

Research Article

# Performance Evaluation of Small Scale Irrigation Scheme and Its Contribution to Household's Food Security: A Case Study of Fitte, Wayu Tuka Woreda, East Wallaga Zone, Oromia, Ethiopia

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## Abstract

Performance evaluation is an important aspect of assessing the success of irrigation management. The Fitte Small-Scale irrigation was used as a case study in this research to evaluate the performance of the small-scale irrigation scheme and its contribution to household food security. The study used a variety of irrigation performance indicators, such as physical, major output, and water consumption (input-related) indicators, to evaluate the schemes performance and develop a feasible water distribution system to satisfy the populations growing food needs. The study was initiated at the beginning of the irrigation season in January 2022. To achieve its objectives, the study utilized primary and secondary data that were collected and analysed. It was reported that CROPWAT 8.0, GIS, Climwat2 software, and statistical tools were utilized to carry out data analysis and manipulation tasks. A variety of performance indicator categories, such as water use, physical outputs, and agricultural outputs, were then used to assess the plan. The findings showed that the Fitte system had an irrigation supply value of 3.9 and a relative water supply value of 3.2. This demonstrates that the irrigation area may be increased by making better use of water because it shows that more water was supplied than was required. In terms of physical indicators, the irrigation ratio was 0.58, and the sustainability of the irrigated area was 0.7. The Fitte scheme's output per unit of water provided, output per unit of irrigation diverted water, output per unit of cropped area, and output per command area were 110,610.7 birr/ha, 129,045.8 birr/ha, 6.8 birr/ha, and 7.8 birr/ha, respectively, according to the analysis. The results show that the Fitte system did not perform well. It is important to remember that the area under irrigation was smaller than the planned command area. The study's findings demonstrate that irrigation improves agriculture by increasing output and productivity, which in turn enhances asset development and food security.

## Keywords

SSI Scheme, Performance, Efficiency, Water, Land, Output, Irrigation, Indicator, Food Security

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## 1. Introduction

Life requires water, which is a component that is vital to life. Every living thing desires it for different reasons and on different scales. Water is essential to human home, agricultural and industrial needs [1]. Water is an important asset for rural development both shortage and mismanagement of water pose a serious and developing threat to life and practical advancement. As water is a constraining figure in most of the world, expanding yield and maintaining food production depends basically on irrigation [2]. One of the crucial factors that significantly contribute to the economic development of many nations is irrigation practice [3]. The majority of Ethiopians rely on rain-fed agricultural production as their primary source of income, much like people in other parts of the world [4]. Extending the new irrigation development is one of the best ways to think about dependable and Sustainable food-security. Water resources are under pressure due to population growth, increased agricultural intensity, increased sectorial calculations for water allocation, and environmental concerns [5]. Expanding irrigation is seen as a key component of food safety and poverty reduction in Ethiopia, and it is a vital tool for promoting economic growth and rural development. One way to increase agricultural productivity and meet the nation's growing food needs is through irrigation [6]. One of the small African nations with an abundance of water resources is Ethiopia. The twelve river basins in our nation have an estimated ground water potential of 2.6 to 30 billion cubic meters and an annual runoff volume of 124 billion cubic meters [7]. The science of artificially applying water to the land in accordance with plant requirements during the growing season to guarantee complete plant nutrition is known as irrigation [8]. The nation has 640,000 acres of irrigated land. Of these 120,000ha are irrigated using rain water collection, 129,000ha are irrigated using medium and large scale systems, and 383,000 ha are irrigated using small-scale irrigation [9]. Ethiopia has not been successful in significantly improving the lives of rural communities or making a notable impact on food security. It's interesting to note that despite this, the World Bank, several development agencies, and various countries have invested in large irrigation projects. However, there seems to be some disagreement on whether it's appropriate to invest in new irrigation projects given the unsatisfactory performance of existing ones [10]. Furthermore, according to [11], over 100 million or 85% of the global population live in rural areas and depend on agriculture as their primary source of income. 4,256,457 of Ethiopia's 5,536,457 hectares of arable land have already been irrigated [12]. The Oromia region has abundant water resources and irrigable land. The region has an irrigation potential of 1.7 million hectares of irrigable land, of which 1,350,000 ha are irrigated in different irrigation systems [13]. Numerous researchers who have examined the issues with the implementation of water system

practices in Ethiopia have concluded that most small scale water system plans have low productive capacity [14]. Process indicators are used to track irrigations actual performance in relation to particular management objectives and systems operational goals [15]. Evaluating and improving the effectiveness of current systems is a desirable way to promote sustainable development and can be used as a starting point or benchmark for future irrigation advancements. Performance evaluation is seen as the informational foundation that drives the successful and effective implementation of management [16]. Performance evaluation can prove to be an effective tool in scrutinizing the attainment of irrigation management within a scheme, thereby satisfying the escalating demands for food among the populace and facilitating the sustainable allocation of water resources for schemes [17]. The purpose of this study was to examine the small scale irrigations scheme's performance evaluation and its impact on the food security of rural households in wayu tuka Woreda, oromia regional state. Fitte small-scale irrigation was used as a case study in order to survey the implementation of small-scale irrigation schemes using physical, main output & water use or input-related irrigation performance indicators from the extensive list of irrigation execution indicators.

## 2. Materials and Methods

### 2.1. Location and Description of Study Area

The Fitte irrigation scheme is found in Western Oromia Regional state under the East Wallaga zone Wayu Tuka Woreda Minya Kura Keble. Wayu tuka Woreda is located 324 km of Finfine at maximum and minimum altitudes of 2200m and 1700m am.s.l. respectively. The geographical location of the study area is sited at latitude 8°57'30"N to 9°0'0"N and longitude of 36°35'30" E to 36°39' 0" E.2.1.

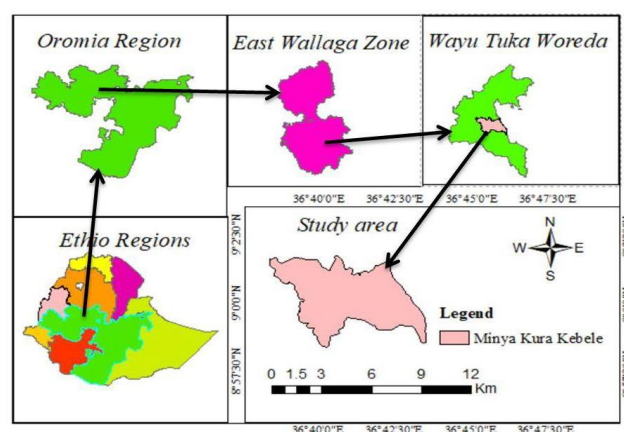


Figure 1. Location map of study.

## 2.2. Data Collection & Analysis

For implementing this research, several data were collected using primary or secondary data depending on the assessment of efficiency and productivity of the area. This data were collected by using different techniques, basically literature surveys, field surveys, formal group discussions, informal group discussions, and through questionnaire surveys to get available real-time data to cover the study period.

## 2.3. Data Collection Method

Primary and secondary sources are the two sources from which the data were gathered. The main sources of data were field observation of the irrigation plan, direct measurements of discharge delivery through the canal and water surface elevation at head, middle, and tail reach of MC and SC. This study was carried out starting in January 2022, during the irrigation season. This investigation has made use of both primary and secondary data.

## 2.4. Primary Data Collection

In order to determine the soil textural classes, soil moisture content and specific gravity, field data was gathered by measuring the canal inflow & taking soil samples from various locations on the farm. As part of the primary data collection process, stakeholders' water management practices and water application methods were observed and examined. It was also noted how the canal's physical features were laid out and shaped. The canal operator, irrigation engineer, and other irrigation project stakeholders were consulted during the data collection process.

### 2.4.1. Soil Sampling

The collection of soil samples is taken from various locations on the farm, depending on the root zone depth of the crop at the upper, middle, and lower areas of the farmland. To ascertain the physical characteristics of the soil, including its texture, field capacity, total moisture content, and permanent wilting point, these samples are collected both before and after irrigation. Composite soil samples are collected from the head, middle, and tail strata at the designated depth in order to identify the textural class of the soil. Composite soil samples were taken from each stratum in order to determine the soil's field capacity and permanent wilting point and, consequently, the amount of TAW present. A pressure plate device was used in the lab to conduct the investigation. Between FC and PWP is the total amount of soil moisture that the plant can access. The amount of TAW moisture is determined by the surface and structure of the soil and indicates the soil's ability to hold water that the plant can absorb. The total amount of water that a crop can draw from its root zone is known as total amount of water. Before a wilting point is reached, a plant is already suffering from water stress. RAW uses the fraction of the total

saturation that can be safely removed before stress occurs. Depend on soil parameters of textural class, FC; PWP could specify the value of depletion fraction from FAO recommendations.

### 2.4.2. Soil Infiltration Rate

The soil infiltration rates of the Fitte scheme are characterized by utilizing a double ring infiltrometer device. Infiltration is the process of sectioning water downwards from the air medium to soil or from the soil surface into the soil medium. This phenomenon has a greater practical importance in irrigation and rain-fed farming systems. Infiltration characteristics of the soil are one of the dominant variables influencing irrigation application. When adequate water is connected and maintained at atmospheric pressure, the flux (i.e., the volume of water passing through a unit cross-sectional zone per unit time) flowing into the soil profile is termed as the infiltration rate. Infiltration rate is very fast at the beginning of water application, but it decreases quickly with the progress of time and eventually approaches a steady value. The consistent infiltration rate that is reached after a few passed times from the beginning of irrigation is named the essential infiltration rate. This value, basic infiltration rate, was used as input data for the CROPWAT 8.0 model for the computation of crop water and irrigation requirements.

### 2.4.3. Water Flow Rate Measurement

Water flow rate estimation could be important information for irrigation scheme performance assessment activities and computation of conveyance efficiency and losses [18]. There are various methods to measure the flow of water within the rivers/canals. For this study, the floating area velocity method is used [1, 19, 20]. For a floating method to determine the canal flow, equipment such as a floating ball, tape meter, and stopwatch is used [21]. For the fitted SSI scheme, the main canal does not have much length since it's divided into two secondary canals at a short (120 m) distance from the diversion head. So the measurement is taken from the immediate iteration of the inlet canal and from a distance of 100 m, i.e., at the place it's divided into two secondary canals, and for the secondary canal, the measurement is taken at the inlet and at the place where it reaches the command area. Measurements are made at the canal's inlet and outlet to determine the actual discharge for a fitted small-scale irrigation scheme. At least three trials are conducted in order to measure the canal discharge for the fitted scheme. For example, T1, T2, and T3.

$$Q = AV \quad (1)$$

Where:  $V = L/T$

L is a Floating length

T is Time to travel a given length

A is cross-sectional Area

#### 2.4.4. Household Survey & Key Informant Interviews

Issues related to production frameworks, organizations, and community-level issues and experiences can be collected through questionnaires, key informant interviews, and focus group discussions.

### 2.5. Sampling Techniques

To determine the sample size, a total of 120 HHs beneficiaries were used as the sample frame or population [15]. Found a streamlined method for determining sample sizes.

$$n = \frac{N}{1+N(e)^2} \quad (2)$$

Where:

n- Is the sample size

N = is the population size/sample frame,

E = is the level of precision

For this study, the calculation has been carried out using a 95% confidence interval ( $\alpha=5\%$ ), a 10% precision level, and a 50% degree of variability (P).

$$n = \frac{120}{1+120(0.1)^2} = 55$$

### 2.6. Secondary Data Collection

The Nekemte meteorological station provided the long-term average climatic data for the Fitte SSI scheme, including mean monthly minimum and maximum temperature and rainfall. The CLIMWAT2 software provided the remaining data, which included relative humidity, wind speed, and sunshine hours. Additional secondary data of total command area, irrigable area, irrigated area, crop yield, and price were collected from Woreda and Zonal agricultural experts, design documents, and from respective stakeholders.

### 2.7. Data Analysis Techniques

For data analysis and manipulation activities, CROPWAT 8.0, GIS, SPSS, Climwat2 software, and statistical tools were employed. Finally, the selected performance indicators were calculated.

### 2.8. Determination of Crop Water and Irrigation Water Requirement

The irrigation scheme's primary crops' total water requirements were estimated using the computer program CROPWAT 8.0. The reference crop evaporation (ETO) was calculated using the Penman-Montieth strategy, as recommended by the FAO (1992). The following equation is used by the program to gauge (ETc):

$$ETc = ETc \cdot Kc \quad (3)$$

Crop coefficients, changes with a crop developing stage. The Kc value of each main crop was taken from FAO publications I & D 24 (1992) and 56 (1998). The determination of irrigation necessity was made after the estimation of effective rainfall by the USDA Soil Preservation Service Strategy. By calculating the soil water balance/budget of the root zone on a daily basis, the timing and the depth of future irrigations can be planned. In order to compute the irrigation water requirement, CROPWAT 8.0 computes a daily water balance of the root zone. Computed as

$$IWR = ETc - R_{eff} \quad (4)$$

Input data of actual irrigated area by crop type was included in order to estimate the total crop water requirement at the scheme level. The farmers' irrigation methods, including application depth, frequency, and duration, were also identified. Water flows and times for individual crop waterways were recorded along with estimates of irrigated area when determining the total water associated with the field. The total amount of water supplied to the rice field was obtained by multiplying the discharge rate by the discharge time. The water depth associated with the field was obtained by separating the total water associated with the irrigated area. Additionally, CROPWAT 8.0 was utilized to ascertain the required irrigation depth at every stage of development in accordance with the established irrigation intervals.

### 2.9. Performance Indicators

Performance indicators can be broadly divided into three categories: physical performance indicators, agricultural performance indicators, and water use performance indicators. The performance of small-scale irrigation projects was assessed and compared at the system level using this study. During the assessment, a number of minor performance metrics were applied to each group.

#### 2.9.1. Water Use Performance Indicators

The water existing for irrigation systems at the head, main canals, secondary canals, and farm gates was calculated from the data measured at the selected locations. Proper water distributions of the diverted amount of water at the head to the whole irrigation system can be measured by the water delivery performances of the existing irrigation infrastructures. The conveyance efficiencies of the main canals and secondary canals and the amount of losses per canal length at the specified locations were computed for each scheme.

##### A. Relative water supply

It was developed by Levine (1982) as an indicator of water supply. RWS shows the adequacy of water connected to the amount of water requested by the crop. It is the ratio of total water provided by irrigation (I) and rainfall (P) to total water



requested by crop (i.e., real crop Evapo-transpiration (ETC)).

$$RWS = \frac{\text{total water supply}}{\text{total crop water demand}} \quad (5)$$

Where:

Total water supply = Surface diversion adding effective rainfall (M<sup>3</sup>),

Crop water demand = Potential Evapo-transpiration (ET), or the ET under well-water conditions for each crop (M<sup>3</sup>).

#### B. Relative irrigation supply (RIS)

This can be the second water supply indicator and portrayed as the ratio of irrigation supply to irrigation requirement. Irrigation water could be a scarce resource in numerous irrigation schemes, and it may be a major constraint for production. This indicator is valuable to survey the degree of irrigation water stress in relation to irrigation demand [1].

$$RIS = \frac{\text{Irrigation water supply}}{\text{Irrigation water demand}} \quad (6)$$

Where:

Irrigation supply = only the surface diversion for irrigation (M<sup>3</sup>),

Irrigation demand = the crop Evapo-transpiration less effective rainfall (M<sup>3</sup>).

### 2.9.2. Agricultural Performance Indicators

#### A. Output per cropped area (birr/ha)

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

$$\text{Output per cropped area (birr/ha)} = \frac{\text{Iproduction}}{\text{Irrigated crop area}} \quad (7)$$

#### B. Output per unit command (birr/ha)

It is computed as the total value of production per command area in the irrigation seasons.

$$\text{OPUCA (birr/ha)} = \frac{\text{Iproduction}}{\text{Command area}} \quad (8)$$

#### C. Output per unit of irrigation diverted water (birr/m<sup>3</sup>)

Usually, one of the indicators of water yield, it is defined as the total value of production per unit of water transferred from the headwaters to the command area during irrigation.

$$\text{OPUIDW (birr/ha)} = \frac{\text{production}}{\text{divertedirrigationsupply}} \quad (9)$$

#### D. Output per unit of water delivered (birr/m<sup>3</sup>)

During the irrigation seasons, it quantifies the value of production per unit of irrigation water delivered to the head of farm inlets.

$$\text{OPUDW (birr/ha)} = \frac{\text{production}}{\text{Volume of water dilevered}} \quad (10)$$

### 2.9.3. Physical Performance Indicators

Under this study, two significant physical performance indicators were chosen to measure the sustainability and irrigation intensities of the systems.

#### A. Rate of Irrigation

The Agriculture and Rural Development Offices collected the indicator information for irrigated areas during the irrigation season and planned irrigation areas.

$$\text{Rate of Irrigation (RI)} = \frac{\text{Actual irrigated area}}{\text{Design of command area}} \quad (11)$$

#### B. sustainability of irrigated area (SIA)

$$\text{SIA} = \frac{\text{Currently irrigable area}}{\text{Initially irrigated area}} \quad (12)$$

## 3. Results and Discussion

### 3.1. Soil Textural Class Identification

Using the USDA SCS Soil Textural Triangle method, the soil textural class of the Fitte irrigation system was identified based on the particle size distribution.

According to Table 1 in the head, middle, and tail of the Fitte irrigation scheme, sand clay loam soil type has been discovered.

**Table 1.** Soil textural class of Fitte small-scale irrigation.

Irrigation scheme	Canal reaches	Soil depth (cm)	Clay%	Sand%	Silt%	Textural classes
Fitte SSI	Head	0-30	28.5	13.3	64.3	sand clay loam
		30-60	32.7	14.3	68.1	sand clay loam
		0-30	27.5	14.7	63.3	sand clay loam
Fitte SSI	Middle	30-60	26.7	15	65.2	
Fitte SSI	Tail	0-30	22	15	62.5	sand clay loam

Irrigation scheme	Canal reaches	Soil depth (cm)	Clay%	Sand%	Silt%	Textural classes
		30-60	23.5	17.1	64.35	sand clay loam

### 3.2. Field Capacity and Permanent Wilting Point

The parameters, such as the field capacity, permanent wilting point, and total available water content of the study area soil, are presented in Table 2 and there is no variation in soil depth in the root zone.

Table 2. Soils FC, PWP and TAM.

Irrigation scheme	Canal reaches	Soil depth (cm)	FC (%)	PWP (%)	TAM (%)	TAM Mm/m
Fitte SSI	Head	0-30	23.5	17.5	6.0	60
		30-60	24.5	18.0	6.5	65
	Middle	0-30	23.3	16.2	7.1	71
		30-60	24.0	17.1	6.9	6.9
	Tail	0-30	23.0	16.2	6.8	6.8
		30-60	24.5	16.0	8.5	8.5

### 3.3. Determine of Soil Infiltration Rate

The soil infiltration rates of this scheme were determined by using double ring infiltrometer. A double-ring infiltrometer of 30 cm diameter and 60 cm diameter was installed by hammering both rings into the root zone.

At the head, middle, and tail ends of the test plot, the Fitte SSI Scheme's basic infiltration rate was 0.22 mm/hr, 0.24 mm/hr, and 0.25 mm/hr, respectively.

### 3.4. Fitte Small-Scale Irrigation Scheme Flow Measurement

This was carried out to ascertain the overall volume of water supplied and to evaluate the canals' efficiency in moving the water. Using a tape measure, the canal's cross-sectional dimension was determined.

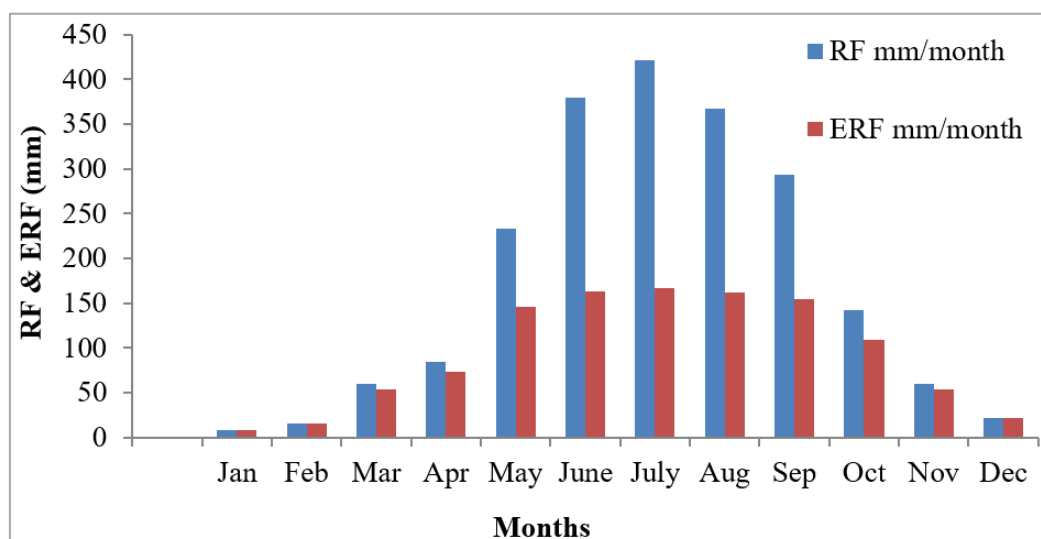
Table 3. Flow measurement of Fitte.

Canal	Area of MC m <sup>2</sup>		Velocity MC m/s		Discharge of MC (m <sup>3</sup> /s)		Discharge of MC (l/s)	
	inlet	outlet	inlet	outlet	inlet	outlet	inlet	outlet
MC	0.275	0.272	0.57	0.56	0.1524	0.01204	151.24	148.04
SC1	0.18	0.155	0.55	0.53	0.07562	0.06372	75.6	63.72
SC222	0.179	0.177	0.54	0.51	0.07562	0.06372	75.62	63.72

### 3.5. Rainfall Data Analysis

In the schemes under the study, the minimum and maximum rainfalls occur in the months of January (8 mm) and July

(422 mm), respectively. While the average total annual rainfall of the study area is 2089 mm, on the other hand, the average total annual effective rainfall amount of the study areas is 1128.6 mm.



*Figure 2. Rain fall and Eff. Rain fall Diagram.*

### 3.6. Determination of Reference Evapotranspiration

*Table 4. Metrological data and reference evapotranspiration.*

Month	Min Temp C°	Max Tem C°	Humidi- ty %	Wind speed km/day	Sunshine Hours	Rad MJ/m2/day	ETo mm/day	ETo mm/month
January	11.7	25.8	46	95	7.9	19.2	3.82	118.42
February	12.3	26.7	43	112	7.7	20.2	4.31	120.68
March	13	27	52	121	7.4	20.7	4.48	138.88
April	13.4	26.7	46	112	7.2	20.5	4.55	136.5
May	12.8	24.4	58	78	5.6	17.7	3.7	114.7
June	11.5	21.7	75	69	4.3	15.4	2.99	89.7
July	11.2	20.7	81	104	3.3	14.1	2.73	84.63
August	11	20.7	81	78	3.4	14.4	2.73	84.63
September	10.6	21.9	71	78	4.2	15.8	3.04	91.2
October	11.4	23.2	62	104	6.7	18.7	3.61	111.91
November	12	24.2	56	104	7.3	18.5	3.64	109.2
December	11.7	24.8	50	104	7.3	17.9	3.6	111.6
Average	11.9	24	60	96	6	17.8	3.6	109.3

### 3.7. Determination of Crop Water and Irrigation Requirement

CROPWAT 8.0 software calculated crop water requirements using information on crop characteristics, soil description, and climate.

**Table 5.** Crop water requirement & irrigation requirement of Fitte SSI scheme.

Crop type	Season I				Season II			
	Area in (ha)	ETc in mm/season	Eff.RF mm/season	IWR mm/seas	Area in (ha)	ETc in Mm/season	Eff.RF mm/seas	IWR mm/seas
Potato	13.2	450.5	121.8	338.6	11.0	558.9	149	417.1
Tomato	6.5	448.7	124.5	340.3	5.5	559.6	150.7	417.8
Maize	3.75	418.4	103.1	317	4.5	388.9	118.4	300.6
Wheat	5	378.1	119.1	292.2	5.75	406.0	115.0	294.3
Beans	3.5	290	46.8	246.7	4.25	289.2	47.1	245.9
Cabbage	3	582	206.2	388.3	4	614.4	224.3	403.3

For the Fitte SSI scheme's 2023–2024 irrigation season, the total crop water demand was calculated as follows:

Crop water requirement:  $\text{Potato} \times (\text{Area Potato} / \text{total Area}) + \text{CWR Tomato} \times (\text{Area Tomato} / \text{total Area}) + \text{CWR Maize} \times (\text{Area Maize} / \text{total Area}) + \text{CWR Wheat} \times (\text{Area Wheat} / \text{Area total}) + \text{CWR Beans} \times (\text{Area Beans} / \text{Area total})$ . The result is 431.55 mm/season for the first cropping season of the scheme.

In order to convert the depth of water demand to the volume of CWR, you need to multiply it by the total irrigated area. This will result in a value of 151,042.5 m<sup>3</sup> per season. Additionally, 169,970.5 m<sup>3</sup> of water were needed per season, and the CWR depth for the scheme's second cropping season is 485.63 mm. As stated below, the same methodology used to determine the total CWR was also used to determine the scheme is total irrigation requirement:

$\text{IWR Potato} \times (\text{Area Potato} / \text{total Area}) + \text{IWR Tomato} \times (\text{Area Tomato} / \text{total Area}) + \text{IWR Wheat} \times (\text{Area Wheat} / \text{Area total}) + \text{IWR Beans} \times (\text{Area Beans} / \text{total Area})$  and the result is 343.97 mm/season, i.e., 120389.5 m<sup>3</sup>/season for the first season, and also, 359.7 mm/season of depth, i.e., 125895 m<sup>3</sup>/season volume of irrigation was required for the second cropping season. It was expected that irrigation infrastructures would supply 495486.72 m<sup>3</sup>/season of water supply at the farm level in order to meet the scheme's irrigation requirements. Therefore, it is sufficient for the actual irrigated area. Also, it's required to calculate the total designed command area to determine the overall irrigation requirement of the scheme. This is calculated as follows:

$\text{IWR of all crops (potatoes, tomatoes, maize, wheat, and beans)} \times \text{total command area}$ , and the result is 1,558,080 m<sup>3</sup>/season.

**Table 6.** The summary of the overall volume of CWR and IWR of the scheme.

Scheme name		Cropped Area (ha)	CWR M <sup>3</sup> /Season	IWR M <sup>3</sup> /Season
Fitte SSI	Season I	35	151042.5	120389.5
	Season II	35	169970.5	125895

### 3.8. Water Use Performance Indicator

The water delivery systems play a crucial role in transporting the diverted water from source to the required area, which is usually the cropped area. To evaluate & analyse the performance of irrigation projects, various parameters such as conveyance efficiency, RWS, and RIS are used. In addition to identifying the spatial variation of the indicators within and between schemes, these indicators aid in characterizing the performance of irrigation projects.

#### 3.8.1. Conveyance Efficiency and Water Conveyance Loss

It was discovered that the total conveyance efficiency of the main canals and secondary canal values at reach two, which show how much water is lost through the canals from the Fitte SSI scheme's source, was 91.55% per 100 meters. In the Fitte SSI scheme, the conveyance efficiency of the secondary canal was 84.3% and 79.6% for SC1 and SC2, respectively. The secondary canal of the fitte SSI scheme is divided into SC1 and SC2. Since it's a two-sided irrigation canal, the conveyance efficiency of SC1 is better than SC2, because SC2 has poor management, problems with the bed slope, etc., so it has poor conveyance efficiency.

#### 3.8.2. Relative Water Supply (RWS)

The Relative Water Supply (RWS) indicates the accessibility of water in relation to crop water requirements. It's important to note that if the figure surpasses one, it means that the entire water applied fulfilled the crop's needs. On the other hand, an RWS value below one might not necessarily indicate an issue. Instead, it could suggest that farmers are imple-



menting deficit irrigation with limited water supply to optimize water yields. The relative water supply value for the Fitte SSI scheme was 3.2, meaning that there was neither a surplus nor a deficit and that the water supplied was adequate to meet crop water demand.

### 3.8.3. Relative Irrigation Supply

It can be inferred from the Fitte small-scale irrigation scheme's relative irrigation values that the scheme head provided enough irrigation supply to meet the scheme's needs. An increase in irrigation area could result from efficient water use, as indicated by the value of 3.9, which shows that there was an excess of water supplied compared to demand. An extra 35 hectares could be irrigated under the Fitte scheme with the current water supply, accounting for 50% water loss.

## 3.9. Agricultural Output Indicators

The farming season's worth of agricultural outputs was computed, and the information needed included crop kinds, the area covered by each crop, average yield and price per crop. The soil and crop management practices, the use of suitable agricultural technology, and the infrastructure for irrigation water delivery all affect each crop's output yield value [22].

### 3.9.1. Output per Cropped Area (birr/Cropped Area)

Output per cropped area was computed using Equation: 7 existing in the Table 7 the results of this indicator 110,610.7birr/cropped area.

**Table 7.** Agricultural Output Indicator of Fitte Scheme.

Scheme name		
Indicator	Fitte	Unit
Output per cropped area	110,610.7	Birr
Output per command area	129045.8	"
Output per unit of irrigation diverted water	6.8	"
Output per unit of water delivered	7.8	"

### 3.9.2. Output Per Unit of Irrigation Diverted Water (birr/m<sup>3</sup>)

The results of this indicator were 6.8 birr/m<sup>3</sup>. This is because there is an excess supply of irrigation water at the head of the Fitte SSI scheme, resulting in a lower OPUIDW. However, the Fitte small-scale irrigation scheme has a medium output/unit irrigation water supply, indicating to some extent good water delivery.

### 3.9.3. Output Per Command Area (birr/ha)

This indicator assesses the productivity of the scheme from its command area rather from the currently irrigated area. It was calculated using by equation 8. The output/unit of command area of Fitte SSI is 129045.8 Birr/ha.

### 3.9.4. Output Per Unit of Water Delivered (birr/ha)

The results of this indicator were 7.8 birr/m<sup>3</sup> of Fitte Small-scale scheme. The result stated that the output per unit of water delivered was also more productive. This higher value of output/unit of water delivered of Fitte small-scale irrigation Scheme suggests; it has good water deliverance.

## 3.10. Physical Indicators

The values of physical indicators for Fitte scheme are shown in the Table 8.

**Table 8.** Data of Command area and value of physical indicator of the scheme.

Parameter	Fitte SSI
Currently irrigated area (ha)	35
Annual irrigated area (ha)	70
Designed command area (ha)	60
Initially cultivated area (ha)	50
Cropping intensity (%)	78
Irrigation ratio (%)	0.58
Sustainability of irrigated land (%)	0.7

### 3.10.1. Household Food Consumption Score

The purpose of this study was to measure the variety and frequency of different foods consumed over a seven-day recall period by gathering data on food consumption from 120 families. The results of a sample of households' food security status using the food consumption score for irrigation-using households are shown below. According to the results obtained by applying the food consumption score cut-off, it was found that 79.2% or 95 respondents of irrigation users had satisfactory food consumption. On the other hand, 15% or 18 respondents of irrigation users had medium consumption, while 5.8% or 7 respondents of the irrigation households had insufficient food consumption score.

**Table 9.** Food consumption score.

Food consumption score	Frequency	Percent
Adequate food consumption (35>)	98	81.7

Food consumption score	Frequency	Percent
Border food consumption (21.5-35)	16	13.3
Poor food consumption ( $\leq 21.5$ )	6	5

### 3.10.2. Household Dietary Diversity

The results of survey in Table 8 show that more than half (79.2%) of irrigation user households had consumed high dietary diversity of greater or equal to 6 food groups. Similarly, 15% irrigation users, had medium dietary diversity of 4-5 food groups. It's found that only 5.8% of irrigation users had consumed low dietary diversity of less than 3 food groups as.

**Table 10.** Household Dietary Diversity.

Food group	Frequency	Percent
High (6>food groups)	95	79.2
Medium (4-5food groups)	18	15
Low (3<food groups)	7	5.8
Total	120	100

### 3.10.3. Food Security Status of Sampled Household

The findings showed that farmers could make a respectable living by producing high-value crops including potatoes, tomatoes, wheat, and beans, which made a major contribution to family crop income. This revealed that irrigated farming has paramount contribution to household crop income in the study area. Besides, irrigated farming has positive contribution to household food security through its contribution in production of subsistent crops and building the capacity of farmers to purchase food crops.

### 3.10.4. Food Availability

The use of irrigation has enabled farmers to increase their production of food. As a result, there is now a greater physical presence of food in the area, with some farmlands producing two to three times as much as before. As observed and surveyed, beneficiaries of the Small Scale Irrigation scheme in the study area could diversify their food sources by planting crops such as potatoes, tomatoes, and others, in addition to producing cereals.

### 3.10.5. Possible Remedial Measures

Upon reviewing the findings and conducting field observations, I suggest the following enhancement strategies to improve the efficiency of the system developed in this study:

1. Setting schedule for the operational and maintenance of the canals

It appears that the current irrigation scheme is not meeting its full potential due to maintenance issues with the canals. The irrigated area is currently below the intended size, and the results have been disappointing. The irrigation scheme faces two primary issues - lack of proper structure and poor canal quality. As a result, water beneficiaries are not receiving water in a timely manner.

2. Instruction/training/ on the Efficiency of Irrigation Water Use

Farmers' negative perception of deficit irrigation, coupled with insufficient training on efficient water usage, has primarily led to the reduction of the command area. Moreover, farmers tend to think that applying more water than necessary at their farms boosts productivity. As a result, many farmers expressed their dissatisfaction with the volume of water they were receiving at the farm gates.

3. Creating fee Collection Strategies for Maintenance Work

The Fitte scheme relied solely on the government for maintenance work, as there were no fee collection strategies in place. However, if water users were charged a fee, they could take care of simple maintenance tasks like preventing seepage, making the scheme self-sufficient.

4. Bylaws

Having clear internal bylaws with specific rules and regulations is essential to ensuring the Small Scale Irrigation system is managed effectively and sustainably. These should be Prepared and endorsed by users to guarantee that the interests of all irrigation are safeguarded. So the implementation gaps, it would be nice if there were written and defined by-laws in Fitte water users association.

## 4. Conclusion and Recommendations

### 4.1. Conclusion

The Study has been carried out by illustrating the schemes by transect walk, fieldwork for flow measurements, infiltration rate experiments and soil sample collection, household survey, and discussion. Then, the evaluation of the performance was based on four groups of IWMI Comparative indicators such as water use physical and agricultural output indicators. The results of water use indicators such as relative water supply and irrigation supply showed that there was excess supplied water relative to the demand. The major agricultural output performance indicators used in this study are output per cropped area, output per unit of command area, output per unit of irrigation diverted water, and output per unit of water delivered. The results of agricultural output performance indicators showed all output indicators. Furthermore, according to the physical performance indicators, the Fitte small-scale irrigation scheme's irrigation ratio is low, indicating that a particular irrigable area was not fully utilized during the production season.

## 4.2. Recommendations

Based on the findings of this research study, the following recommendations are provided to improve the performance evaluation of SSI and its contribution to the HH Food Security fitte scheme.

Water delivery efficiencies of the scheme are very low. In the future, if all the canals are made in line and the cleaning of the canals from time to time, the seepage could be reduced.

To enhance the Fitte Small Scale Irrigation system's production value, it's essential to introduce high-value crops, intensify agriculture, boost land and water productivity, and increase irrigation intensity.

In addition, this strategy requires an appropriate cropping pattern with market connectivity.

To optimize the use of the limited water resources at the Fitte irrigation system, it is important to distribute water in accordance with the planned and predicted planting patterns, as well as the irrigation schedule. Doing so will help ensure the most effectual use of the water resources.

Using formal payment collation mechanisms and issuing lawful receipts is crucial to ensure transparency and accountability in maintenance works. It also helps to encourage farmers to actively participate in such work, as they can have a clear understanding of the process and the funds involved. Ultimately, this can lead to a more efficient and effective system for everyone involved.

It is essential to ensure a fair price and timely reach for farming inputs to support farmers. Despite the government's efforts, some farmers still find it challenging to afford these inputs. I believe that the government, cooperative organizations, and private companies must work together to ensure a consistent and affordable supply of these inputs in adequate quantities and on time.

## Abbreviations

CRW	Crop Water Requirement
Eff	Effective Rain Fall
ETC	Crop Evapo-transpiration
FAO	Food And Agriculture Organization
FC	Field Capacity
GIS	Geographical Information System
HHs	Households
IWR	Irrigation Water Requirement
Kc	Cropcoefficients
MC	Main Canal
OPCA	Output per Cropped Area
OPPUWD	Output per Unit of Water Development
OPUCA	Output per Unit Command Area
OPUIDW	Output per Unit of Irrigation Diverted Water
PWP	Permanent Welting Point
RAW	Readily Available Water
RF	Rain Fall
RIS	Relative Irrigation Supply

RWS	Relative Water Supply
SC1	Secondary Canal One
SC2	Secondary Canal Two
SIA	Sustainability of Irrigated Area
SSI	Small-Scale Irrigation
TAW	Total Amount of Water

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## Data Availability Statement

All information provided to this publication is presented in the full document.

## Conflicts of Interest

The authors declare no conflicts of interest.

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