosis constraint, better understanding determinants of performance and compare its performance with others or within the same system over the time (Unal et al., 2004).More importantly, if an irrigation system committed to the farmers satisfaction, it can supply more and better sustainability information.

2.6 Irrigation Water Control and Management

Water management is defined as the planned development, distribution and use of irrigation water in accordance with predetermined objectives and with respect to both quantity and quality of the water resources. It is the specific control of all human intervention on surface and subterranean water.

Every planning activity that has something to do with water can be looked upon as water management in the broadest sense of the term. According to U.S Bureau of Reclamation (2005); Irrigation Water Management means management of irrigation water on the farm. There is no way that the cultivated area without a water management system can contribute significantly to the required increase in food production (Schultz, 2002).

Performance assessment for any irrigation system is essential to assess how far the goals and objectives set forth at the time of project formulation of the system have been achieved. This is a useful tool to provide necessary feedback for improving the systems management by initiating remedial measures (Raghuwanshi, 2001).Performance assessment of irrigation can be defined as the systematic observation, documentation and interpretation of activities related to irrigated agriculture with the objective of continuous improvement (Bos M. D., 2007).The ultimate purpose of performance assessment is to attain an efficient and effective use of resources by providing relevant responses to management at all levels. Therefore, it contributes the system management in determining whether the performance is satisfactory and, if not, which and where remedial actions need to be taken in order to remedy the situation.

Efficient operation and management for small scale irrigation system plays an important role in the sustainability of irrigated agriculture. Hence, irrigation project performance studies are being used with increasing frequency to encourage this objective. Furthermore, performance analysis is an essential part of management, it is needed to target and monitor actual achievements in the operation and take appropriate actions if required. Performance of an irrigation system could be assessed for a number of reasons, some of needs are; to assess development against strategic goals of a system, to improve operations, to evaluate impact of water delivery service on the whole performance of the agricultural sector, to recognize cost effectiveness and financial viability of the system, and for comparison of one with other irrigation systems (Molden, et al., 1998).

Many scholars emphasized the importance of performance evaluation for an irrigation system. Much of the work to date in irrigation performance assessment has been focused on both external and internal processes of irrigation systems. These process indicators relate performance to management targets such as timing, duration, and flow rate of water, area irrigated and cropping patterns. (Kloezen, et al., 1998); stated that effective irrigation management requires reliable performance assessment.

Good farm irrigation management assures correct frequency of irrigations, correct application depth, uniform irrigation, minimum runoff, and minimum deep percolation except for that required for salt management, minimum erosion, and optimal return on irrigation investment. Performance evaluation is basically to ensure all activities proceed smoothly as planned towards achieving those objectives and that system managers are alerted.

2.7. Performance Evaluation of Irrigation Practices

Purpose of irrigation performance evaluation (Kloezen, et al., 1998).According to

(FAO, 1989); The principal objective of evaluating surface irrigation systems is to identify management practices and system configurations that can be feasibly and effectively implemented to improve the irrigation efficiency. An evaluation may show that higher efficiencies are possible by reducing the duration of the inflow to an interval required to apply the depth that would refill the root zone soil moisture deficit.

The evaluation may also show opportunities for improving performance through changes in the field size and topography. The surface irrigation system is a complex and dynamic hydrologic system and thus, the evaluation processes are important to optimize the use of water resources in this system (Walker R., 1987)The performance of an irrigation system is represented by its measured levels of achievement in terms of one or several parameters that are chosen as indicators of the system's goals (Style, 2002)The cause of the poor irrigation performance has been blamed on technical, financial, managerial, social, and institutional causes.

As (Jayakumar, 2003) indicated performance assessment practices are very much essential because of their central role in effective management assessment practices are very much essential because of their central role in effective management. (Dawit Z.et al., 1997).Defined performance as a measure of "how close an irrigation event is to the reference irrigation. Performance evaluation in irrigation can be defined as the systematic observation, documentation and interpretation of activities related to irrigated agriculture with the objective of continuous improvement.

Performance assessment is an activity that supports the planning and implementation process. The ultimate purpose of performance assessment is to achieve an efficient and effective use of resources by providing relevant feedback to the project management at all levels (Bos, et al, 2004). (Schultz, et al., 2002); described that the aim of performance assessment is to select a small number of powerful, easily observable indicators that allow reliable conclusions to be drawn.

The performance assessment should be a regular, short duration process for investigating suspected critical shortfalls in performance. According *to* (Bos R. , 2000)the wide objectives of performance assessment is to upgrade management capabilities in both public and private sector irrigation and drainage projects with a view to improving the efficiency with which available resources are used. As such, the assessment should become part of the routine management procedures of the irrigation institution.

(Small, et al., 1992) ; Identified four different interrelated purposes of performance assessment: operational, accountability, intervention and sustainability. Operational performance assessment relates to the day to day, season to season monitoring and evaluation of system or scheme performance. Accountability performance assessment is carried out to assess the performance of those responsible for managing a system or scheme. Intervention assessment is carried out to study the performance of the scheme or system and generally, to look for ways to enhance that performance.

Performance assessment associated with sustainability looks at the longer-term resource use and scheme or system impacts. (Yashima, 1997)*)* described that the responsibilities of irrigation managers in irrigation performance evaluation encompass (1) evaluating the existing situation of irrigation performance in their systems, (2) identifying constraints to proper performance if the performance is not satisfactory, and (3) implementing management interventions to improve the performance. At all levels, performance must be evaluated using a combination of targets and associated set of standards that describe the acceptable range of values around that target (Bos, et al., 1994).

2.8. Irrigation performance indicators

Performance indicators measure the value of a particular item such as yield or canal discharge and have to include a measure of quality as well as of quantity and be accompanied by appropriate standards or permissible tolerances (Rust, 1993).The improvement of irrigation practice requires knowledge of crop water requirement and yield responses to water, the constraints that are specific to each irrigation method and irrigation equipment, the limitation to water supply system and the financial and economic implication of irrigation practice. Improvement of irrigation method requires the considerations of the factors influencing the hydraulic process, the water infiltration and uniformity of water application to the entire field (Hlavek, 1992).

Performance evaluation exercises are meaningful if related with certain management objectives that are defined for certain given situation. Some key indices or terms are developed that are used to describe the achievement of these objectives, followed by the identification of variables that are controllable and measurable and can be regulated to achieve the established indicators. The indices are used to evaluate the farm irrigation system that could be categorized into delivery subsystem (the system extending from head works to field canals), and water use subsystem (part of the system extending from field canals to water application system).

The indices should be subjected to management control so that they can be manipulated to improve system performance (Walker R., 1987).Efforts have been made over the years to develop appropriate evaluation models that could use the irrigation parameters and variables to evaluate irrigation performance. Among these, the volume balance model is the basis for most design and field evaluation procedures. This has been proven with field and laboratory data. In addition, few of these criteria reflect the view of the farmers (Gowing J.et al., 1996). It is therefore essential that evaluation of the performance of surface irrigation systems be continued with a view to improve the performance of the systems and also to incorporate the view of the stake holders, i.e. the farmers in particular.

Different indices have been developed that are used for evaluating the performances of individual irrigation systems and for comparing the performances of different irrigation systems as well as farms. The type and number of indices (indicators) used for a particular situation depend on the level of details required for quantification, and on the number of disciplines selected for assessment. These may include, Agricultural, water use, economics, environment, management, physical etc. which are regarded as external indicators (Bos G. , 1997). The common efficiency terms used for on-farm irrigation system evaluation (internal process indicators) include application efficiency, storage efficiency and adequacy, and recently complementary terms such as runoff ratio, deep percolation ratio, are being applied (Jureims, et al., 2001). The principal terms and their uses are described as follows.

2.8.1. Internal performance indicators

These indicators examine the technical or field performance of a project by measuring how close an irrigation event is to an ideal one. An ideal or reference irrigation is one that can apply the right amount of water over the entire region of interest (i.e. depth of root zone) uniformly and without losses. Analysis of the field data allows quantitative definition of the irrigation system performance. The performance of irrigation practice is determined by the efficiency with which the water is conveyed through the canal, how irrigation is applied to the field, how adequate the amount is and how the application is uniformly applied to the field (Feyen, 1999).

2.8.1.1 Conveyance Efficiency

Significant volume of water is lost by the networks of the conveyance canals due to seepage and evaporation depending on the nature of the soil and agro-climatic zone in which the canals are located. Conveyance efficiency is defined as the ratio of the amount of water that reaches the field to the total amount of water diverted into the irrigation system. The concept can also be viewed as the evaluation of the water balance of the main, lateral and sub-lateral canals and related structures of the irrigation system (Rust, 1993).It is one of the several closely related and commonly used output measures of performance that focus on the physical efficiency of water conveyance by the irrigation system (Bos G. , 1997). Losses of irrigation water in the conveyance system can be a major component of the overall water losses particularly for farms located at significant distances from water sources where the main canals are long and unlined. The amount lost depends on quality of operation, and maintenance, and the nature of the soil that affects the seepage rate.

2.8.1.2 Application Efficiency

The Application Efficiency is a term initially formulated by (Israelsen, 1932)and measures the ratio between the volumes (depth) of water stored in the root zone for use by the plant to the volume (depth) of water applied to the field. As reported by (Walters, 1991)the term has been expressed in different ways over the years to include different parameters by different authorities. Field irrigation efficiencies are influenced by factors such as soil type, field application methods, depth of application and climate. Very high values are achieved in arid climates and where water shortages prevail.

2.8.1.3 Deep percolation Ratio

A component of the irrigation applied to a field percolates into the soil below the root zone. Part of the water is intentionally added to the irrigation water to maintain the salt balance of the soil through leaching additional salt brought by the irrigation water itself or through capillary process from saline groundwater (Rycroft, 1983).The volume of percolated water in excess of the leaching requirement is considered as lost water and is used to define the efficiency of irrigation. DPR expresses the ratio between the percolated water beyond the root zone to the volume of water applied to the field (Feyen, 1999).

2.8.1.4 Storage Efficiency

Storage efficiency is an index used to measure irrigation adequacy. It is the ratio of the quantity of water stored in the root zone during irrigation event to that intended to be stored in the root zone. The value of E_s is important either when the irrigations tend to leave major portions of the field under-irrigated or where under irrigation is purposely practiced to use precipitation as it occurs. This parameter is the most directly related to the crop yield since it was reflecting the degree of soil moisture stress. Usually, under-irrigation in high probability rainfall areas is a good practice to conserve water but the degree of under irrigation is a difficult question to answer at the farm level (Walker R., 1987).

2.8.1.5 Overall scheme efficiency

Irrigation efficiencies are evaluated at scheme or farm level for the purpose of identifying the losses that occur in the irrigation system starting at the water abstraction point, through the conveyance system down to water application in the field, to determine the overall irrigation efficiency. As reported by the (MoAFS, 2002)for small irrigation schemes in Tanzania typical values proposed were 28 and 34% for poorly operated and for well operated canals, respectively. In addition to design and other technical factors, the farm efficiency is much regulated by the operation of the main supply system to meet the actual field supply requirements and the skill of the system operators.

2.8.2 Productivity Performance Indicators

Many indicators used for external performance evaluation can be calculated from secondary data rather than primary data. These set of indicators are designed to show gross relationship and trends and are useful in indicating where more detailed study should take place, where a project has done extremely well, or where dramatic changes take place.

2.8.2.1 Irrigated Agriculture Performance Indicators

They are used for the evaluation of the project performance in terms of the production its results in. It expresses output of irrigated area in terms of gross or net value of production measured at local prices. This addresses the direct impact of operational inputs in terms of such aspects as area actually irrigated and crop production, over which an irrigation manager may have some but not full responsibility.

2.8.2.2 Water use performance indicators

This deals with the primary task of irrigation managers in the capture, allocation and conveyance of water from source to field by management of irrigation facilities. Indicators address several aspects of this task: efficiency of conveying water from one location to another, the extent to which agencies maintain irrigation infrastructure to keep the system running efficiently and the service aspects of water delivery which include such concepts as predictability and equity.

2.8.2.3 Physical Performance Indicators

Physical indicators are related with the changing or losing irrigated land in the command area by different reasons. Among those reason water scarcity and input availability are the main reason why lands in command area are not fully under irrigation in a particular season. From physical performance; irrigation ratio and water delivery ratio are the two main indicators.

2.8.2.4 Economic Performance Indicators

This indicator considers the production and the total cost of infrastructure for scheme. It deals with the total revenues from the scheme, total cost spent for running the project and initial investment costs. Economic indicators deal with how much investment cost is spent on the project in comparison with total production and how much fee collected from water users for yearly maintenance and operation expenditure and whether the system is self-sufficient or not (Vermillion D., 2000)

2.9 Concept of Food Security

Food security has been defined as a situation when all the people, at all times, have physical and economic access to sufficient, safe and nutritious food needed to maintain a healthy and active life (FAO and WFP, 2010)The concept of food security is built on four pillars: Food availability refers to physical presence of sufficient quantities of food at a household level, whether from production or markets. Food access refers to people have sufficient resources to obtain appropriate food for a nutritious diet. Food utilization is understood as people have sufficient knowledge of nutrition and care practices and have access to adequate water and sanitation. Food stability refers to the need to assess food in both short and long term (Hartwig de H.,et al, 2011). The above discussion relates household food security to the ability of the household to secure food, either from own production or through purchase of adequate food for meeting dietary needs of its members (Nyange, 2001). When analyzing food security at household level we have to look at food supply and distribution, effective access to food by households and effective consumption by individuals (World Bank, 2003).

Household food security implies that each member of the household in general has access to food. Although food availability at the household level is a key issue, there are intra household factors that may affect equitable and adequate access to food by all members (Maxwell and Franken Berger, 1992). Maxwell and Frankenberg (1992) indicated that 7 household food security has social linkages including access to health services and good healthy environment, education and adequate care of children and women. These non-food linkages influence households' decisions regarding livelihood resources, such as income and labor which are direct determinant of household food security. Household food security in developing countries is determined by what a household is able to produce, process, store, prepare and buy from the market.

In turn these are determined by the agricultural resource availability to that household such as climate and ecology, the amount and quality of land, the level and type of technology, the availability of production assets as well its economic and social capacity to access food (Maxwell and Frankenberg, 1992). Food insecurity is defined as a situation where people, individuals at times, lack physical and economic access to sufficient, safe and nutritious food needed to maintain a healthy and active life. According to (Frongillo, E. A.et, al, 2012)household food insecurity results when food is not available, cannot be accessed with certainty in socially acceptable ways, or is not physiologically utilized completely. Food insecurity occurs whenever enough and safe foods are not available or the ability to acquire such foods is limited.

2.9. 1.Food Insecurity Coping Strategies

Food insecurity coping strategies are activities, which maintain food security or combat food insecurity that has occurred at the household level. Coping strategies are directly attributed to household activities rather than external factors. According to literature (Hadley, C.,, 2007)there are four categories of strategies, namely consumption, expenditure, income, and migration. Consumption strategies include buying food on credit, 8 relying on less-preferred food substitutes, reducing the number of meals eaten per day, regularly skipping food for an entire day, eating meals comprised solely of vegetables, eating unusual wild foods, restricting consumption of adults so children can eat normally, and feeding working members at the expense of non-working members. Expenditure strategies include the use of savings and avoiding health care or education costs in order to buy food. Income strategies include, the use of pension, small businesses and selling household and livelihood assets such as livestock. Migration strategies include sending children to relatives or friends‟ homes or migrating to find work (Maxwell et al., 2008).

2.10. Household Dietary Diversity (HDD)

Dietary diversity refers to the number of different types of food or food groups consumed over a given reference period (Hoddinott, et,al). The dietary diversity questionnaire is based on a set of food group questions and can be used to find a household's dietary diversity score by categorizing different types of food based on nutrients they comprise (Swindale A. et, al, 2006)A rise in the dietary diversity increases the chances of a household becoming food secure (FAO, 2007). The reasoning is that a household is more likely to have both economic and physical access when on average; it consumes six or a number of various food groups within many food groups (Swindale, 2007). In both developed and developing countries, a number of studies have showed a positive relationship between household dietary diversity and improved nutritional intake (ThroneLyman, 2009). The measure of the dietary diversity is based on surveys and monitoring activities. Savy et al. (2006) explain that this measure is much more effective when utilized at the end of the period of food-scarcity in order to identify households that are more affected by 9 food insecurity. Several authors have criticized the effectiveness of this method. The dietary indicator is most likely to become an effective tool only in households that consume most common foods such as cereal (Swindale, 2007). There is no simplicity with regards to the number of food groups that will indicate adequate clarification on the quality of a diet (FAO, 2008)

2.11. Concept of Irrigation

Irrigation is defined as application of artificial water to the living plants for the purpose of food production and overcoming shortage of rainfall and help to stabilize agricultural production and productivity (FAO, 2005). According MoIWE (2012) modern irrigation has been documented in the 1960s where the government designed large irrigation projects in the Awash Valley to produce food crops for domestic consumption and industrial crops for exports. Irrigation development is being suggested as a key strategy to improve agricultural productivity and to encourage economic development (Bhattarai et al., 2007).

The adoption of new technology (e.g. irrigation) is the major powerful for agricultural growth and poverty reduction (Norton et al, 2010). Small-scale irrigation is a type of irrigation defined as irrigation, on small plots, in which farmers have the controlling influence and must be involved in the design process and decisions about boundaries (Tafesse, 2007). In Ethiopia, modern small scale irrigation schemes have been constructed by the federal or regional government in order to overcome the catastrophic climatic change and drought since 1973. Such schemes involved dams and diversion of streams and rivers. 10 2.3. Empirical Literature Review

2.12. Problems Encountered in Small Scale Irrigation Participation

Tadesse et al, (2004) conduct a study on the economic importance of irrigation in Donny and Bato Degaga small holder‘s irrigation schemes in the Awash Valley of Oromiya Regional state with the objective of investigating the impact of irrigation schemes on food security. The finding indicated that the challenges of small-scale irrigation are; low fertilizer application, poor on-farm management, inequitable distribution of labor for the maintenance of irrigation canals, irrigation water loss, tendency of considering irrigation infrastructure as government‘s property and market problems.

A study conducted by (Oruonye, 2011)inaccessibility to irrigation farmland, Lack of farm inputs, fertilizer and chemicals, lack adequate startup capital and lack of sufficient water are the greatest challenges to sustainable small scale irrigation in the study area. A study conducted by (Shimelis D., 2006).Also indicated that in the Gibe Lemu irrigation scheme the main problems that constrained the supply of adequate irrigation water. The study conducted that small scale irrigation improves farm households' diet, incomes, health and food security (Torell and Ward, 2010). Thus, the study built the model to illustrate the contribution of small scale irrigation in ensuring food security and attracting inward investment in the economy. The study conducted by Abonesh (2006) in eastern Showa using Heckman two stage analyses revealed that those households with access to irrigation are at better position in securing enough food than their counterparts. Azemer (2006) also studied food security and economic impact of irrigated agriculture in Teletle irrigation scheme of North Shoa Zone. The finding of his study demonstrated better performance of irrigated agriculture in crop production and productivity than rain fed agriculture.

A study conducted by Hagos, et al. (2009) also indicated that irrigation in Ethiopia increased yields per hectare, income, consumption and food security. Irrigation schemes in South Africa have increased employment opportunities, and stabilized and increased rural wage rates; and increased family consumption of food through enhancing food availability, reducing levels of consumption shortfall, increasing of irrigation incomes and reducing food prices thereby ensure food security Fanadzo (2012).

2.13 Determinants of Household Food Security

A study conducted by Epherm (2008) household food security in the north eastern part of Ethiopia are strongly associated with various socio-economic and bio-physical factors that influence the food security status of households were age of household head, dependency ratio, size of cultivated land, total number of livestock owned, manure application, land quality and farmer's knowledge on the effect of land degradation on food security. According to studies conducted in Ethiopia, ownership of livestock, farmland size, family labor, off farm income, market access, use of improved technology, education, health status, amount of rainfall and distribution, crop diseases, number of livestock, and family size are identified as major determinants of household food security (Regassa N., 2011)and (Bedeke S., 2012).

The study conducted in Nigeria by (Olyuole) using probit model found out that sex of household, educational level, age of household head and income have positive influence on food security; whereas, households size has negative influence on household food security. However, study, by Sikwela (2008) in South Africa using binary log it model showed that per aggregate production, fertilizer application, cattle ownership and access to irrigation have positive effect on household food security; whereas, farm size and family size have negative effect on household food security. On other hand, (Fekadu A, 2012)using multivariate logistic regression analysis indicated that dependency ratio, household family size and market accessibility have showed significant and negative effect on food security; whereas cultivable land size, access to irrigation, number of livestock showed positive role for food security.

Other similar, study conducted by Bogale and Shimelis (2009) using binary model reveals that age of household head, cultivated land size, livestock ownership, total income of the household, irrigation and amount of credit receive have negative and significant effect on household food security. Similarly, as studied by Beyena and Muche (2010) using binary logit model showed that age of the household head, size of land cultivated, livestock ownership, soil and water conservation practice and oxen ownership have positive and significant relationship with household food security; whereas, education of household head, household size and off-farm/non-farm income have negative and significant influence on household food security.

2.14. Conceptual Framework of Household Food Security Determinant Factors

As clearly discussed in literature review section and as revealed in figure 1 below, that household food security were affected by different factors. The analytical frame work shows that the linkage between household food security and variables assumed that affect household food security in study area. According to their nature, these variables are categorized under four categories. Demographic characteristics which include age, sex, educational level of the household head, family labor and dependency ratio. Institutional factors category includes access to credit, health status, market distance, and contact with development agent and food aid. Socio-economic factors involves, farm size, livestock size and non-farm income activity.

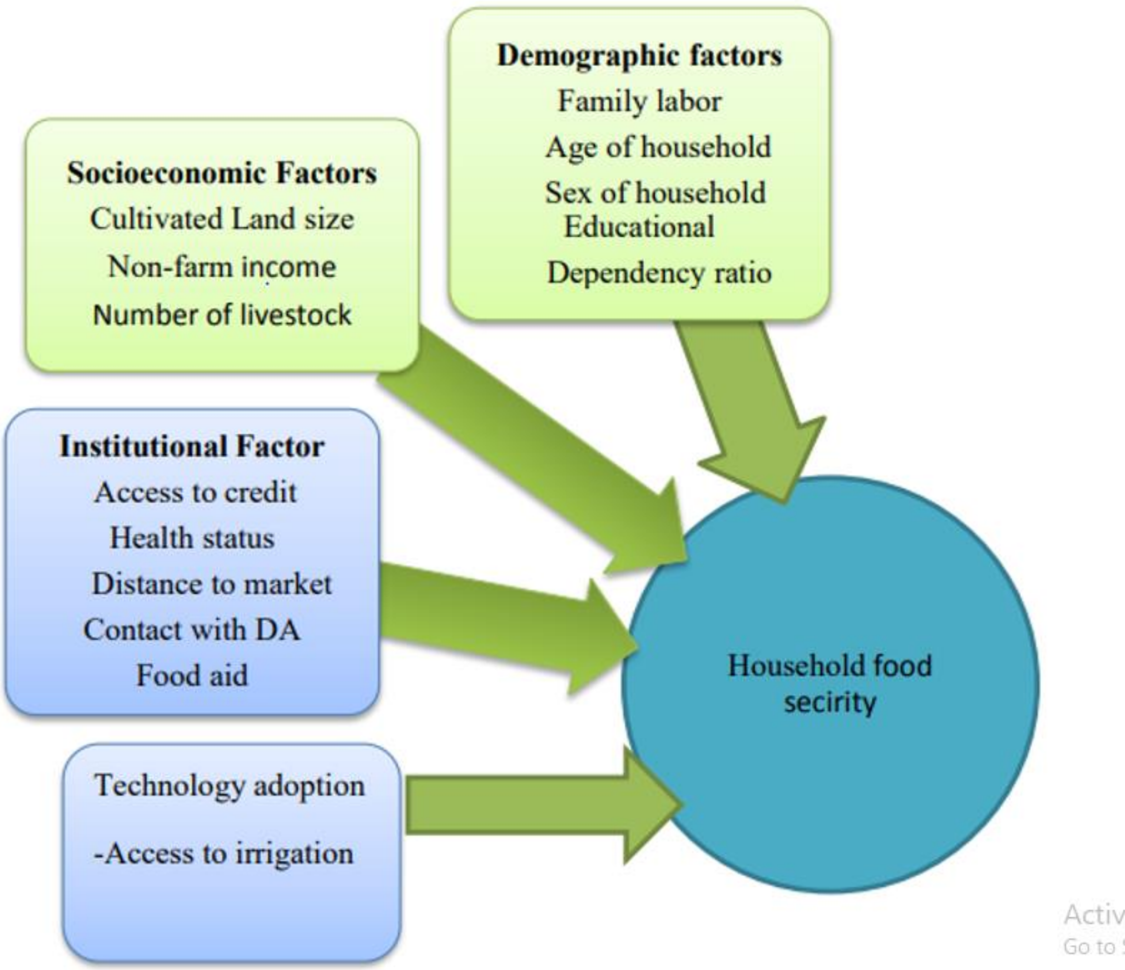

Figure1.Conceptua Frame work of House Hold Food Seccurity Determenant Factors

3 MATERIALS AND METHODS

3.1 General Description of the Study Area

The study was conducted in Kachabirra Woreda is one of the Seven Woreda in Kembata-Tembaro Zone Administration of Southern Nations Nationalities and Peoples Regional (SNNPR) State of Ethiopia. The Woreda comprises 21Kebele Administrations (all of them are Rural Kebeles). The Project area is situated on geographical grid of $7^{0}15`$N Latitude and $37^{0}45`$E Longitude with altitude of 1864m.The irrigation scheme covers command area of 75 ha and 128 beneficiaries, with 170 male households and 58 female households. Up on the development of the project, each farmer was cultivating his own land separately. This has created disagreements among farmers. The source of water for the irrigation project is Sembeta River. The Sembeta River is diverted to the canal by constructing a diversion wall at a location where there is small natural protruding land in the river. The diverted water is then blocked by a weir near the main gate to raise the head of the water in the canal. Total population of the Kebele is 6718 from these 3450 are male and 2768 are female.

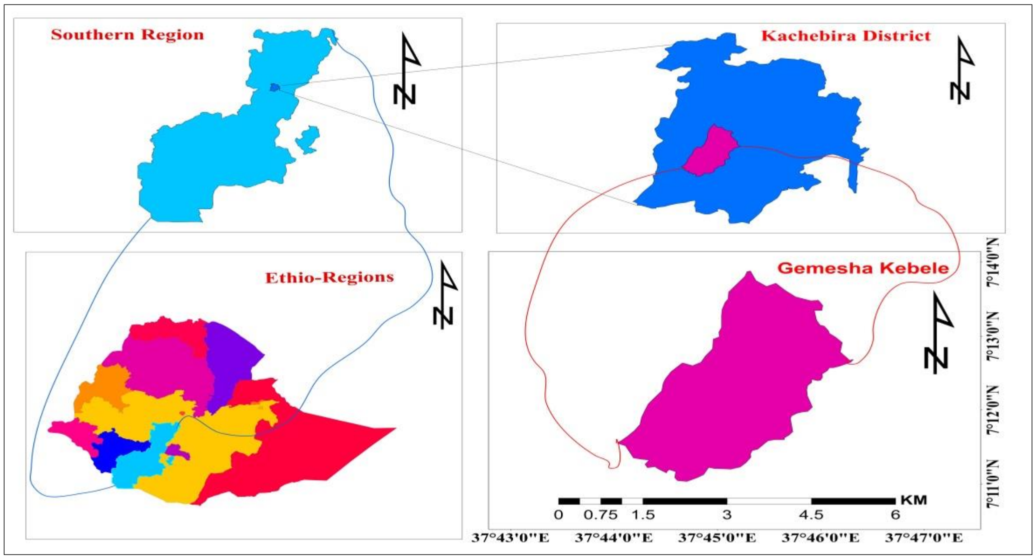

Figure**2**: - Location Map of the area

3.1.1 Topography of study area

Climate is a long period average weather condition of a defined geographical area. It is determined by altitude, latitude, prevailing winds, cloud cover, pressure and wind belts. Altitude is by far determinant factor for the spatial variation of weather and climate. Among the elements of weather and Climate, temperature and rainfall are important elements in determining the pattern of population settlement, the range of crops and vegetation that can be grown, soil formation processes and biodiversity and agro ecology of a given area.

3.1.2 Land use pattern and vegetation

The smallholder farmers practice mixed farming system that integrates both crops and livestock (animals used for traction, meat and milk). The vegetation of the study area consists of different species of trees and grasses. Scattered bushes and shrubs are found along river valleys and hillside steep slope. These areas are under intensive cultivation. The main annual and perennial crops grown in the district are maize, sorghum, hot pepper, sweet potato, haricot bean, mango, banana, coffee, sugarcane) and bread wheat. Production depends mainly on the rainfall. The dominant crop in the district is maize and teff.

3.1.3Soil

The soil's moisture holding capacity, intake rate and depth are the principal criteria affecting the type of system selected. Sandy soils typically have high intake rates and low soil moisture storage capacities and may require an entirely different irrigation strategy than the deep clay soil with low infiltration rates but high moisture-storage capacities. Sandy soil requires more frequent, smaller applications of water where as clay soils can be irrigated less frequently and to a larger depth. Many countries are expected to face insufficient water resources satisfy their current agricultural, domestic, industrial and environmental water demands within the next two decades. The world population is forecasted to grow by about 30% by the year 2025, reaching 8billion people. As a results of improved communications, globalization and more urbanization, the living standards of the people are expected to increase.

This means competition among the agricultural, industrial, domestic and other users will increase in unprecedented levels (The state of the world's land and water resources for food and agriculture: Managing systems at risk. , 2011)Irrigation is an agricultural activity that delivers water to fill the soil moisture deficit. For the farmers, it is a component of successful crop husbandry particularly in a dry climate.

A consistent and appropriate irrigation water supply can result in enhancements in agricultural production and assure the economic vitality. Many civilizations have risen on irrigated agriculture. These provide basis for their society and enhance food security of their people. Some have estimated that as little as 15-20% of the world wide total cultivated area is irrigated (FAO, 1989). Irrigation can be defined as the science of artificial application of water to the land in accordance with the crop requirement through the cropping period for full-fledge nourishment of the crops (Etich, 2011)The utilization of important resources in irrigated agriculture is very important for sustainable production of irrigated agricultures. The potential efficiency of the system evaluated by on-farm operations.

Performance assessment has been an essential part of irrigation since man first started harnessing water to improve crop production. Evaluation involves measuring conditions at one or more points in a field selected to be typical or representative for the irrigation projects (Pereira and Trout, 1999). Ethiopia is one of few African countries endowed with abundant water resources. The country has 12 river basins with an annual runoff volume of 124billion cubic meter of water and an estimated ranges of 2.6 to 30billion cubic meter ground water potential (EPCC, 2015). The irrigation potential is also estimated about 5.3million ha from 15million ha of total cultivated area. The irrigation area of the country is 640,000ha. Of these 120,000ha using rain water harvesting, 383,000ha from small scale irrigation and 129,000ha from medium and large scale irrigation systems (Awulachew, 2010).Nevertheless, Ethiopian irrigation projects, in most cases, have failed to significantly enhance the livelihoods of rural communities or substantially impact food security. The World Bank, various development agencies and numerous countries have invested in large irrigation projects, but there is disagreement on whether investing in new irrigation projects is appropriate because of the less than satisfactory performance of existing projects(Burt and Styles, 1999). Most of the government initiated and community-managed projects are confronted with multifaceted technical and socio economic problems, which have resulted in low land, water and labor productivity. Agriculture is regarded as the backbone of Ethiopian economy and a key driver of its long term growth and food security. Agriculture directly supports 85% of the population constitutes. Of which 43% of gross domestic product, and 80% of export value (Awulachew, 2010)Agriculture employs 80% of the labor force while 85% of the population, which currently is above one hundred million, depends on agriculture for a living and live in rural areas (Awulachew, 2006).

Materials used for sample collection and analysis Number Material type Purpose

1. Core sampler: - To collect undisturbed soil samples for soil moisture test

2. Auger: - To dig soil samples for texture analysis

3 .Oven dry: - To dry the wet soil

4. Measuring tape (50 m):- To Measure the dimension layout of the farm

5. Stopwatch or clock: - To record time

6. Analytic balance:-To measure soil weight

7. Par shall flume: - To measure the rate of flowing water in the field canal

8. Plastic Bag:-To take soil samples to the laboratory

9. GPS:-To collect different coordinate points

10 .Water level: - To check the slope of Par shall flume

11 .Hammer:-To hit the core sampler

12 .Stakes: - To fix the measuring place

13. Floating object One liter empty bottle (Flow velocity measurement)

14. Staff gauge:-To insert it to measure water.

3.2 Data collection

The study was carried out starting from November to March; 2021/22 of the irrigation season. In this study; primary and secondary data have been gathered and engaged for the study purpose. For field data collection and measurement purposes; auger for soil sample taking, Core sampler auger for bulk density, Measuring tape for measure of the field sizes and flow distances for surface velocity calculation in the main canal, Sensitive weighing balance for measure of fresh and dry weight of the soil, Cans, for putting soil in to oven dry, Pressure palate for determining, field capacity(FC) and permanent wilting point(PWP) of the soil, Stop watch for time recording of floating materials and time of application of irrigation water to the field, Floating material for measuring flow velocity and three inch Par shall flume with dimensions 14 feet long, 12 inches deep and 10 inches wide for measuring amount of water applied to the field. (Kandiah, 1981).

3.21 Primary data collection

Every day field observations were made to observe and investigate the method of water applications and practices related to water management techniques made by the farmers. Measurements of flow velocity, canal cross sectional area and discharge at different points of irrigation scheme was taken. To determine soil texture of field, soil samples from the three selected locations based on distance from main canal of the scheme at three different depths based on maximum root zone of the selected crop wheat was collected. And also using core sampler auger; undisturbed soil samples was collected from different depths and the bulk densities at different depths were determined. Soil samples were also collected to determine the soil moisture content one day before and after irrigation. Type of crop, effective root depth, total growing period, crop coefficient and maximum allowable depletion fraction were collected. Primary data the primary data were collected directly from the field and laboratory. Such activity includes; discharge measurements, measurement of actual water surface elevation in the main canal, questionnaires, number of beneficiary farmers/households from Abuare Kebele, filed observations and laboratory results. The details of the way, locations (sites) and time of collecting these data are discussed in the following section.

A) Flow measurement

B) Flow measurement is one of the main activities of data collection. It helps to know the conveyance and application efficiency. Flow measurement takes place both conveyance and water application area. The field application water is measured by Par shall flume which is a horizontally constricted vertical throat in an open channel used to measure the discharge entering into the field (sample) plot.

C) The canal discharge were measured by area-velocity method due to the absence of other materials (current meter). Difficult to use Par shall flume because canal is too large.

I) Estimation procedure the following presents the procedure for measuring the discharge using a floating object. Equipment:

Step 1: Select a straight section of the canal at least 10m long

Step 2: Place two stakes, one each side, at the upstream end of the selected portion of the canal. They should be perpendicular to the centerline of the canal

Step 3: Measure 10 meters or more along the canal

Step 4: Place two stakes at the downstream end of the selected section of the canal, also perpendicular to the centerline of the canal

Step 5: Place the floating object on the center line of the canal at least 5m upstream of point and start the stopwatch when the object reaches point where first stakes are placed

Step 6: Stop the stopwatch when the floating object reaches point of downstream stakes location, and record the time in seconds

Step 7: Repeat steps 5 and 6 at least four times in order to determine the average time necessary for the object to travel from one point to another point. The object should not touch the canal embankment during the trial, but if it does the operation must be repeated and the time for the bad trial must not be included when calculating the average time

Step 8: Measure the canal cross section at the selected canal section.

Step 9: Calculate the surface velocity, Vs, and then the average flow velocity, V, using the equations $Vs = L / t$, where t is the travel time is seconds, based on the average of four clear runs of the floating object, and $V=0.85*Vs$ 0.85 is a constant velocity reduction factor. This is used by FAO (1985 to 1993), as a reduction for turbulent nature of the flow to have a mean velocity. The relationship with the depth of flow is another reason. So, my canal depth was in the range of the corresponding correction factor

Step 10: Calculate the wetted area of the cross-section

Step 11: Calculate the discharge, Q, in the canal, Q = V * A Where Q in m3 /s B) Field observation For the period of field observation, the conditions of existing irrigation structures were inspected during off and on irrigation time. During field observation the overall operational activities were identified and a number of functional and non-functional structures in the scheme were recorded.. C) Water surface elevation measurement Measurement of water surface elevation of the main canal during irrigation season were considered at the head, middle and tail reach of the system is important to identify scouring and siltation locations on the conveyance system. At each reach of the main canal, the actual data were taken at every ten meter distance intervals along the main canal up to the entire length (representative monitoring locations).

The actual water surface depth from canal bottom were measured by using staff gauge and measuring tape meter. D) Soil sample collection To determine soil texture of each farmer's field plot, nine (9) composite soil samples from three locations from each scheme at three different depths were collected. And also using core sampler undisturbed soil samples were collected from different depths and the bulk densities at different depths were determined. Soil samples were also collected to determine the soil moisture content two day before and after irrigation event by collecting soil samples from the scheme with an interval of 30cm to a depth of 90cm. It is based on the major crops depth that planted on the scheme that the effective root zone of the irrigated vegetable crop is not more than this depth. Here, the major crops that are grown in the area have a depth less equal or the depth taken for the study.

The moisture content of the collected soil samples was determined using gravimetric method. The soil samples were taken on the selected field plots with different depth intervals down the pit using different materials. The collected samples were used to determine bulk density, soil texture, soil moisture content, field capacity, permanent wilting point and others. The sample field plots were selected based on the availability of water reaching from the conveyance system or distance from the water source to the command area. Sampling methods in this study a random sampling method was used to select the farmers for the surveys. To evaluate farmer's perception about scheme performance and institutional aspects a sample were taken from the beneficiaries of the irrigation schemes by preparing questionnaires.

3.2.2 Secondary data collection

For the selected sembeta small scale irrigation scheme, secondary data levels like climatic data, investment cost, fees from irrigation users', total irrigation users in the command area, operation and maintenance costs were collected from the Kechabira woreda , Water Resource and Irrigation office at regional and zonal levels.

3.3Determination of Crop Water and Irrigation Water Requirement

Crop water requirements (CWR) refer to the amount of water required to compensate for evapotranspiration losses from a cropped field during a specified period of time and irrigation water requirement refers to the amount of water, in addition to rainfall, that must be applied to meet a crop's evapotranspiration needs without significant reduction in yield. Crop water requirements are expressed usually in mm/day, mm/month, or mm/season.

CROPWAT 8.0 computer program was used to estimate the total water requirements of wheat crop in the irrigation scheme. FAO (1992) Penman-Monteith method was selected to calculate the reference crop evaporation (ET_O). 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 (^{0}C), relative humidity (%), wind speed (km/day) and sunshine hours (hr). The program estimates (ETc) based on equation: -

$$\mathrm{ETc} = (\mathrm{ETo} * \mathrm{Kc}) ------------------------------(1)$$

Where:

ET_c is actual evapo-transpiration of crops (mm)

ET_o is reference evapo-transpiration (mm)

K_c is the crop coefficient (dimensionless)

3.4 Soil Data Analysis

Soil samples were collected from the field to analyze its selected physical properties. The soil physical and chemical properties to be analyzed include soil texture, bulk density Total Nitrogen, Available phosphorus, PH values, Organic matter and soil moisture contents at field capacity and permanent wilting point. Bulk density was determined using the core sampling method (Blake, 1965). Water contents at field capacity at 0.33 bars and permanent wilting point at 15 bars was determined in Ethiopian Construction and Supervision Works Corporation; Research Laboratory and Training Center using the pressure plate apparatus (Grewal, 1990).

3.4.1 Soil Texture

Soil texture is the amount of sand, silt and clay in the soil. It has a strong influence on water storage and availability because of the variation in the particle size distribution and the surface area. Smaller particles fit together more tightly than larger particles and therefore the pores for air and water are also smaller. Small pores retain water against gravitational forces, drainage and also against plant use, while the larger pores found in sand allow water to drain. Ideally, a soil was contain a range of pore sizes, larger pores which drain readily so as to prevent water logging following soil saturation and smaller pores which store water for plant use. Not all water held in very small pores is available to plants because water can be retained strongly (IMG, 2010).

The textural triangle diagram was used to identify the proportion of sand, silt and clay percentages (Appendix figure 1).

3.4.2 Bulk density of the soil

Bulk density refers to the soil overall density or compactness of a soil and should be distinguished from the soil density of the solid soil constituents, usually called the particle density. The bulk density is affected by structure of the soil, i.e., its looseness or degree of compaction, as well as by its swelling and shrinkage characteristics, which are dependent upon clay content and wetness. The bulk density is also the ratio of oven-dried mass of a soil to its volume for undisturbed soil condition and is expressed on dry weight basis of the soil as (Blake, 1965): -

$$B_d = \frac{M_d}{V_c} \qquad (2)$$

Where Bd is the soil bulk-density (gm cm^{-3})

Md is the weight of oven dried soil (gm)

VC is the volume of core (cm^3)

3.4.3 Soil pH

Soil pH was determined for the identification of whether the soil has acidity or salinity problem. It was measured in 1:2.5/soil: water mixture by using pH meter. Distilled water was used as a liquid in the mixture. Ten gram air dried < 2 mm soil was weighed into 100 ml beakers and 10 ml distilled water was added to 1:2.5/ soil: water suspension and transferred to an automatic stirrer, to be stirred for 30 minutes and pH on the upper part of the suspension was measured.

Soil acidity is a potentially serious degradation issue. When soil becomes too acidic it can:

Decrease the availability of essential nutrients

Increase the impact of toxic elements

Decrease plant production and water use

Affect essential soil biological functions like nitrogen fixation

Make soil more vulnerable to soil structure decline and erosion

3.4.4 Organic matter content

Applying organic matter is one of the best methods in achieving and maintaining a fertile soil for this improves the cohesiveness of the soil, increases its water retention capacity and promotes a stable aggregate structure (Morgan, 1989).Titration method, which is oxidation under standardized condition with potassium dichromate in sulpheric acid was followed for organic carbon determination. Finally, conversion of organic carbon to organic matter is by multiplying percentage organic carbon by 1.724 to obtain organic matter content.

3.4.5 Total Nitrogen and available Phosphorus

(Sadras,0.,et al). (No date) suggested that nutrient availability, particularly nitrogen and phosphorus, are critical to high yield and water productivity. Total Nitrogen was determined by Kjeldhal method in the laboratory. The procedure was based on the principle that the organic matter was oxidized by treating soil with concentrated sulfuric acid, nitrogen in the organic nitrogenous compounds being converted into ammonium sulfate during the oxidation. NH4+ ions in the soil were trapped by the acids which were liberated by distilling with NaOH. The liberated NH4+ is absorbed in boric acid and back titrated with standard H2SO4. Phosphorous is known as the master key to agriculture because lack of available P in soil limited the growth of both cultivated and uncultivated plant (Foth, D.H. and G.B. Ellis, 1995).To correct this deficiency farmers are advised to add P to their soil in the form of manure or fertilizer. Available phosphorus was determined by Olsen method which is sodium bicarbonate method.

3.4.6 Moisture Content of Soil

The moisture content of the collected soil samples were determined using gravimetric method. In this method soil samples were taken with soil auger and weighed and dried in an oven at 105 ^oC for about 24 hours, until all the moisture is driven off. After removing from oven they were cooled slowly at room temperature and weighed again. The difference in weight is the amount of moisture in the soil (Michael, 1978).

$$W_\theta = \left(\frac{W_w - W_d}{W_d} * B_d * 100\right) --------------------------(3)$$

Where

W_θ is gravimetric soil moisture content (% volume bases)

W_w is wet weight of the soil (g)

W_d is dry weight of the soil (g)

B_d is bulk density of soil (g cm^{-3})

3.4.7 Total Available soil Water

(Grewal, 1990); observed that knowledge of the soil water content at field capacity (FC) and permanent wilting point (PWP) is important for irrigation scheduling, assessing plant water requirement and soil suitability for different land uses. Studies by Salter and Williams (1980) provided a framework for estimating field capacity and permanent wilting point. The total Available Soil Water (TAW) was computed from the soil moisture content at Field Capacity (FC) and Permanent Wilting Point (PWP) using expression:

$$\mathrm{TAW} = \left(\frac{\mathrm{FC} - \mathrm{PWP}}{100}\right) * B_d * Rz ------------------------ (4)$$

Where TAW is total available water (mm), FC and PWP in % on weight basis, Bd is the bulk density of the soil in gm cm^{-3} and Rz is the maximum effective root zone depth in mm.

3.4.8 Readily Available Water

It is the portion of the total available water (FC – PWP) which is most easily extracted by the plant roots without creating stress. The water content near to PWP cannot be easily extracted by the plant roots. Therefore, only part of the TAW is used before the next irrigation. The term Maximum or Management Allowable Deficiency, (MAD) can be used to compute the amount of water that can be used without adversely affecting the plants and can be expressed as a fraction of the TAW. This value varies with the crop type and could be obtained experimentally. Once the MAD is known, it is possible to compute the net irrigation water requirement, IR_n, necessary to restore the main root zone, to FC. Readily available water can be expressed in equation given in equation (5).

$$\mathrm{RAW} = (\mathrm{TAW} * \mathrm{P}) ------------------------------ \quad (5)$$

Where

RAW is readily available water

P is in fraction for allowable soil moisture depletion for no stress

3.4.9 Irrigation Scheduling

For determination of irrigation schedule of the irrigation scheme and to make comparison with the current irrigation practices; moisture content, field capacity, permanent wilting point, depletion fraction at each growing stage data were collected. Additionally, farmer’s irrigation practices were determined; such as irrigation methods, irrigation frequency and interval of irrigation, and application depths. During the determination of the amount of water applied to the field, the average water flow rate to the farm inlet and respective time were recorded with the size of the fields being irrigated. The total volume of water applied to the field was obtained by multiplying the discharge rate with the inflow time. The depth of water applied to the field was obtained by dividing the total volume of water applied to the area irrigated. Considering the daily CWR, TAW, Dz, Bd and p, the irrigation interval could be computed from the expression (Rao *et al.*1992):-

$$\text{Interval(days)} = \frac{\text{RAW}}{\text{CWR}} \text{-------------------------- (6)}$$

3.5.Performance Evaluation Methods

Performance of the scheme was evaluated using both internal and productivity performance indicators. The internal performance indicators were conveyance efficiency, application efficiency, storage efficiency, deep percolation ratio and overall scheme efficiency. For computation of absolute performance efficiencies, irrigation fields with wheat crop were selected. The standardized performance indicators established by IWMI was taken to measure external indicators. The external indicators included in this study were agriculture, water use, physical and economic performance indicators (Molden, et al., 1998).

3.6. Internal Performance Indicators

These indicators examine the technical or field performance of a project by measuring how close an irrigation event is to an ideal one. An ideal or reference irrigation is one that can apply the right amount of water over the entire region of interest (i.e. depth of root zone) uniformly and without losses (Yesuf.K., 2003).

3.6.1 Conveyance Efficiency

To estimate conveyance efficiency, the average flow velocity and the flow velocity of the water at the surface, the surface velocity, vs. was first determined. The surface velocity was determined by measuring the time it takes for a floating object along the canal. The floating object was placed in the center of a canal and the time measurement was repeated three times to avoid mistakes. The stretch of canal used for measurement should be straight and uniform, in order to avoid changes in the velocity and in the area of the cross-section, because any such variation reduces the accuracy of the velocity estimation. A piece of citrus fruit lemon makes a good float, as it is less affected by wind than a wooden stick. A reduction factor of about 0.85 should be used to convert surface velocity to average velocity (Tigabu T., 2017).

$$\text{Surface velocity}\left(\frac{\text{m}}{\text{s}}\right) = \left(\frac{\text{L}}{\text{t}}\right) \text{-------------------------- (7)}$$

$$\text{Average velocity}\left(\frac{\text{m}}{\text{s}}\right) = \left(\frac{0.85 * \text{L}}{\text{t}}\right) \text{------------------------(8)}$$

The cross section of the canal was measured up carefully in a number of places along the test distance and the average cross-sectional area calculated (A sq. m). Geometry of the Sembeta irrigation canal is rectangular; so cross-sectional area was calculated as (Garg, 2005)

$$A = (b * y) ----------------------------------- (9)$$

Where

b is base width of canal

y is water depth in the canal

Discharge can be calculated by multiplying average velocity and cross sectional area of the irrigation canal as (Tigabu T., 2017).

$$Q\left(\frac{m^3}{s}\right) = \left(\frac{0.85 * L * A}{t}\right) ---------------------------- (10)$$

Conveyance efficiency is the ratio of water delivered in to the field from outlet point of the canal (Q_o) to water entering in to the canal at its starting point (Q_i). Accordingly, the conveyance efficiency of the canal was computed by taking discharges measurement at different points. The measurements also were taken throughout study period at initial and final points of main canal (Ramulu.S.). The conveyance efficiency of the scheme was also computed as:-

$$E_c = \frac{Q_o}{Q_i} * 100 ------------------------------ (11)$$

Where E_c is conveyance efficiency (%)

Q_i is depth of water diverted from the source (m^3) (Jureims, et al., 2001)

Q_o is depth of water applied to the field (m^3).

3.6.2 Application Efficiency

According to **(Jureims, et al., 2001)**application efficiency is a common measure of relative irrigation losses and this definition is valid for all situations and all irrigation methods. Losses from the field occur as deep percolation and as field tail water or runoff and reduce the application efficiency. To compute the application efficiency it is necessary to identify at least one of these losses as well as the amount of water stored in the root zone.

The application efficiency was computed as the ratio of quantity of water stored in to the root zone of crops (NIR) to the quantity of water actually delivered in to the field (GIR). In this particular research soil samples were collected from different selected fields of the scheme at depths of 20cm interval based on maximum root depth of the selected wheat crop and the amount of water stored in the root zone determined by gravimetric method. Application efficiency was computed as follows (Ramulu.S.):

$$\text{Ea} = \frac{\text{NIR}}{\text{GIR}} * 100 \text{ ---------------------------------- } (12)$$

Where

E_a is application efficiency (%),

NIR is average depth of water applied to the root zone as storage (mm), and

GIR is average depth of water applied to the field (mm).

The amount of water applied through Par shall flume to a field is a function of time, flow and area. The time of irrigation is easily recorded. The amount of area irrigated is also easily calculated. However, estimating flow rate in an open ditch of Par shall flume by equation given by (Kandiah, 1981).

$$\text{t} = \frac{\text{A} * \text{GIR}}{6\text{Q}} \text{ ---------------------------------- } (13)$$

Where

t is time of application (min)

A is area of the plot (m^2)

GIR is amount of water applied to the field (cm)

Q is flow rate or discharge (l/s)

3.6.3 Deep Percolation Ratio

The runoff ratio was normally being considered for this particular study as zero as the farmers are using furrows whose tail ends are closed. However, the deep percolation ratio was computed as the ratio of the percolated water beyond the root zone to the volume of water applied to the field. It was computed using the following formula (Feyen, 1999):

$$\text{DPR} = (100 - \text{Ea} - \text{RR}) ----------------------------- (14)$$

Where

DPR is deep percolation ratio (%)

E_a is application efficiency and

RR is runoff ratio.

3.6.4 Storage Efficiency

The storage efficiency is an index used to measure irrigation adequacy. It is the ratio of the

Quantity of water stored in the root zone during irrigation event to that intended to be stored in the root zone. After determining the storage and the required depths; the storage efficiency was calculated using the following formula (Ramulu.S.).

$$\text{Es} = \frac{\text{NIR}}{\text{Wn}} * 100 -------------------------------- (15)$$

Where:

E_s is storage efficiency (%),

NIR is water stored in the root zone (mm)

W_n is water desired to be stored in the root zone (mm).

3.6.5 Overall Scheme Efficiency

Irrigation efficiencies are evaluated at scheme or farm level for the purpose of identifying the losses that occur in the irrigation system starting at the water abstraction point from the sources, through the conveyance system down to water application in the field, to determine the overall irrigation efficiency. As reported by the (MoAFS, 2002)for small irrigation schemes in Tanzania typical values of overall scheme efficiency proposed were 28 and 34% for poorly operated and for well operated canals, respectively. In addition to design and other technical factors, the farm efficiency is much regulated by the operation of the main supply system to meet the actual field supply requirements and the skill of the system operators (FAO, 1989). Finally, the overall scheme efficiency was calculated as the product of conveyance and application efficiency. It was computed using following formula (Ramulu.S.):

$$E_p = (E_c * E_a) ---------------------------------- (17)$$

Where

E_p is overall scheme efficiency (%)

E_c is conveyance efficiency (%) and

E_a is application efficiency (%).

3.7 Productivity Performance Indicators

The external performance of the scheme was evaluated using some selected comparative indicators, which are normally classified into four groups, namely agricultural, water use, physical and economical performances as standardized by IWMI (Molden, et al., 1998). To compute the total production of scheme in selected crop wheat grown in the respective sites, average yield per ha as well as an average price for the crop per kg was collected for scheme. The design feasibility study documents of the irrigation projects was collected from the Regional irrigation and water resource Bureau for Sembeta irrigation project and was used as a source of information on the operation and maintenance costs of the irrigation projects. The results obtained on all the indicators were used to evaluate the performance of the scheme. For the evaluation of irrigated agriculture performance, four indicators related to the output of different units were used. They are used for the evaluation of the project performance in terms of the production it results in. The selected indicators used to evaluate irrigated agriculture performance are output per cropped area (Birr ha^{-1}), output per command area (Birr ha^{-1}), output per irrigation supply (Birr m^{-3}), Output per water consumed (Birr m^{-3}) as the ratio of production in Birr per volume of water consumed (m^3) (Molden, et al., 1998).

3.7.1Agricultural Performance Indicators

Output per unit irrigated area (Birr/ha)

It was computed as the total value of production per harvested area in the irrigation season. The harvested /irrigated / area includes the areas that were irrigated in the irrigation season.

$$\text{OPUIA} = \frac{\text{Seasonal value of production}}{\text{Irrigated harvested area}} ---------------------- (18)$$

Where:

OPUIA is output per unit irrigated cropped area

Seasonal production is the output of the irrigated area in terms of gross or net value of production measured at local price.

Irrigated harvested area is the areas under crops.

Output per unit command area (Birr/ha)

This indicator quantifies the value of production that obtained per unit command irrigable area. The computed value indicates the level of utilization 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 intensive 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 (Molden, et al., 1998).

$$\text{OPUCA} = \frac{\text{Seasonal value of production}}{\text{Command area(Nominal)}} ---------------------- (19)$$

Where

OPUCA is output per unit command area

Seasonal production is the output of the irrigated area in terms of gross or net value of production measured at local price.

Output per unit irrigation water supply (Birr/m^3)

This is one of the water productivity indicators and 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. Supplied irrigation water is the volume of surface irrigation water diverted to the command area can estimated by equation below (Sakthivadivel, R., et al, 1999).

$$\text{OPUIS} = \frac{\text{Seasonal value of production}}{\text{Total diverted irrigation water}} ---------------------- (20)$$

Where

OPUIS is output per unit irrigation water supply or diverted

Seasonal production is the output of the irrigated area in terms of gross or net value of production measured at local price.

Total diverted irrigation supply is the volume of surface irrigation water diverted to the command area, plus net removals from groundwater.

Output per unit water consumed (Birr/m^3)

This indicator derived from the general water accounting frame work (Molden, et al., 1998). Consumed water is the actual evapo-transpiration 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 evapo-transpiration relative to the diverted and delivered amount of irrigation water. It has a contribution for irrigation management aspects; to take measurements those minimize evapo-transpiration losses (Sakthivadivel, R., et al, 1999).

$$\text{OPUWS} = \frac{\text{Seasonal value of production}}{\text{Total water consumed by the crop}} ------------------ (21)$$

Where OPUWS is output per unit water consumed

Seasonal production is the output of the irrigated area in terms of gross or net value of production measured at local price

Total volume of water consumed by ET is the actual evapotranspiration of crops

3.7.2 Water Use Performance Indicators

These indicators depict the state of water availability or shortage and how tightly supply and demand are related. Both RIS and RWS relate supply to demand and show some indication as the condition of water abundance or scarcity and how tightly supply and demand are matched.

Relative irrigation supply (RIS)

This is the ratio of annual irrigation supply (which excludes rainfall) to annual irrigation demand. Irrigation water is a scarce resource in many irrigation schemes and is a major constraint for production. This indicator is useful to assess the degree of irrigation water stress or abundance in relation to irrigation demand. It is the inverse of irrigation efficiency presented by (Bos, 1997).

Values of Relative Irrigation Supply (RIS) higher than one indicate that excess irrigation water is being supplied and RIS values greater than RWS values is a sign that major amount of water supplied in the area is from irrigation. The indicators are estimated as per the equations below (Molden, et al., 1998):

$$\text{Relative irrigation supply} = \frac{\text{Irrigation supply}}{\text{Irrigation demand}} ----------------- (22)$$

Relative water supply (RWS)

This is the ratio of total annual water supplied (irrigation plus rainfall) to the annual crop water demand can estimated by equation below (Levine, 1982). It signifies whether the water supply is in short or in excess of demand.

$$\text{Relative water supply} = \frac{\text{Total water supply}}{\text{Crop demand}} - (23)$$

3.7.3 Physical Indicators

According to Sener et al. (2007) developed a relation between currently irrigated areas to the command (nominal) area to be irrigated; to quantify the level of utilization of the potential irrigable area for irrigated agriculture for a particular production time period.

Physical indicators are related with the changing or losing irrigated land in the command area by different reasons. The selected indicator used for evaluation of physical performance is irrigation ratio which can be expressed as the follows (Molden, et al., 1998).

$$\text{Irrigation ratio} = \frac{\text{Irrigated crop area}}{\text{Command area}} - (24)$$

Where irrigated crop area (ha) is the portion of the actually irrigated land (ha) in any given irrigation season and command area (ha) is the potential scheme command area.

3.7.4. Economic Performance Indicators

Finally, the economic indicators deal with how much investment cost is spent on the project in comparison with total production and yearly maintenance and operation expenditure and whether system is self-sufficient or not. The economic performance indicators used in the evaluation for this particular study are gross returns on investment and financial self-sufficiency. The gross return on investment is calculated as the ratio of production to the cost of infrastructure at the irrigation scheme and the financial self-sufficiency was calculated as the ratio of revenue from irrigation to the total operational and maintenance expenditure (Vermillion D., 2000).)

$$\text{FSS} = \frac{\text{Revenue from irrigation charges}}{\text{Total operation and maintainance expenditure}} - - - - - - - - - - - - - - - (26)$$

Where, FSS is financial Self Sufficiency

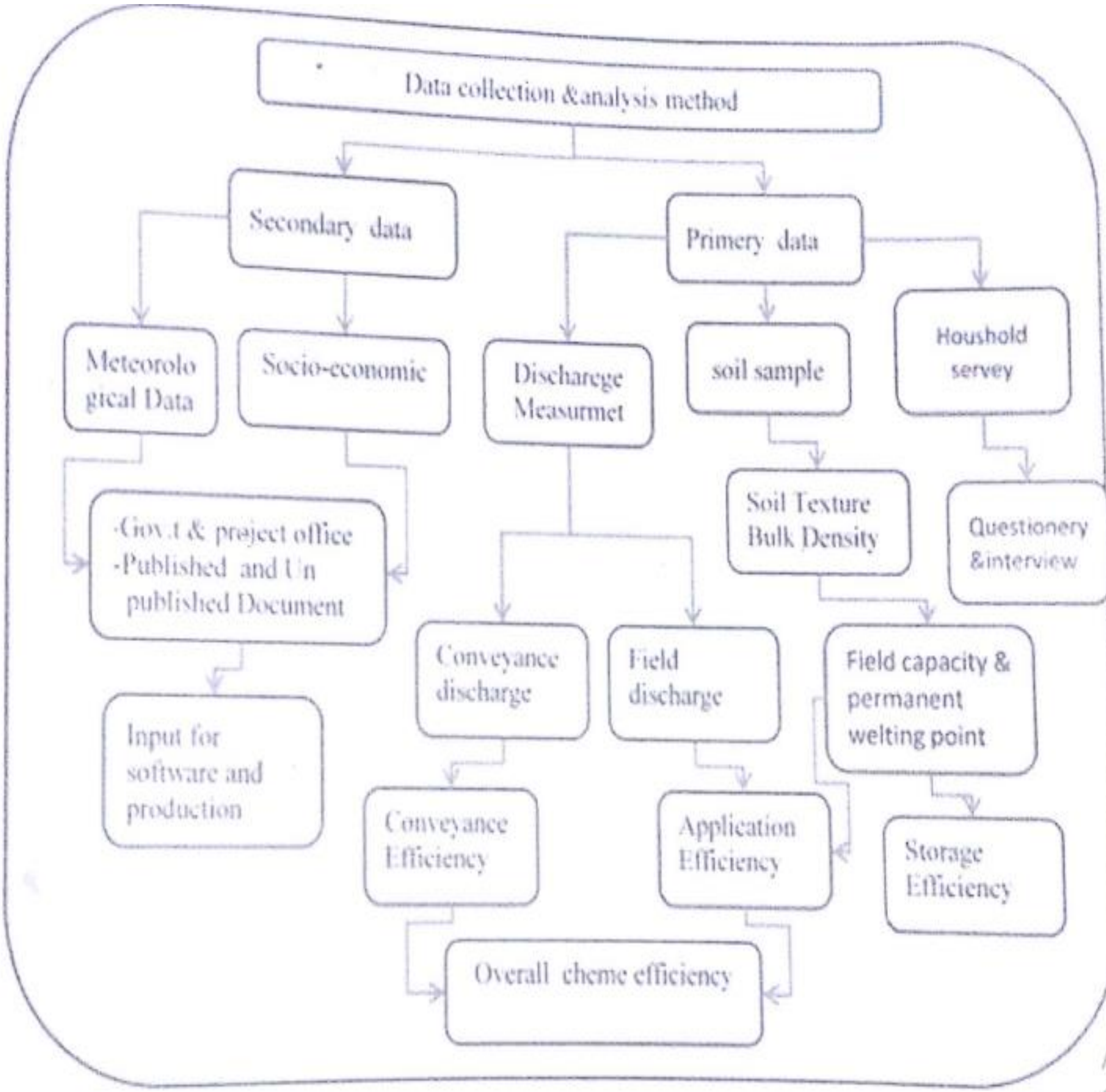

Figure 3 Overall conceptual framework Methodologies

4 RESULTS AND DISCUSSION

4.1 Soil Physical and chemical properties

The soil textural classes in the project area were clay loam for the selected farms at upper head, middle reaches and tail end part of the irrigation scheme by using textural triangle (Appendix figure 1) and indicating that soils of the scheme at all upper, middle and tail reaches are more or less similar in texture .The bulk density values ranged from 1.18 to 1.33 g cm^{-3} at sembeta irrigation system. Electric conductivity is 0.17, 0.17 and 0.19 at head, middle and tail respectively. Total nitrogen is 0.16, 0.18 and 0.15 at head middle and tail respectively. PH value of soil is 6.22, 6.47 and 6.34 at head middle and tail respectively. Organic matter content of the soil is 2.127.

Table 4.1 Selected soil physical characteristics of the irrigation scheme

Field code	Soil depth(cm)	Particle size distribution (%)			Textural class	Balk density (g cm^{-1})
		Clay	Silt	Sand		
H	0-60	40	22	38	Clay loam	1.33
M	0-60	40	22	38	Clay loam	1.25
T	0-60	40	26	34	Clay loam	1.18

Table 4.2 Selected chemical properties of soil

Canal reaches	PH	OM (%)	N	P(ppm)
Head	6.22	4.3125	0.16	49.76
Middle	6.47	3.398	0.18	11.85
Tail	6.34	4.071	0.15	13.78

4.2 Irrigation Water Requirements of wheat crop in the Study Area

The seasonal and irrigation water requirement of the crop wheat grown in the study area during the study period was estimated by the CROPWAT 8 model. The results indicated that for crop, the seasonal crop and irrigation water requirements were equal since there was no rainfall during the study period. Accordingly, the seasonal crop water requirement of wheat, which was mainly practiced in the study area, was from November to March. The seasonal crop water requirement determined was at 471.5126 mm.

Table4.3 Seasonal crop water requirement for wheat based on crop calendar

Months	Dev. Stage	No-of days	Kc	ETo (mm/day)	Etc (mm/day)	Etc (mm/period)	Etc (mm/month
January	Dev.t	2	1.36	4.10	5.576	11.152	153.472
	Mid	28	1.24	4.10	5.084	142.352	
February		26	1.24	4.39	5.4436	141.5336	148.908
	Late	4	0.42	4.39	1.8438	7.3752	
March		23	0.42	4.82	2.0244	46.5612	46.5612
November	Initial	17	0.5	4.82	2.41	40.97	40.97
December		28	0.5	4.88	2.44	68.32	81.5936
	Dev.t	2	1,36	4.88	6.6368	13.2736	
Seasonal Etc							471.5126

4.3 Internal Process Indicators

4.3.1 Conveyance efficiency

The results of the conveyance efficiency evaluation revealed that this indicator varied within a different points, of the scheme .It average value is 62.3%. However, the values of conveyance efficiency for the Sembeta irrigation scheme is below the recommended value i.e.70% unlined poorly managed main canals (MoAFS, 2002).

4.3.2 Application efficiency

The application efficiency of a given irrigation scheme tells us whether the irrigation water is stored in the intended soil profile or lost as surface runoff and deep percolation. An average application efficiency of the study area was 64.2%. A light soil with high infiltration rates favors deep percolation losses at the top of the fields, resulting in low field application efficiency. The finding indicates that the application efficiency of upper head and middle reach of irrigation scheme was slightly better than tail end part of irrigation scheme. This may be associated with the textural class of the soil and field furrow preparation. Generally the application efficiency of both upper head and middle reach of scheme are typical results for furrow irrigation (Savva and Frenken, 2002), which is recommended as 50-70% for properly designed furrow irrigation.

4.3.3 Deep percolation ratio

Deep percolation ratio indicates the irrigation applied to a field percolates into the soil below the root zone. Average deep percolation ratio at irrigation scheme was found to be 35.8%. In the schemes, there is high deep percolation ratio which indicates over irrigation.

4.3.4 Storage efficiency

The result of average storage efficiency of selected fields from irrigation scheme was 76 in general the storage efficiency of the scheme was very good as compared to 63% storage efficiency usually found in typical furrow irrigation systems (Raghuwanshi, 2001).

Table 4. 4 .Different values of selected internal performance indicators of the scheme

Internal performance Indicators	Average values obtained from the scheme
Conveyance efficiency(Ec)	62.3%
Application efficiency(Ea)	64.2%
Dee percolation ratio(DPR)	35.8%
Storage efficiency(Es)	76%
Overall scheme efficiency(Ep)	39.9966%

4.4 Productivity Performance Indicators

4.4.1 Irrigated agriculture performance indicators

This includes performance indicators, which are associated with the production. The major of such performance indicators included are output per unit cropped area, output per unit of command area, output per unit irrigation supply and output per unit water consumed.

4.4.1.1 Output per unit cropped area

The output per unit cropped area shows the response of each cropped area on generating gross return. This parameter gives a clue about the management practice in every scheme. According to the yield collected and evaluated from each of three reaches of the irrigation scheme; the outputs per unit cropped area were 100000Birr per command area, 150000Birr ha^{-1} and 90000 Birr ha^{-1} from head, middle and tail end of the scheme respectively and an average value of output per unit cropped area of 68,333Birr ha^{-1}. Based on this evaluation it is possible to say that the response or income per cropped area at middle part of the irrigation scheme was relatively better than that of tail end of irrigation scheme. This income reduction in upper and tail end of the irrigation scheme was mainly due to over irrigation beyond crop water requirement and under irrigation respectively.

4.4.1.2 Output per unit of command area

This indicator expresses the average return per design command area. It is an indication of whether all the command areas are generating returns or not. The outputs per unit command area of irrigation scheme was 20,400,000Birr per command area. Which was very low production value as compared to 76,800,000Birr per command area for good yield bulb under irrigation as stated in (FAO 1986).

4.4.1.3 Output per unit irrigation supply

The outputs per unit irrigation supply show the revenue from agricultural output for each meter cube of irrigation water supplied. The outputs per unit irrigation supply at the three level of the scheme were 12.7 Birr m^{-3}, 31.96 Birr m^{-3} and 21.15Birr m^{-3} at head, at middle and at tail end of the scheme respectively and an average output per unit supply of the scheme was 21.93 Birr m^{-3}. This indicates that production value per unit irrigation supply in middle reach is better than head and tail reach. Higher value of this indicator in the middle reach indicates lower irrigation supply and lower value obtained in upper and tail end of the scheme indicates lower production due to over irrigation and under irrigation respectively.

4.4.1.4 Output per unit water consumed

The output per unit water consumed is used to describe the return on water actually consumed by the crop. This indicator gives due attention to the water consumed by the scheme and tells us how water is efficiently utilized.

The outputs per unit water consumed in this study were 21.41 Birr m^{-3}, 54.28 Birr m^{-3} and 23.32 Birr m^{-3} at head, middle and tail end part of the irrigation scheme and an average output per unit water consumed of the scheme was 33.00Birr m^{-3}. This result shows that the water use efficiency in the middle part of the scheme was good as compared to outputs per unit water consumed at upper and tail part of the scheme. Lower return on water consumed in upper and tail end part of irrigation scheme was over irrigation and under irrigation in the system respectively. Lower return on water consumed was not only result of water scarcity but excess water would not improve the productivity but could reduce it.

4.4.2 Water use performance indicators

4.4.2.1 Relative water supply

The relative water supply depicts whether there is enough irrigation water supplied or not. Both the relative water supply and relative irrigation supply relate supply to demand and give some indication as the condition of water abundance or scarcity and how tightly supply and demand is matched. The relative water supply value below one normally indicates that the water applied is less than the crop demands and values above one indicate extra water is added to the root zone beyond plant demands. In this study the relative water supply in the three stages of the system were 1.61, 1.59 and 0.86 at head, at middle and at tail end of the system level and an average relative water supply of 1.35 .The results in upper and middle parts of the scheme which was greater than one represents the supply is enough to meet the crop insist but at the tail end part of the system, the result was less than one which indicates that there was less amount of irrigation water diverted to the field below crop demands. In order to maximize water use efficiency of the scheme, it is required that the amount of water supplied to be reduced in both upper head and middle reaches of the scheme and amount of water supplied to be maximized in the tail end part of the system.

4.4.2.2 Relative irrigation supply

The relative irrigation supply shows whether the irrigation demand is satisfied or not. Since there was no rainfall in the area during study period; the value of relative irrigation supply and relative water supply is the same which means 1.61, 1.59 and 0.86 at head, at middle and at tail end of the system. Irrigation ratio for the Sembeta irrigation scheme was 1.00, which means that 100% of command area was under irrigation

4.5. Economic performance indicators

4.5.1 Financial self-sufficiency

Financial self-sufficiency indicates the ratio of revenue from the irrigation users' to the expenditure for operation and maintenance. The total operation and maintenance cost was 2,180,392.32 Birr of and the annual revenue from irrigation users' was 743,600 Birr which was very low according to cost expended for operation and maintenance. The financial self-sufficiency of this particular research value 0.34 indicated that the revenue collected from irrigation charges was not sufficient for operation and maintenance of the project. As a result, the government covers the operation and maintenance cost of the irrigation scheme and it is considered as subsidy and irrigation scheme was not maintained and extra amount of irrigation water lost from the system. Economic performance indicators showed that the scheme had a serious problem about the collection of water fees.

Table 4. 5 Different values for selected external performance indicators of the scheme.

External Indicators		Average value obtained from the scheme
Agricultural Performance	Output per cropped area(Birr ha^{-1})	68,333
	Output per unit cropped area(ton ha^{-1})	4.1
	Output per unit command area (Birr per command area)	10120
	Output per irrigation supply (Birr $m^{-3)}$	21.9
	Output per unit water consumed (Birr m^{-3})	33.00
Water use Performance	Relative water supply (ratio)	1.35
	Relative irrigation supply (ratio)	1.35
Physical performance	Irrigation ratio	1
Economic performance	Financial self-sufficiency(ratio)	0.34

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The performance evaluation of the Sembeta irrigation scheme indicated that the availability of irrigation water is not a constraint at farm level and higher amount of water was diverted in upper and middle part of the system. Since the intension of analysis to investigate how consistent or how the performance of irrigation scheme was consistent with respect to the irrigation system. The conveyance efficiency of the scheme at the level showed some low values, even in the lined part of the main canal due to lack of regular maintenance, sediment deposition, use of illegal diversion gates for irrigation water. The application efficiencies in both upper and middle reach of the scheme has however, showed good when compared with application efficiency of 50- 70% for furrow irrigation observed in other African countries. The relative water and irrigation supply for both upper and middle reaches show that there is ratio greater than one, which implies the amount of water applied during irrigation events, was much higher than what was required by crop. This type of irrigation affects the crop production by reducing aeration for crop planted, water logging and also causes water wastage that can cultivate extra fields. But in tail end of the scheme lower ratio of relative water and irrigation supply which indicates amount of water applied during study event was much lower than desired amount of water to be applied. The output per cropped area at upper and tail end was extremely low as compared to middle reaches of the scheme, implying that the irrigation practice in upper and tail end of the scheme was relatively poor due to over and under irrigation respectively.

In general, based on the evaluation carried out, it can be concluded that yield obtained from Sembeta irrigation scheme at the middle part of the scheme was relatively better than the upper and tail end part of the scheme .This was due to the fact that the system permitted farmers to apply large and small volume of water to their fields. The study covered the minimum set of indicators that can be used to evaluate the health of the system. The small number of samples cannot permit a deep analysis of the indicators, but the study showed the usefulness of the indicators. The method can be useful tool in performance measurement and in the discovery of possible improvement needed.

The results of the determinants of food security indicate that age of household, education level, cultivated land holding, access to irrigation, dependency ratio, family labor, health status and non-farm activity were the major factors that significantly influence on households household food security. Education, cultivated land holding, access to irrigation, family labor, health status and non-farm activity positively affected the household food security in the study area. Age of household head and dependency ratio negatively affected household food security

. Finally the results of this study indicate, the main constraints for irrigation use and performance of irrigation in the study area were long distance between their farm, lack of irrigable farm land (lack of suitable land that can be for used irrigation), market problem, lack startup capital and irrigation tool, presence of pests and disease.

5.2 Recommendations

Huge amount of money has been invested to operation and maintenance in addition to investment cost for construction of Sembeta modern irrigation scheme and farmers are expected to use water efficiently. Even though there was no sign of being unproductive from the time of the irrigation establishment, irrigation water considerably wasted by farmers themselves. Farmers should be advised to appropriate irrigation water management so as to get much return from the production.

Earlier to developing an irrigation scheme for farmers, the capability of farmers whether they manage it or not must be considered. And close monitoring should be practiced than completely left the operation and maintenance for farmers. Especially issues like crop water requirements have to give much emphasis. Improvement of irrigation efficiency of the scheme needs tackling of all problems around area of water management and the infrastructure. Farmers at the head and middle of the system generally apply more water than needed for potential yield and excess water not improve the productivity but was reduce it. Instead the excess water were diverted to tail end part of the scheme receiving less water than needed to produce potential yields, then the production would have increased.

Therefore to reduce over and under irrigation, the following ideas are recommended:-

1. Regular training on over all irrigation water management, scheme operation and maintenance should be given to beneficiary farmers.
2. Institutional support, continuous monitoring and evaluation of the scheme are necessary to take immediate correction action on the problems created on the scheme; and to provide feedback information important for the maintenance of the scheme.
3. Empowerment of the water user association is fundamental for irrigation scheme sustainability. Hence, water user association of Sembeta irrigation scheme has to be further strengthened. Effort should also be made to bring all beneficiaries of the irrigation scheme under one water user association.

4. Assigning DA and Office assistant for the water user association in order to improve water application for irrigation, especially on water diversion and overall irrigation water management.

5. Additional research should be done on the overall performance of the small scale irrigation scheme in the Kembata Tembaro Zone in order to assess internal and external performance of the scheme.

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APPENDICES

7.1 Appendix I. Tables

Table 1. Average climatic data of the study area

Month	Min Temp(^{0}c)	Max Temp(^{0}c)	Humidity (%)	Wind(km/day)	Sun(hour)	Rain fall (mm)	ETo(/day)
January	13.3	29.1	62	95	8.1	20.0	4.10
February	14.0	29.7	60	104	7.6	20.3	4.39
March	13.9	28.9	65	181	7.5	21.0	4.82
April	13.9	28.1	75	130	7.1	20.4	4.29
May	13.5	26.4	77	112	6.1	18.3	3.76
June	13.1	24.3	80	104	5.9	17.6	3.44
July	12.8	22.0	80	95	3.8	14.5	2.86
August	12.2	22.5	77	104	4.3	15.7	3.06
September	12.8	25.5	81	86	5.6	18.0	3.46
October	12.8	27.3	71	95	7.2	19.8	3.94
November	13.0	29.2	70	78	8.9	21.2	4.13
December	12.9	29.0	58	69	8.3	19.8	3.88

7.2 Appendix II. Figure 1

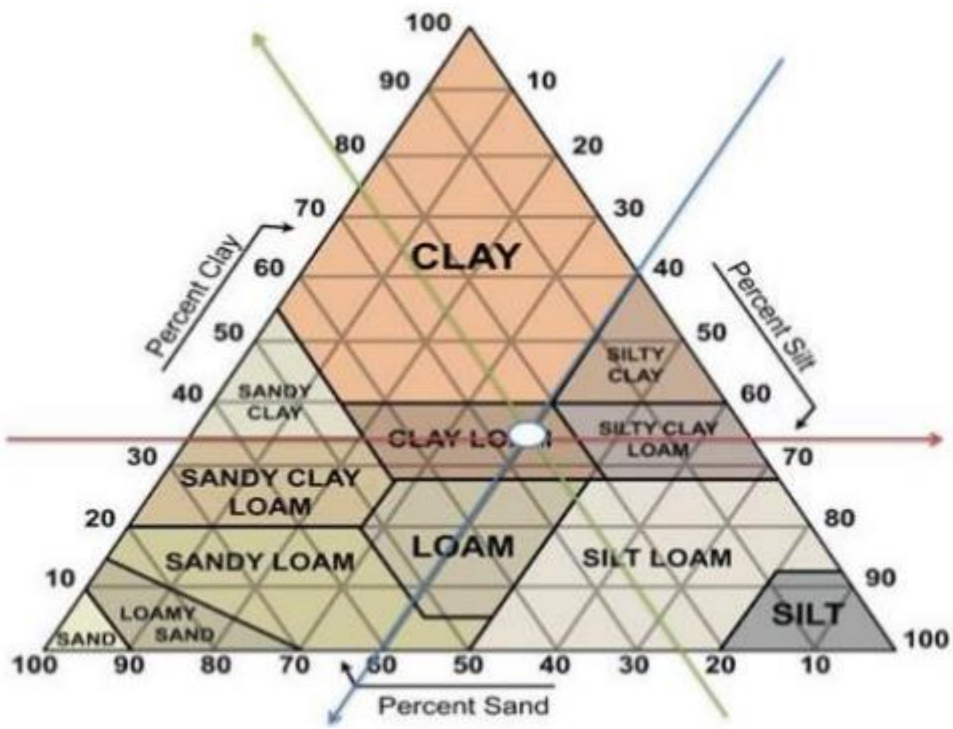

Figure4.Determination of soil textural class on textural triangle

Figure5 Par shall flume