JOWRM

Journal of Water Resources Management

Journal homepage: https://journal.water.gov.my

e-ISSN: 2811-3578

Contribution of Small-Scale Irrigation Practices on Rural Household Income in Gulomekada Woreda

Brhane Gebremedhin[1], Alem-meta Assefa[2], Mare Addis[3]*

[1]Zalambessa Secondary High School, Tigray

[2]Department of Geography and Environmental Studies, Wollo University, Dessie P.O. Box 1145, Ethiopia

[3]Department of Geography and Environmental Studies, Wollo University, Dessie P.O. Box 1145, Ethiopia

*Correspondence

Email: [3]mare.addis@eiabc.edu.et

Received 12 December 2024;
Accepted 23 June 2025;
Available online 28 June 2025

Abstract: The irrigation sector in Ethiopia is expanding rapidly, yet it contributes less to the national economy compared to rain-fed agriculture and livestock due to various challenges. The Ethiopian government is focusing on enhancing agricultural productivity through small-scale irrigation schemes, which significantly impact food production and household food security. This paper examines the effects of small-scale irrigation on household income in the Gulomekeda Woreda of Eastern Tigray Zone, utilizing both purposive and random sampling methods with a sample size of 130 households. The study analyzes social, economic, technological, and environmental factors influencing irrigation practices and household income. Data were collected through focus group discussions, key informant interviews, and questionnaires, with SPSS software used for analysis.

The findings indicate that small-scale irrigation greatly enhances household income and food security, with irrigation users reporting higher incomes than non-users. Factors such as farming type, modern input usage, and market distance significantly influence participation in irrigation. Additionally, land size, livestock, non-farm income, and various support mechanisms positively affect involvement in small-scale irrigation. However, challenges such as water shortages, lack of oxen, inadequate administration, and crop failures hinder the effectiveness of these schemes. The study suggests that low irrigation performance is tied to poor project design and insufficient community involvement. Overall, the research concludes that small-scale irrigation plays a crucial role in boosting farmers' household incomes.

Keywords: Small Scale Irrigation, Household Income, Gulomekada Woreda, Ethiopia

1. Introduction

Ethiopia, one of the world's poorest countries, has about 29.2% of its population living below the poverty line [1]. Most Ethiopians rely on unpredictable rain-fed agriculture, which contributes over 40% to the national income, primarily from smallholder farmers [2]. Expanding irrigation could significantly enhance agricultural development and food security [3].

Globally, irrigated land has grown from 50 million hectares in 1900 to 267 million today, with developing countries holding 75% of it [4]. Currently, only 6% of Africa's agricultural land is irrigated. Irrigation plays a crucial role in agricultural productivity, household income growth, and poverty reduction. To meet food demands by 2020, irrigated food production must rise from 35% in 1995 to 45% [5]. According to a 1997 United Nations report, irrigated agriculture contributed nearly 40% of global food production from just 17% of cultivated land. This aligns with the FAO's projection that, to meet food demands by 2020, the share of irrigated food production would need to rise from 35% in 1995 to 45% by 2020. This highlights future global concernsover access to irrigation water, especially in arid regions. African irrigation agriculture plays a less significant role compared to other regions, with irrigated land below the world average. This underutilization is linked to poor poverty reduction outcomes on the continent [4]. Prioritizing irrigation development is crucial, given Africa's agricultural potential and the high number of rural poor who could benefit from increased productivity.

Many Sub-Saharan countries recognize irrigation's importance for food production, leading to increased investments [7]. Over the past 30 years, the average expansion rate of irrigated areas in Africa has been 2.3%. Currently, about 12.2 million hectares are irrigated, with Egypt, Madagascar, Morocco, Nigeria, South Africa, and Sudan making up nearly 75% of this total

**Corresponding author: mare.addis@eiabc.edu.et*

[4]. However, despite some progress, the overall impact of irrigation development has been limited [8].
Ethiopia has a long history of traditional irrigation, but modern irrigation began in the 1950s under imperial rule, focusing on large-scale projects in the middle Awash Valley for sugar, fruit, and cotton production. Successive regimes, including the current Ethiopian People's Revolutionary Democratic Front (EPRDF), have prioritized irrigation development to boost agricultural productivity and food security while aiming for sustainable practices [9].

However, challenges persist. Per capita land availability is declining, and agricultural productivity is hampered by erratic rainfall, leading to low farm output, poverty, and health issues [10]. Poor irrigation management practices exacerbate these problems, with inadequate skills and institutions resulting in infrastructure decay and conflicts over water access. Additionally, insufficient participation from beneficiaries, land tenure insecurity, and socioeconomic barriers hinder effective irrigation development [11]. Fluctuating rainfall severely impacts rain-fed agriculture, causing frequent crop failures and food insecurity. To achieve sustainable food security and rural transformation, enhancing irrigation practices is crucial [12]. In the Tigray region, agriculture heavily relies on rainfall, which is often erratic and variable. This has led to crop production failing to meet population growth due to recurrent droughts and environmental degradation [13]. To address this, irrigation is essential; it can boost yields by up to four times compared to rain-fed farming and offers economic benefits through higher-value crops.

Despite approximately 300,000 hectares being suitable for irrigation, only 4.2% (12,607 hectares) is currently irrigated [14]. In response, the Tigray regional government launched the Sustainable Agricultural and Environmental Rehabilitation of Tigray (SAERT) program, constructing several dams [15].

Gulomekada Woreda, located in the Eastern zone of Tigray, faces chronic food insecurity due to insufficient rainfall and frequent droughts. It is one of 31 districts targeted by regional food security initiatives [16]. Challenges for smallholder farmers include limited knowledge of market-oriented crop production, poor work habits, lack of interest in purchasing irrigation materials, financial constraints, and inadequate infrastructure.

Researchers have studied the impact of irrigation on smallholder farmers. For example, Tedros [17] examined how small-scale irrigation affects household income and food security in the Gum-selsa and Shilena schemes in Tigray, focusing on specific crops. Hadushe [18] investigated micro irrigation's effects on household income in Eastern Tigray, but both studies limited their scope to crop and livestock income without considering the overall household income. These studies did not address the full contribution of small-scale irrigation, particularly in Glomekada Woreda. To fill this gap, the current research aims to evaluate the contribution of small-scale irrigation to household income. To achieve the main objectives, the following specific objectives were stated: 1. Comparing incomes of irrigation users and non-users, 2. Identifying determinants of household income for both groups and 3. Assessing challenges affecting farmers' participation in small-scale irrigation.

2. Research Methods and Materials

2.1. Description of the Study Area

Gulomekada is one of the nine Woredas in the Eastern Zone of Tigray Region. It is located at a distance of 912 km north of Addis Ababa and about 135km north east of Mekele, capital city of Tigray region. The study area has an absolute location of 14°16'45''-14^{0}32'5''N and 39^{0}14'-39°36'30''E latitude and longitude, respectively (Fig. 1). The Woreda (district) has an elevation of 1600 -3062 meters above sea level. Relatively, the district is bordered in the south by Gantaafeshum, Werieleke in the west, Eritrea in the north, Irob in the east, Saesitsaedaemba in the south east. The total area of the Woreda is 703.2km^2. The land form is made up of plateaus, and mountains.

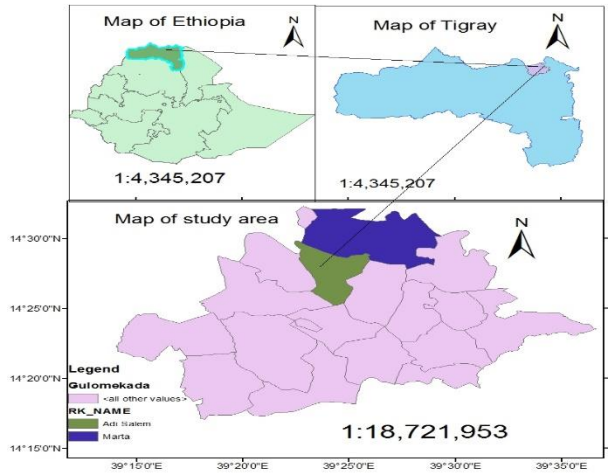

Fig 1 - Map of the study area

2.1.1. Climate

The climatic condition of the district is categorized under Woinadega (Temperate) (52.7%) and Dega (Cool Temperate) (47.3%) climate zone. The district characterizes bimodal rainfall pattern with main rain occurring during the summer season (from June to September) and a short rainy season during spring **(**Belg) (between January and April). The mean maximum and minimum temperature of the district are 20.5ºC and 10ºC, respectively (Fig. 2).

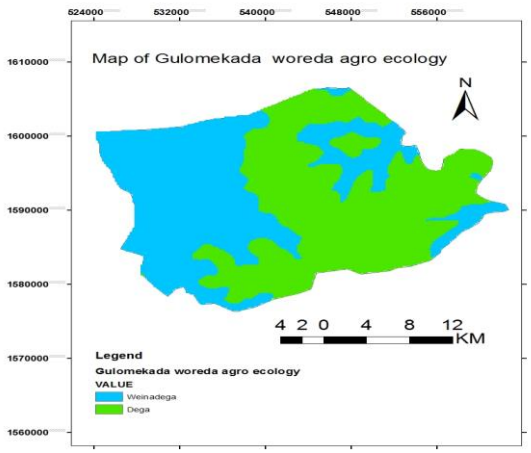

Fig 2. Agro ecological zone of the study area

2.2 Methodology

2.2.1 Research Design

The study employed mixed research design composed of both qualitative and quantitative research approaches. This is due to the fact that the contributions of small scale irrigation on rural household income as well as factors which affect the income of the household in the study area need quantitative and qualitative data collection and analysis. Hence, quantitative and qualitative data collection and analysis was employed.

2.2.2 Sampling Techniques

The study used both purposive and simple random sampling techniques to select the respondents to fill the questionnaires. Firstly, purposive sampling technique was used to select the study district for the reason that the district practices small scale irrigation for the last couple of years. Therefore, to examine its contribution and to identify the income difference between irrigation user and non-user the researcher initiated to select this specific district for the study. Secondly, out of 17 rural kebele administrations, two rural kebeles (Marta and Addis alem) were selected for the study using simple random sampling techniques (Table 1) Using [19] formula the sample households were determined as shown below:

$$n = \frac{z^2 \cdot p \cdot q \cdot N}{e^2 \cdot (N-1) + z^2 \cdot p \cdot q} \quad (1)$$

n: The required sample size
zz: Z-score (related to confidence level = 1.96)
pp: Proportion of success in the population (estimated proportion 0.5)
qq: q=1−p
NN: Population size
ee: Margin of error (5% or 0.05)
Accordingly,

$$n = \frac{(1.96^2) \cdot (0.5) \cdot (1-0.5) \cdot 197}{(0.05^2) \cdot (197-1) + (1.96^2) \cdot (0.5) \cdot (1-0.5)}$$

$$n = \frac{189.12}{1.45} \approx 130$$

Table 1 - Summary of sample respondents

NO	Kebele administration	User	Non-user	sample user	Sample non user	Total sample
1	Marta	53	51	32	33	65
2	Adisalem	47	56	33	32	65
	Total	90	107	65	65	130

Qualitative data samples were selected purposively for interview from the informants which includes Woreda irrigation expert, agricultural extension expert working in selected kebele, scheme committee members, and kebele administrative bodies. In general, key concerned bodies were selected purposively in each kebele for the study.

2.2.3 Data Sources and Collection Techniques

In order to achieve the objectives of the study, both primary and secondary data sources were employed.

Primary Data Collection Tools

The primary data collection techniques included questionnaire, key informants interview and non-participator observation for the study.

Key Informant Interview

The district's irrigation expert, agricultural extension experts working in selected kebele, scheme committee members, irrigation user and non-user household and kebele administrative bodies was included to collect information for the study. Checklists were prepared for the following issues; the source of credit, the motivating factor to participate in irrigation, the impact of market information of farming activity, indictors of wealth in rural farm households and application of agricultural input in the study area. Key informants' interviews were prepared based on the specific time schedule to collect the necessary data.

Questionnaire

Structured questionnaire was employed to collect primary data from respondents. The questionnaire was composed of demographic, socioeconomic, physical and institutional factors. Ten data collectors who completed grade ten were selected so as to collect reliable data from the respondents of the study area. The questionnaire has included both close ended and open ended questions. The questionnaire was first prepare in English and later translated into the local language (Tigrigna) so that the respondents can easily understand the questions.

Secondary Data Collection

In addition to primary data, the study employed secondary data reports from Federal, Regional and district's Agricultural and Rural Development Office as well as reports from CSA, FAO at different years.

2.2.4 Data Analysis Techniques

The study employed both quantitative and qualitative methods of data analysis. The qualitative data that was collected through key informant interview and field observation was analyzed textually. This could support the data collected through questionnaire. On the other hand, the quantitative data were analyzed using the chi-square and T-Test. The data was entered to statistical package for social science (SPSS). The data that was collected from household survey presented and analyzed through descriptive and inferential statistics. Descriptive statistics state/express with the help of tables, percent and frequencies. Inferential statistics used are t-test and Chi-square test.

Chi-square test has employed to assess the association between irrigation user and non-users with relevant to categorical variable (such as sex of the household head, educational back ground of the household, and accessibility of market information.

Dependent variable: For this study, the dependent variable (Y) is the contribution of small scale irrigation.

Independent variable: For this study, the independent variables (X) are those factors affecting small scale irrigation. The following factors (X) (independent variables) such as age of household, gender, and educational back ground, and family size, application of agricultural input and accessibility of market information are expected to influence the small scale irrigation and household income of the farmers (Table 2).

Table 2 - Description of the dependent and independent variables used in the model

Independent variables	Measurement	Type of variable	Expected sign
Age	Years	Continuous	+
Sex	Male=1 female =2	Dummy	+
Education	Illiterate =1 primary school = 2 secondary school = 3 preparatory and above =4	Dummy	+
Family Size	Number of family at household level	Continuous	+
Application of agricultural input	Yes =1 No =2	Dummy	+
Accessibility	Access to irrigation water =1 No access irrigation water =2	Dummy	+
Years of farming experience	Number of years	Continuous	+
Livestock holding	Numbers of livestock unit	Continuous	+
Size of cultivated land	Size of farm land in hectare	Continuous	+
Access to credit	Access to credit =1 No access to credit=2	Dummy	+
Access to extension service	Access to extension=1 No access to extension=2	Dummy Dummy	+ +

3. RESULTS AND DISCUSSION

3.1 Factors Affecting Irrigation Activity of the Study Area

Now a days, the participation of household heads in small scale irrigation activity shows increment due to its vital role play in improving income and reduce the problem of food crisis. However, there are various factors that affect the practice of small scale irrigation in the study area. These factors are categorized in to four as; Demographic factors, socio-economic factors, Administrative factors and Natural factors.

3.1.1. Demographic factors

Irrigation income and food security of households was negatively affected by demographic factors. These variables could affect the level and degree of income and food security. The major ones of the study area include gender, age, and status of education, marital status, and family size, the income of small scale irrigation user and non-user households had influenced by gender of the household.

Sex of Household: Table 3 shows that out of the total irrigation user respondents 68% of them were males and 32% female headed. Similarly, from the total non-irrigation respondents 53% were male non-irrigators and the remaining 47% were females. The chi square test indicated that the sex of households had significant difference between irrigation users and non-users at 0.05 significance level. This result revealed that, in the study area male population were largely participated in irrigation activity while female headed households faced labor shortage due to work burden at home and focused more on domestic household works. Awoke *et al.,* [20] explain that the sex of the household head had a positive relationship with the food security status of the households.

Age of Households: The result of the study in Table 3 showed that 26% of household small scale irrigation users were between the ages of 22-37, 54% of respondents of irrigation users were aged between 38-53 years as well as 20% were between the ages of 54-70. On the other hand 34% of non-irrigation users were between 22- 37 years, 32% had ages ranging between37-53 and 24% of the non-users were 54-70 years old. The chi-square result of the study revealed that the age of household heads indicated significant difference between small scale irrigation user's and non-users at 0.05 significance level. This survey result indicated that larger portion of household small scale irrigation users were grouped at the economically active age group. The result of this study is consistent with the study conducted by Awoke *et al.,* [20]. Their result showed that age of the household heads increase will increase the experience of households in agricultural production and have more farming experience and more output resulting in their families have a better probability of being food secure. Conversely, a study highlighted that younger farmers (ages 18-30) are increasingly adopting modern agricultural technologies, including irrigation, due to better access to information and resources. This challenges the notion that older age is synonymous with greater irrigation usage. Feleke *et al.,* [21] has also reported a positive effect of age on households' decisions to participate in small-scale irrigation.

Education Status of Households: Education Status of Households is a vital tool for farmers to use modern technology and different agricultural inputs. As to the survey result of Table 3, 17% of respondents of irrigation users and 34% of non-irrigation users could not read and write, 31% of users and 43% of non- users complete grades 1-4, 40% of the irrigators and 13% of non-irrigators were completed grades 5-8 and 12% of small-scale irrigators as well as 9% of non-irrigators completed high school and above. The chi square value of educational level of household irrigation users and non-users had significant difference at 0.05 significance level. This result indicates that majority of the irrigation users where learned 1-8 grades as compared to the non-irrigators. This difference in educational level could result in the variation household income. Daru *et al.,* [22] ratified that there was a significant association between household educational level and their decision to participate in small-scale irrigation.

Marital status of Households: Marital status of Households had also affect productivity and income of household heads. Table 3, shows out of the total respondents 11% of irrigators and 17% of non-irrigators were unmarried, 46% of irrigators and 23% of non-irrigators were married respondents. 28% of the irrigation user respondents as well as 37% non-irrigator respondents were divorced farmers and 15% users, 23% of non-users were widowed heads. The statistical analysis of the survey result revealed that there is no significant difference in the marital status of small scale irrigation users and irrigation non-users. This means the statistical analysis revealing no significant difference in the marital status of small-scale irrigation users and non-users suggests that while marital status may influence individual productivity, it does not necessarily differentiate between those who use irrigation and those who do not. This aligns with findings that indicate the complexity of factors influencing agricultural productivity, where marital status is just one of many variables [23].

Table 3 - Demographic characteristics of households

Demographic data	Irrigation		Mean	chi-square
	irrigation user %	Non-irrigation user %		
Male	68	38	53	11.150***
Female	32	62	47	
Age				
22-37	26	42	34	6.306 **
38- 53	54	32	43	
54-70	20	26	23	
Educational level				
Illiterate	17	34	25	13.568**
Elementary(1_4)	31	43	37	
Junior(5_8)	40	14	27	
High school (9-12)	8	6	7	
Diploma and above	4	3	4	
Marital status				
Single	11	17	14	7.746
Married	46	23	35	
Divorced	28	37	32	
Widowed	15	23	19	

***significant at 0.01 level, **significance at 0.05 level, *significant at 0.1

Family size of households: Family size of households indicate that the presence of large number of children in the house requires large amount of food demand. Table 4 shows that 18.4% of irrigation user sampled households had between 0-2 number of children, those households with 3-5 children were accounted about 47.8%, and respondents who had 6-8 average number of children were accounted about 33.8%. Similarly, out of the total non-irrigation user respondents, parents had 0-2 average children were about 13.8%, 55.4% of non-user respondents had also 3-5 average number of children and 30.8% of the parents had 6-8 number of children. The mean household size of irrigators is 1.96 and non-irrigation users are 2.1. The chi-square shows, there is significant mean family size difference between irrigation users and non-users at 0.01 significance level. Therefore, more than 86% of non-irrigation user households had above 3 family members compared to 81.6% irrigation user with above 3 family members. So non-irrigators have been faced food crisis due to the higher number of dependent children than the irrigation users. Beneberu and Biazin [24] explain that households with increased family members within a household need more food than a household with a small family size, resulting in a shortage of food.

Table 4 - Family size of households

Family size	Irrigation=65 user		Non-irrigators=65		chi-square
	Frequency	%	Frequency	%	19.107***
0-2children	12	18.4	9	13.8	
3-5 children	31	47.8	36	55.4	
6-8children	22	33.8	20	30.8	
Mean(Sd)	2.1(0.7)	100	1.2(0.6)	100	

*** = Significant at 0.01 level

3.1.2. Physical and socio economic data of respondents

Accessibility of Irrigation Water

As we can see from Fig. 3, 64% of the respondents get sufficient water for irrigation and the remaining 36% of the respondents do not get access of irrigation water. Based on this, it can be said that all irrigation user respondents have sufficient water for irrigation and the remaining 85% non-user households does not have sufficient water for irrigation.. According to the sample respondent during interview, accessibility of water is the major factor to participate in irrigation farming. From this result, we could suggest that accessibility of irrigation water and participation on small scale irrigation is positively correlated. This implies that households with good access of water force to participate in small scale irrigation. In line with this, Hussain [25] confirmed that access to reliable irrigation water can enable farmers to practice new technologies and intensify cultivation, leading to increased productivity, overall higher production, and greater returns from farming. This can open a new employment opportunity and improve incomes in the rural areas.

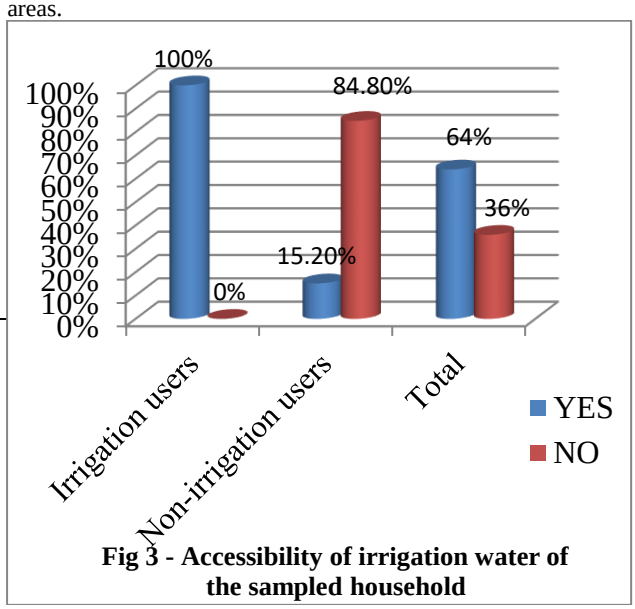

Fig 3 - Accessibility of irrigation water of the sampled household

Problems faced on irrigators: Small scale irrigation user households were subjected to various challenges. As in Fig. 4 below**,** about 52% of irrigation user respondents had faced shortage of water, 26% of them were problem of crop failure, 16% respondents had faced crop disease and pests 6% of household respondents were faced problem of agricultural weeds. The result indicates that the major Problem of irrigation user households were shortage of water followed by crop failure. Such problems influence productivity and household income.

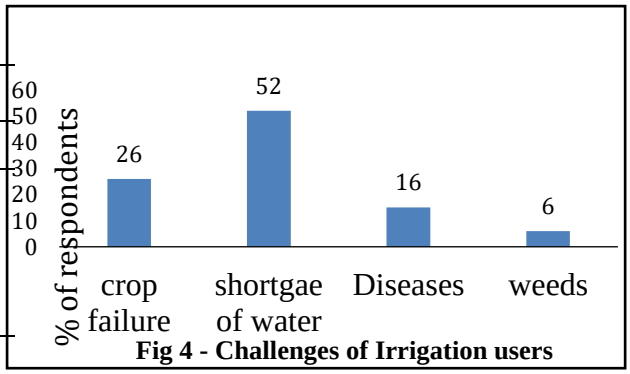

Fig 4 - Challenges of Irrigation users

Published by JPS Publishing
https://journal.water.gov.my

3.2. Reasons for non-users of irrigation in the Study Area

From the total sample respondents, 50% of households are non-irrigation users. They are not directly benefit from irrigation farming. The survey result indicates that the major problem associated with this includes scarcity of irrigation water, lack of labor power to participate in small scale irrigation, price of water service and lack of awareness about irrigation farming. Out of the above-mentioned problems, more than 74.10% of non-irrigators have stressed on the problem of scarcity of water, 15.2% lack of labor power, 5.4% price of water and the remaining 5.3% are the problems related to no awareness about irrigation farming (Fig. 5). The information obtained from Woreda irrigation experts and kebele agricultural experts, the major problem of non-irrigators to be irrigator includes accessibility of water for irrigation, lack of interest by the households to invest in their farm land, infrastructural problem and lack of capital to distribute irrigation water access to all kebele.

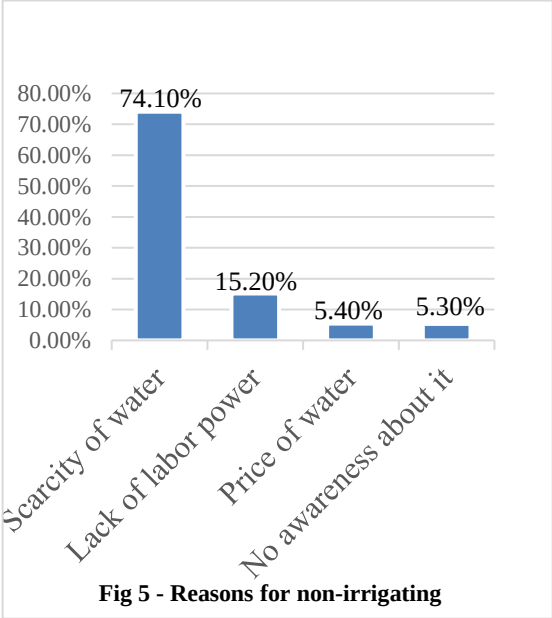

Fig 5 - Reasons for non-irrigating

3.2.3 Total Size of Cultivated Land and Its Effect on the Use of Irrigation Schemes

Size of cultivated land: Size of cultivated land is the determinant factors for the agricultural production of households. It is dependent and determined by different natural resources. One of the influencing resources is the size of cultivated land. Irrigation users who owned 0.5 *timad* of land were 12.5%, 30.5% of the respondents had one *timad* of cultivated land, 43% respondents had 2 timad cultivated land and 14% of them were owners of 3 *timad* of land. Similarly, out of the total non-irrigation users 23% respondents owned 0.5 timad of cultivated land, 43% of the respondents had one timad, 29% of the household heads owned 2 timad of cultivated land area and 5% farmers were owners of 3 timad land (Table 5). The result of the survey shows that the mean cultivated land size of users of irrigation was 2.5 and non-user of irrigation was 2.1. The chi square test indicated that there is significant mean cultivated land size difference between the users and non-users of irrigation at 0.05 significance level. Therefore, irrigation user households had larger *timads* as compared to the non-irrigation user respondents in the study area. This implies, household heads with larger plots of agricultural land were earned higher agricultural production than the non-users. Funmilola and atricia [26] found that irrigation land positively determines food security.

Table 5 - Size of cultivated land

	Irrigation user (65)		non user(65)		chi-square
Hectare	Frequency	%	Frequency	%	
≥0.5	8	12.5	15	23	6.92**
1	20	30.5	28	43	
2	28	43	19	29	
≥3	9	14	3	5	
Mean(Sd)	2.5(0.88)	100	2.1(0.8)	100	

**= significance level at 0.05

Land ownership: For agrarian countries like Ethiopia, agriculture is the main stay for the large rural population. Land ownership of irrigation user farmer varies from household to household. Fig. 6 shows that about 69% of small scale irrigators owned cultivated land earned from the government, 17% household respondents were inherited the irrigated land from old parents and the remaining 14% farmers were practiced irrigation on rented land. Therefore, the result indicated that most households of the irrigation scheme could ensure food security more than those who irrigated on the rented land. This result is consistent with the study done by Pokhrel *et al.*, [27].

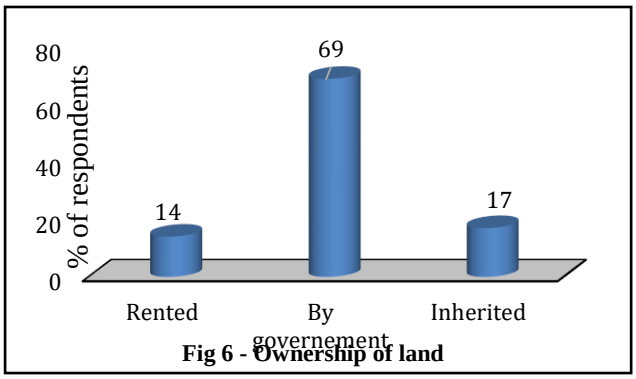

Fig 6 - Ownership of land

Distance of the market: Agricultural and non-agricultural products of households either produced for consumption or sell in the market. Some farmers sell their products in their village, district market and others sell in the zonal market. However, the distance of the market influences farmers in different ways. Jeffrey *et al.*, [28] found that for crop producers, an increase in distance to market both reduces the likelihood of market participation and increases the likelihood of crop production for household consumption. Those who live near to the market benefited more than those who inhabited in the far distant. Table 6 indicated that 11% of irrigation user respondents live within 3-5km, the majority with 75% irrigators inhabited within 6-8km and the rest 14% were lived in 9 and above kilometer from the district market. On the other hand, 95% non-irrigator households live within 6-8 km and 5% respondents were live in 9km and above from the nearby market. The study shows majority of household heads of irrigators and non-irrigators were settled at a medium distance from the market. The chi-square result of the study revealed that there is a significant difference between household residence and the nearby market. Therefore, the result is significant at 0.01significance level.

Table 6 - Distance of Kebele from Market

Market distance(KM)	Irrigation user=65 %	Non-irrigation user=65 %	Mean	chi-square
3-5	11	-------	6	
6-8	75	95	85	11.523**
≥9	14	5	9	

***=significance level at 0.01

Farming system of households: Farmers of the study area were practiced different farming systems. Table 7 revealed that 86% of irrigation user respondents apply mixed farming system, 11% of household heads cultivate various cereals and 3% of the farmers participated on animal rearing. Similarly, non-irrigators who use mixed farming system were 89%, 10% of the non-users were participated in cereal cultivation and 2% of them were reared animals. According to the survey result, the mean farming system of irrigation users was 1.24 and 1.23 was for non-irrigation users. The result shows that there is mean difference between irrigation user and non-users at 0.05% significance level. Therefore, farming system had an impact on household income difference between users and non-users of irrigation. The findings is also substantiated by the impact analysis of Phogella and Anbaw [29] in small-scale irrigation on household income revealed that there was a significant difference on the income of households between irrigation-user and non-irrigation-user.

Table 7 - Type of Farming

Type of farming	Irrigation users=65		Irrigation non-users=65		chi-square
	Frequency	%	Frequency	%	
Mixed farming	56	86	58	89	5.175*
Animal rearing	2	3	1	2	
Cereal production	7	11	6	9	
Mean(Sd)	1.24(0.64)	100	1.23(0.63)	100	

*=significant at 0.01

Household heads of the study area sold their agricultural products in different market centers. Some farmers sell in the zonal market, others sold in the district market while others had sell in their village. The study result shows that 4% respondents of small scale irrigation users sold their farming products in the zonal market, majority of farmers with 74% were sell the irrigation and agricultural products in the district market and 22% respondents have been selling in their village. In the other hand, 3% non-irrigation users sold in the zonal, 89% farmers sold their rain-fed products in the Woreda market while 8% of non-irrigator respondents sold in the nearby village (Table 8).The result implies majority of the sampled households sell their products in the market found in the district capital. The chi-square value shows that the difference between irrigator and non-irrigators in the center of market for selling products is significant. The field result is significant at 0.05 significant level.

Table 8 - Market Where Products Sold

Market Place	Irrigation type		Mean	chi-square
	Irrigation user=65(%)	Non - irrigation user=65(%)		
Zonal market	4	3	4	
Woreda market	74	89	81	5.406*
Village market	22	8	15	

*=significance at 0.05%

Household Market sold items: Household heads of the study area had supplied different items to the market. The supplied items could vary between small scale irrigation users and non-irrigation user farmers. As reported in Table 9, 30.8% of irrigation user respondents sold cattle, 40% of them have been selling vegetables, 23% irrigation users supplied cattle products and 6.2% them sold different items. On the other hand, out of the total non-irrigation user respondents 55.4% were selling animals, 40% respondents have been selling cattle products and 4.6% non-irrigators were supplying other items, such as firewood, cactus, and animal dung to the market. The survey result revealed that majority of the small scale irrigation users were supplied vegetables and irrigation out comes to the market but non-users of irrigation could not do it. This result implies that small scale irrigation users had diversified sources of household income than the non-irrigation users. This shows that irrigation-users had a better crop income than those non irrigation user households. In Ethiopia, Mengistie and Kidane [30] found that the use of irrigation technology significantly improved crop income. Therefore, irrigators had the potential to resist problem of food crisis.

Table 8 - Items Supplied to Market

Type of products	Irrigation user=65		Non- irrigation user=65	
	Frequency	%	Frequency	%
Cattle	20	30.8	36	55.4
Vegetables	26	40	------	----
Cattle products	15	23	26	40
Others	4	6.2	3	4.6

Non-farm income of Households: Farmers of the study area were engaged in various activities to improve household income. The dominant activities include, income secured from rain-fed cultivation, irrigation, livestock rearing, private employment, remittance, labor work, trade and non-farm employment. The result in Table 10 indicates that out of the total irrigation user households, 52% participated in non-farm

activities and 48% of them were not involved in non-farm income. Similarly, 78% of non-irrigation user households have been participating in non-farm activities while the remaining 22% did not participated. The result show that the mean non-farm income of irrigation users is 1.4 and non-irrigation households is 1.2. Therefore, there is significant mean non-farm income difference between irrigation users and non-users of irrigation at 0.05 significance level. This implies that the livelihood of non-irrigation users were largely dependent on non-farm activity. According to Gebru *et al*., [31] the diversification into non-farm activities plays a significant role in the context of inadequate and rain-fed-dependent agricultural income households.

Table 9 - Non-farm Income of Households

Non-farm income	Irrigation user=65		Non-irrigators=65		chi-square
	Frequency	%	Frequency	%	
Yes	34	52	51	78	6.884**
No	31	48	14	22	
Total	65	100	65	100	
Mean(SD)	1.4(0.5)		1.2(0.4)		

**=significance level at 0'.05

Factors that determine household income: There are different factors that determine household income in positive or negative ways. As it is described in Table 11, by the respondents, the main factors that determine household income are access to irrigation, family size, livestock holding, educational background, access to credit etc. respectively. While the p-value =0.02 and chi-square value = 22.123 indicated that there is a significant difference among the factors that determine (predict) household income. According to Lokee [32] conclusion, age of the household head affect the household income level that increase in one's age increases the level of household income, total hours worked also increases their incomes and the household incomes are also affected by the size of the household and therefore, increase in the household size reduces the level of the household incomes mainly due to dependence burdens in form of spending on education and increased feeding expenses and that, the work type engaged in by the household head affects the household income level.

Table 10 - Factors that determine household income

Predictors	Frequency	%	Valid %	Cumulative%	P-value	chi-square
Accessibility of irrigation water'	32	24.6	24.6	24.6		
Sex of house hold head	11	8.5	8.5	33.1	0.02	22.123[a]
Educational back ground	15	11.5	11.5	44.6		
Family size	20	15.4	15.4	60.0		
Dependency ratio	10	7.7	7.7	67.7		
Livestock holding	17	13.1	13.1	80.8		
access to credit	13	10	10.0	90.8		
application of input	12	9.2	9.2	100.0		
Total	130	100	100.0			

Frequency of cultivated land: Some farmers cultivate their farmland two times in a year while others do it once in a season. Therefore, farming outputs of farmers may vary between the irrigator and non-irrigator households. Hence, income level might also varied. Table 12, revealed that 88% small scale irrigators cultivated their farmland twice in a season, while 12% household heads cultivated once in a year. Similarly, 82% of the non-irrigators cultivated once in a year and the remaining 18% respondents of non-irrigation users were two term producers. The survey result of the study showed that majority of the small scale irrigation user's income was better than non-irrigation users. The chi-square value shows there is no significant difference in frequency of frequency of cultivated land between irrigation users and non-users. Despite the observed differences in income and cultivation frequency, the chi-square analysis indicated no significant difference in the frequency of cultivated land between irrigation users and non-users. This suggests that while irrigators may cultivate more frequently, the statistical significance of this difference in frequency may not be strong enough to draw definitive conclusions about the impact on income level [33].

Table 11 - Frequency of Production

Terms of production	Terms of Irrigation: irrigation user%	Terms of Irrigation: non irrigation user%	Mean	chi-square
Twice a year	88	18	53	.000
Once a year	12	82	47	

Household income: Participating in irrigational activities has its own impact on the total income of households.as it is indicated in Table 13, the p-value is <0.05 and the mean difference is 2.308 and 1.477, respectively. This implies that there is a significant difference in total household income before and after participating in irrigation.

In addition, according to the respondents which is shown on the bar graph (Fig. 7) 49.2% of them replied that their income was low before engaging in irrigation, while 32.3%, 18.5% replied that it was medium and high, respectively. On the other hand, 52.3%, 47.7% of the respondents 'replied that their income was high and medium, respectively after they are engaging in Irrigation. Therefore it is possible to conclude that participating in irrigation has a positive impact on rural household income. The households of irrigation users reported an average annual gross farm income that exceeded that of non-user households

by 7,219.8 birr. This finding aligns with a study by Ayele *et al.*, [34] in the Lake Tana basin, which noted that access to irrigation significantly increases household mean income by 3,353 birr per year, representing a 27% rise compared to non-irrigating households. Additionally, Kinfe [35] found that households in Central Tigray with one hectare of irrigable land had a well-being advantage of 23,327.8 birr over non-user households.

Table 12 - Household income

Items	One-Sample Test					
	t	df	Sig. (2 tailed	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Level of income before irrigation	24.194	64	.000	2.308	2.12	2.50
Level of income after irrigation	23.656	64	.000	1.477	1.35	1.60

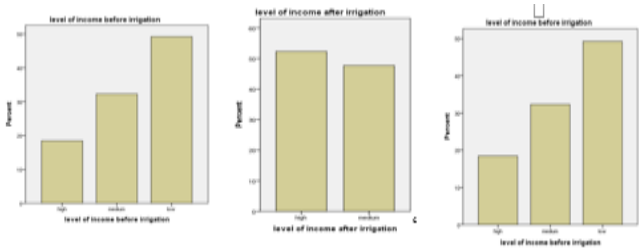

Fig 3 - Level of income of respondents before and after using irrigation

Institutional Factors

Institutional issues also hider agricultural production of household heads in different ways. The main institutional variables were access to credit, use of modern inputs, and level of food aid, availability of motor pumps, and support of extension agents were positively or negatively affect income of the household.

Access to Credit: Availability of credit is helpful variable which enable households to purchase different modern technological inputs necessary for irrigation activity such as; motor pumps, seed varieties, fertilizers, and also important to buy oxen and others. Farmers with credit access may purchase food when shortage occurs. However, some farmers were not accessed to credit due to high interest rate. Therefore, credit determines agricultural production and income of irrigation user and non-user households. As indicated in Table 14, 18.5% of small scale irrigation user farmers have been accessed to more than 7000 Ethiopian Birr (ETB) credit access, 37% of user farmers had receive medium credit and the majority respondents with 44.5% were the lowest receivers of credit. Similarly, 4.5% non-irrigation respondents had accessed high credit, 18.5% users received medium credit and 77% of the non-user households had received the lowest credit amount. The survey result indicates that the mean credit use of irrigation users was 2.2 and non-users were 2.7. Therefore, the chi-square result indicated that credit access of households had significant mean difference between irrigation users and non-users at 0.01 significance level. The result shows irrigation user farmers had better access to credit because household heads had the power to return their loans by cultivating vegetables and crops using irrigation. Funmilola and Patricia [26] the possible explanation is that credit allows the household to be involved in income-generating activities so that derived revenue increases the financial capacity and purchasing power of the household to escape from the risk of food insecurity. Beneberu and Biazin [24] also explain that households with better access to credit use more farm inputs such as fertilizer, improved seed and agricultural chemicals that maximize production and productivity and improve household consumption. Daru *et al.*, [22] confirmed that farmers who get credit might use it for the purchase of improved seeds, fertilizer, herbicides, pesticides, farm materials, and farm oxen to increase their agricultural production.

Table 13 - Access to Credit in ETB

Credit Access	Irrigation users=65		Irrigation non-user =65		chi-square
	Frequency	%	Frequency	%	
≥7,000	12	18.5	3	4.5	14.982***
3500-7000	24	37	12	18.5	
≤3500	29	44.5	50	77	
Mean(Sd)	2.2(0.7)	100	2.7(0.85)	100	

. ***=significance level at 0.01

Contact of Extension agents: Household head contact with irrigation and extension agents had an impact on irrigation and agricultural production. Irrigation Agents could help farmers in providing training, advice and technical as well as professional support to increase household income and realize food security. According to, Table 15, 32% irrigation user farmers had a contact with extension agent, 52% of the respondents contacted once in two weeks and about 16% irrigation user households had contacted extension agent once a month. Similarly, 10% of the non-user irrigation households were contacted extension agent one day per a week, 49% farmers had a contact with extension agent and 41% of households got help from extension experts one time in a month. The chi-square value shows that the mean contact with extension of irrigation users was 1.8 and non-users were 2.3. The chi-square value shows that contact of households to extension agent had significant difference between irrigation user and non-user at 0.01 significance level. According to the result, irrigation user framers had a number of contacts with extension and irrigation agents than the non-users of irrigation. Daru, *et al.*, [22] study result confirmed that there was a significant association between the frequency of extension contact and farmers' participation in small-scale irrigation Therefore, irrigation user households had better farming output compared to the non-irrigation user farmers.

Published by JPS Publishing
https://journal.water.gov.my

Table 14 - Contact with Extension Agent

Duration of DA contact	Irrigation user=65		Non-Irrigation user=65		
	Frequency	%	Frequency	%	
Once a week	21	32	6	10	11.403**
Once in 15 days	34	52	32	49	
Once a month	10	16	27	41	
Mean(Sd)	1.8(0.7)		2.3(0.6)		
		100		100	

***= significance level at 0.01

Household dietary status: dietary diversity is a useful food security indicator and is defined as the number of different food groups consumed over a given period of time [36]. Dietary status is varied between irrigation user and non-user households. According to Table 16 below, 46% irrigation user households had consumed more than 5 food groups in a day, 38% respondents feed on 3-4 food items and 16% of the irrigators had consumed below 2 food types. Similarly, 32% of non-irrigation users of respondents had consumed more than 5 food items, 34% of them also had medium and low feeding systems. It is found that, more than 84% of irrigation user respondents had consumed high dietary diversity greater than 3 food groups. The result indicated that the mean food consumption level of irrigation users is 1.69 and non-irrigation users are 2.0. The table below shows that there is significant mean food consumption level between irrigation users and non-irrigators at 0.05 significance level. Therefore, small scale irrigation users had higher diet diversity than the non-irrigation users.

Table 15 - Household Food Consumption

Household food type	Irrigation type				chi-square
	irrigation user=65		Non-irrigation user=65		
	Frequency	%	Frequency	%	
≥5	30	46	21	32	
3_4	25	38	22	34	6.280**
2≤	10	16	22	34	
Total	65	100	65	100	
Mean(SD)	1.6(0.7)		2.0(0.8)		

**=significance level at 0.05

Five food types= Cereals, vegetables, pulse, egg, fruits.

3.3. Income and Expenditure Distribution of Households

Source of household income: The result in Table 17 shows that irrigation user households had obtained total annual income of 33,291.60 ETB from farm and non-farm activities. More than 60% of the total income of irrigation user households was earned from irrigation and rain-fed farming. While the 40% of the annual income gained from livestock, remittance and non-farm activities. Similarly, irrigation non-user respondents had obtained total annual income of 16,402.25 ETB. Non-irrigators' highest income was obtained from livestock which accounts about 39% followed by 35.6% of income earned from rained farming, the rest 25.4% of non-irrigation user income came from remittance and non-farm activities. The result shows that irrigation user respondents were obtained better income than non-irrigators. Therefore, the problem of food security is higher in non-irrigators compared to the irrigation users. A study conducted in Ethiopia found that households engaged in small-scale irrigation had significantly higher annual incomes compared to those who did not use irrigation. Specifically, the adoption of small-scale irrigation increased the average annual income by approximately 60,273.27 (ETB), which is a 54.88% increase compared to non-irrigators. This indicates that irrigation plays a crucial role in enhancing household income through both farm and non-farm activities [36]. Food Security and Income Correlation: Another study in Ethiopia demonstrated that participation in irrigation not only improved household income but also positively affected food security. Households that utilized irrigation reported better food availability and dietary diversity, which are critical components of food security. The study indicated that irrigation users had a higher average income and food expenditure, reinforcing the idea that irrigation contributes to better economic outcomes for households [37].Therefore, the problem of food security is higher in non-irrigators compared to the irrigation users. Similar study by Abonesh *et al.*, [38], mentioned based on Coping Strategy Index the non-irrigator households are more food insecure as compared to irrigator households.

Table 16 - Income Distribution of Households in (ETB) (Average)

Source of income	%	Irrigation user	Non irrigation user	%
Irrigation	37.8	12,600.50	----------	----
Livestock	24	8040	6420	39
Rainfed farming	23	7600.45	5842	35.6
Remittance	9.6	3200	2540	15.5
Irrigation and rainfed farming	60.8	20,200.95	5842	
Non- farm	5.6	1850.65	1600.25	9.9
Total	100	33,291.6	16,402.25	100
Family spending	31.5	10,448.45	8560.40	52
Net income	68.5	22,843.15	7841.85	48

Cost distribution of household income: Table 18, indicated that irrigation user respondents spent 10,448.45 ETB. Out of the total household income, 42% have been spending for household food consumption and transport and 29.5% of it paid out for family use to purchase commodities at home. Similarly, non-irrigation user households were spent a total of 8560 ETB in the year. Non-irrigation user respondents were also spend more on household food consumption and transportation 44.4% and 32% consumed at home by the household members which was about 32%. This result showed that non-irrigation users spent consumed more 52% compared to the irrigation users spent 35%. Therefore, irrigation user respondents had saved than the non-irrigators.

Table 17 - Cost Distribution of Households

Irrigation user	%	Expenditure of respondents	Non irrigation user	%
4,400	42	Consumption and transportation	3,800	44.4
858.45	8.5	Education	650	7.6
3,100	29.5	Family use	2,750	32
500	4.8	Social life	410	4.8
940	9	Inputs	500	5.8
650	6.2	Other	450	5.4
10,448.45	100	Total	8,560	100

3.4. Qualitative Responses of Households

3.4.1. Focus Group Discussion

In the focus group discussion, there was one group with 7 persons. The participants of the group discussion were not involved in either in interviews or questionnaires. The group participants provided additional evidences supporting household questionnaire and the data collected from interview to get qualitative evidences about the role of small scale irrigation on the household income. According to group participants, the sources of water for the small scale irrigation of the sampled households in the study area were a dam. It was constructed by the *Tigray* Water Resource Bureau (TWRB) in the year of 2012 by government budget. Small scale irrigation users have been facing various challenges such as, shortage of water, shortage of water pumps, problem of motor technician, shortage of rainfall, lack of credit, expensiveness of modern inputs, shortage of crop failure, shortage of oxen, shortage of land. Products of the irrigation scheme were cultivated for household subsistence and for market.

Participating in small scale irrigation had positive impact on improving household income and alleviating food insecurity, accumulating asset, to fulfill food self-sufficiency. Though not enough, sampled household heads had access to credit. The source of credit was mostly non-governmental organizations such as the Relief Society of Tigray (REST), Catholic Church. As the district was a drought prone area the non-governmental organizations supported the society of the Woreda in general and the study areas in particular to eradicate poverty and provide food during food crisis. The sampled households of the study area were not less supported by extension workers and development agents. The Kebeles was subjected to erratic rainfall and was drought prone Kebeles due to the impact of climate change which began before ten years. In the Kebeles, rainfall was fluctuated and rained for three months in a year which led to serious food crisis. In the Kebeles, the recent food crisis was appeared in the year of 2016. To reduce the acute food crisis, the government provided them wheat and oil food. In addition, the households withstand the shortage of food by selling animals and their products; conserve every drop of water, participating in off-farm income, receive remittance.

Most farmers of the sampled household heads improved their livelihood after began to participate on irrigation. There was a difference between the sampled irrigation users and non-users on their household income.

3.4.2 Interview Responses

Data gathered through interview is a qualitative obtained from the informants of irrigation agent, extension expert, safety net program coordinator, Kebele leader, credit and saving institutions, women and youth associations of the Woreda. The respondents were purposely selected to provide additional data about the small scale irrigation. According to the Kebele administrator, the Kebele and district administration in particular and the regional and federal governments in general were had a commitment particularly to improve the income of the rural society at household head level. The major challenges of the study area were serious climate change which resulted in shortage of food, shortage of rainfall, crop failure and dry, fluctuation of rain, dependence of the community in food aid, shortage of water, farmers focus on non- cash crops. In the Kebeles, almost all of the sampled farmers were receive food aid due to shortage of food. Households of the study area were less accessed to credit because the interest rate of the credit and saving institutions of the district was high and could not compatible with the economic power of the households.

The extension agent and irrigation agents of the Woreda said that though the carrying capacity of the dam is high that can accommodate large population, but due to the designing problem with few tributaries it holds water below the expected and lasted for 3-5 months depending on the rainfall. Therefore, farmers are subjected to shortage of water for their irrigation area. In addition, irrigation user households are categorized in groups and provided motor pumps for each group where the motors were donated by government and NGOs but due to the absence of technician most of them are malfunctioned. As a result, productivity and food security of the households is not realized. However, compared to the non-users of irrigation, irrigation users have better income produced twice a year. Moreover, these agents also added that most irrigation user households get programmed training by sharing experiences from other areas. However, they are still focusing in one or two non-cash crop cultivation because they fear off leaving the Safety Net Program.

Small scale irrigation users of the sampled farmers produced twice a year. As the result, their household income was improved as compared to the non-irrigation user farmers because they depended on rain-fed farming. In addition to the lack of oxen, shortage of rain, shortage of land, the non-irrigation user households were expected food aid and safety net program from the government because if a farmer can be food self-sufficient, he could not get food aid from the government. That is why they did not fully participate in irrigation activity.

There are different studies that show a positive impact of small-scale irrigation on food security. A study conducted by Mangisoni [39] in Malawi shows that more than 70% of all the adopters were food insecure before adoption of the irrigation but their food security has significantly improved because of irrigation practice. A study conducted by Graciana [40] in Swaziland concluded that irrigation has positive impact on food

security. Moreover, Issahaku [41] have found that irrigation has a positive impact on household food security.

4. Conclusion

The Ethiopian government is promoting small-scale irrigation development through supportive policies. Irrigation enhances food production, reduces crop failure risks, and boosts household income, enabling farmers to engage in diverse activities like growing vegetables, fruits, and raising livestock.
This study focuses on a Kebele in the Gulomekeda district, where small-scale irrigation has been implemented since 2012. It assesses the impact of irrigation on household income by interviewing 130 randomly selected households. Analysis was conducted using SPSS software.
Findings indicate that small-scale irrigation significantly improves household income and food security. Men participated more than women, largely due to domestic responsibilities. Households using irrigation reported higher incomes than non-users. Factors positively influencing participation in irrigation included farming type, modern input use, market distance, land size, livestock, and access to credit.
Challenges such as water shortages, lack of oxen, weak administration, and inadequate resources hinder irrigation effectiveness. Responses also highlighted issues like insufficient technicians and low credit access. The study concluded that effective small-scale irrigation can significantly enhance farmers' household incomes.

5. Recommendations

- ✓ **Impact of Small-Scale Irrigation**: It positively affects rural household income but has limited coverage; expansion and technological improvements are needed.
- ✓ **Collaboration for Food Security**: Government and NGOs should coordinate efforts to expand small-scale irrigation, addressing community-specific challenges.
- ✓ **Narrowing Income Gaps**: Focus on factors affecting livelihoods to reduce income disparities between irrigation users and non-users.
- ✓ **Support for Farmers**: Provide credit, skilled manpower, motor pumps, and modern agricultural technologies to boost farming outcomes.
- ✓ **Awareness and Participation**: Promote the importance of irrigation systems and involve small-scale irrigators in efficiency improvements.
- ✓ **Natural Resource Management**: Engage the community in protecting resources, utilizing them properly, and mitigating climate change impacts.
- ✓ **Drought Coping Mechanisms**: Encourage diversification of income through cash crops and managing family size in famine-prone areas.
- ✓ **Capacity Building**: Focus on empowering communities to achieve food security without reliance on aid, enhancing irrigation and non-farming activities.
- ✓ **Institutional Commitment**: Ensure professional support from institutions to improve agricultural production and household income.
- ✓ **National Emphasis on Irrigation**: Both federal and regional governments should prioritize small-scale irrigation to enhance the national economy and household incomes.
- ✓ **Decentralized Support**: Implement a decentralized approach to boost agricultural production and alleviate poverty among irrigation users and non-users.

Acknowledgements

We would want to thank Gulomekeda Wereda Agricultural Office experts for providing all necessary data. We are also very glad to acknowledge the sampled households for their willingness in responding to our questionnaire at the expense of their valuable time.

References

[1] World Bank (2013). “Getting to Poverty: Lessons from the World Bank’s Record on Supporting Poverty Reduction in Country Programs.” Approach paper by Independent Evaluation Group, World Bank, Washington, DC.
[2] MoARD (Ministry of Agriculture and Rural Development) (2010). Ethiopia’s Agriculture Sector Policy and Investment Framework: Ten-year Road Map (2010-2020).
[3] Abeba, T. (2013). Design of Drip Irrigation System for the Production of Commonly Grown Vegetable Crop: Case study of Semi-Arid Region of Tigray Gereb Tetati dam; (Master’s thesis) Addis Ababa University, Ethiopia
[4] FAO. (2012). Irrigation water requirement and water withdrawal by country FAOAUASTAT report November 2012 United nation.
[5] Ebrahim EA and Toy A. Impact of irrigation participation on household’s food security in a rural area of Ethiopia: application of propensity score matching (PSM) method for causal inference. Front. Sustain. Food Syst. 8:1403317. (2024), doi: 10.3389/fsufs.2024.1403317
[6] FAO. (2000). The socio economic impact of smallholder irrigation development in Zimbabwe: Case studies of ten irrigation schemes. FAO sub regional office east and Southern Africa (SAFR).Harare
[7] Tafesse, M. (2003). Small scale irrigation for food security in Sub-Sahara Africa. Report and recommendation of CTA visit Ethiopia 20-29 January, CTA working document No 8031. CTA Wageningen, Netherlands.
[8] Inocencio, A., Kukuchi, M., Tonosaki, M, H., Maruyama, A., Merrey, D., Sally, H., &Jong, I. (2007). Costs and performance of Irrigation projects; A comparison of Sub-Sahara Africa and other developing Region, IWMI, Research report 109: Colombo, Sir Lanka
[9] MoWR. (2002). Water sector development programme 2002-2006, Volume II, Main Report of water resources, federal democratic Republic of Ethiopia, Addis Abeba, October, 2002.
[10] Awulachew, B., Yilma, D., Loulseged, M., Loiskandi, W., Ayana, M., & Alameraw, T. (2007). Water resource and irrigation development in Ethiopia, International water management institute, (Working paper 123), Colombo, Sri Lanka
[11] Mekonnen, A., Kidane, D., & Tekelay, D. (2014). *Analysis of pastoralist adaptation to climate change and variability in the dry land area of Afar:* Ethiopia. Proceeding of high level
[12] Awulachew, B., Merrey, D., Kamara, B., Van koppen, B., Penning de Veries, F., Boelee, E., & Makobe, G. (2005). *Experience and Opportunities for promoting small/micro irrigation and drain water Harvesting for food security in Ethiopia*, International water management institute (Working paper 98). Colombo, Sri Lanka

[13] Haile, T. (2008). Impact of irrigation development on poverty reduction in Northern Ethiopia, Doctoral dissertation National university of Ireland

[14] Tilahun, H., Paulos, D. (2004). Results to date and plan of research on irrigation and its impact. Paper presented at the Workshop on the impact of irrigation on poverty and environment, Workshop proceedings.

[15] Gebrehawaria, G., & Regassa, N. (2009). Poverty reduction with irrigation investment: analysis of small scale irrigation impact on poverty in Tigray, Ethiopia international water management institute, Norwegian University (UMB), Norway

[16] MoARD (Ministry of Agriculture and Rural Development) (2013). Annual Progress Re-port for the Year 2011/12 GTP Period. Addis Ababa.

[17] Tedros, T. (2014). *Contribution of small holder irrigation to household income and food security:* A case of Gum-selsa and Shilena Irrigation schemes, Hintalo wegerat, South east zone of Tigray, (Master thesis) Mekelle University, Ethiopia

[18] Hadush, H. (2014). Adoption and impact micro irrigation on household income: The case of Eastern Tigray, (Master's thesis) Mekelle University, Ethiopia

[19] Kothari CR (2004). Research Methodology, Methods and Techniques. 2nd ed. New Age International: University of Rajasthan, Jaipur 418 p

[20] Awoke, W., Eniyew, K., Agitew, G., Meseret, B., & Read, R. (2022). Determinants of food security status of household in Central and North Gondar Zone, Ethiopia. Cogent Social Sciences, 8(1). https://doi.org/10.1080/23311886.2022.2040138

[21] Feleke, E., Assefa, E., Zeleke, T., & Hawassa, E. (2020). Effects of small scale irrigation on household income and its implication for livelihood sustainability in the drought prone central rift valley of Ethiopia. Journal of Sustainable Development in Africa, 22(1), 104–131.

[22] Daru, G., Melak, D., Awoke, W., & Alemu, S. (2023). Farmers' participation in small-scale irrigation in Amhara region, Ethiopia. Cogent Economics & Finance, 11(1). https://doi.org/10.1080/23322039.2023.2213951

[23] Addisu Mulugetea. (2018). The Impact of Small Scale Irrigations on Households Income and Food Security: The Case of Leza Small Scale Irrigation Scheme in Jabithena Woreda, Amhara Region. Unpublished Master's Thesis, Debre Markos University and Yom Institute of Economic Development.

[24] Beneberu and Biazin (2020). Small-scale irrigation and its effect on food security of rural households in North-West Ethiopia: A comparative analysis. 31 Ethiop. J. Sci. & Technol. 13(1): 31-51, January 2020

[25] Hussain, I. (2004). *Assessing the impact of irrigation on poverty:* Approaches, Method, case Study and lesson IWMI, poverty in irrigated agriculture

[26] Funmilola A. Patricia O. (2014). Determinants of food security among low-income households in Maiduguri Metropolis of Borno State, Nigeria Asian J. Soc. Sci. Humanit., 3 (1) (2014), pp. 74-86

[27] Pokhrel, B. K., Paudel, K. P., & Segarra, E. (2018). Factors affecting the choice, intensity, and allocation of irrigation technologies by US cotton farmers. Water, 10(open in a new window) (6(open in a new window)), 1–12. https://doi.org/10.3390/w10060706

[28] Jeffrey R. Alwang, Chair; Everett B. Peterson and Daniel B. Taylor (2012). The Impact of Distance to Market on Smallholders Crop and Technology Choices. Thesis submitted to the faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of Master of Science in Agricultural and Applied Economics.

[29] Phogella MG, Anbaw WS. (2023). Household income difference between irrigation user and non-users: Evidences in southern Tigray, Ethiopia. AGBIR. 2023; 39(2):479-481.

[30] Mengistie D, Kidane D. (2016). Assessment of the impact of small-scale irrigation on household livelihood improvement at Gubalafto District, North Wollo, Ethiopia. Agriculture. 2016; 6(3):27.

[31] Gebru, G.W., Ichoku, H.E. & Phil-Eze, P.O. (2018). Determinants of livelihood diversification strategies in Eastern Tigray Region of Ethiopia. Agric & Food Secur 7, 62 (2018). https://doi.org/10.1186/s40066-018-0214-0

[32] Lokee, M. (2014). Effect of food insecurity on household income in Karamoja a Case Study of Katikekile Sub-County, Moroto District.

[33] Awol Hussen and Arebu Hussen (2024). Influence of Small-Scale Irrigation on Livelihoods of Rural Farm Households in the Case of Legehida District, Ethiopia. The scientific world Journal. Doi: 10.1155/2024/9982796

[34] Ayele GK, Nicholson CF, Collick A, Tilahun SA, Steenhuis TS (2013). Impact of small-scale irrigation schemes on household income and the likelihood of poverty in the Lake Tana basin of Ethiopia: In Wolde Mekuria. (ed). Rainwater management for resilient livelihoods in Ethiopia: Proceedings of the Nile Basin Development Challenge science meeting, Addis Ababa, 9–10 July 2013. Technical Report 5. International Livestock Research Institute. Nairobi, Kenya. pp. 17-18.

[35] Kinfe A. (2012). Irrigation versus rain-fed agriculture: Driving for households' income disparity. Ethiopia Agric. Res. J. 2(1):27-28.

[36] Hoddinott, John and Yisehac Yohannes (2002). Dietary Diversity as a Food Security Indicator. Food and Nutrition Technical Assistance Project, Academy for Educational Development, Washington, D.C.

[37] Ebrahim EA and Toy A (2024). Impact of irrigation participation on households food security in a rural area of Ethiopia: application of propensity score matching (PSM) method for causal inference. Front. Sustain. Food Syst. 8:1403317. doi: 10.3389/fsufs.2024.1403317

[38] Abonesh Tesfaye, Ayalneh Bogale, Regassa E. Namara, and Dereje Bacha (2008). The Impact of Small Scale Irrigation on Household Food Security: The Case of Filtino and Godino Irrigation Schemes in Ada Liben District, East Shoa, Ethiopia" published in the journal Irrigation and Drainage Systems, volume 22, issue 2, pages 145-158, DOI: 10.1007/s10795-008-9047-5

[39] Mangisoni JH. (2008). Impact of treadle pump irrigation technology on small-holder poverty and food security in Malawi: a case study of Blantyre and Mchinji districts. Int J Agric Sustain. 2008. https://doi.org/10.3763/ijas.2008.0306.

[40] Graciana P. (2011). The impact of small scale irrigation schemes on household food security in Swaziland. J Sustai Dev Africa. 2011; 13:102–17.

[41] Issahaku IE. (2018). Impacts of small scale irrigation on food security and rural livelihoods empowerment in lawra municipality. A thesis submitted to the department of environment and resource studies, faculty of integrated development studies, university for development studies, in partial fulfilment of the requirement for the award of master of philosophy degree in environment and resource management,

Funding
The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

Competing Interests

Financial interests: Author A, B and C declare that they have no financial interests.
The authors have no relevant financial or non-financial interests to disclose."

Author Contributions
All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by [Brhane Gebremedhin], [Alem-meta Assefa] and [Mare Addis]. The first draft of the manuscript was written by [Brhane Gebremedhin] and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.