

Research Article

# Impacts of Irrigated Water Use on Household's Income in South Wollo Zone, Amhara Regional State, Ethiopia

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## Abstract

Agriculture is the backbone of the Sub-Saharan African economy. Ethiopia's GDP is also shared by 45 from the agriculture sectors. However, it is confronted and challenged by variable rainfall and climate changes. Particularly, in South Wollo zone, agriculture is not exceptional in facing such daunting challenges and effects of variable rainfall and climate change despite there are abundant alternative irrigated water resources. River and groundwater sources have not yet been used as alternative uses for agricultural production. As a result, rural households' income couldn't meet their minimum food and nonfood requirements. This study, thus, attempted to evaluate the impact of irrigated water use on rural household's income in South Wollo Zone, Amhara regional state, Ethiopia. In pursuit of this, it employed a descriptive type of research design and triangulated research approach that consists of both quantitative and qualitative techniques. Primary and secondary data were collected from small scale irrigated households and secondary sources. Binary logistic regression was used to determine major significant factors that affect households' irrigated water use for agricultural production. A propensity core matching model was employed to evaluate irrigated water use and agriculture on household's income. This study result (binary logistic regression result) showed that the household's family size, land size and willingness were significant factors that determined irrigated water use for agricultural production at 95 percent level of significance. The propensity score matching model result also shows that irrigated water use significantly created significant impact on household's income. It is, thus, keenly important to change and improve the smallholder farmer's land size, extension services, rural credit, technology, education level, awareness about family size, and willingness to use irrigated water sources, such as, ground and river water for agriculture agricultural production that increase their level of income.

## Keywords

Households, Smallholder Farmers, Income, Irrigated Water Use, Agriculture

## 1. Introduction

Agriculture is the dominant form of economic activity worldwide and it also provides different ecosystem services. In Sub-Saharan Africa (SSA), agricultural development is the main vehicle to end poverty as the majority of the population depends on agriculture for their livelihood [1]. However, agriculture by its nature is highly sensitive to climate varia-

tions such as insufficient rainfall, rainfall variability, and drought [2]. Water resource is lifeblood to exist on land. It is an economic good when firms use to produce goods like packing water and soft drink producing. It is among the major natural resources that determines agricultural production. It is also an economic good when farmers use to produce eco-

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economic goods like commercial cereals and vegetables using irrigated water sources. Water is among the most vital and versatile natural resources [1] and has always played an essential role in Ethiopian society as it is an input to almost all production systems [2]. Water is also considered as an essential resource for irrigation. Irrigation can be defined as an artificial application of water to soil for the purpose of supplying the moisture essential in the plant root-zone to prevent stress that may cause reduced yield and/or poor quality of harvest of crops [3]. This is an intentional action taken by humans to apply water for growing crops, especially during dry seasons where there is a short of rainfall. Water applications to crop fields are of various types. The most commonly used and most ancient type is surface irrigation methods through the use of gravity forces [4]. This was used especially across river sides, and it doesn't depend on mechanized equipment. It is obvious that modernized irrigation systems, nowadays, are mostly used work based on the pressurized energy system [5].

Agriculture still remains the main stay of Ethiopian economy, where around 95% of the country's agricultural output is produced by smallholder farmers [6]. It is the backbone of the Ethiopian economy; it contributes 70% of export earnings, 80% of employment and 40.2% of the country's gross domestic product [7]. However, agriculture could not get due attention to ensure food poverty in the rural areas. This might be the fact that agriculture depends on variable rainfall and triggered by continuous drought.

Agriculture is also the main source of livelihood for the mass of population in the least developing countries, including Ethiopia. However, this agriculture is, still, confronted by climate variability and temperature, which is stagnant to ensure and improve the overall development. This might be the fact that variable rainfall and inability to use irrigated water, lack of technology etc caused and determined slow productivity and growth. Ethiopia is not exceptional in facing such daunting subsistence agricultural problems and resultant outcomes in households where there is the highest rainfall variability that adversely affects its productivity in the South Wollo Zone, Ethiopia.

It is still recognized that agriculture is a mainstay of the Ethiopian economy [8]. The country is endowed with ample water resources with 12 river basins with an annual runoff volume of 122 billion m<sup>3</sup> of water and an estimated 2.6-2.65 billion m<sup>3</sup> of groundwater potential [9]. Due to this, Ethiopia is considered to be the water tower of Africa [10]. The cultivated agricultural land of Ethiopia currently under cultivation is about 12 million ha [11].

According to different scholars' findings show, for instance, in the highlands of Ethiopia, irrigation practices have long been in use since ancient times for producing subsistence food crops [12]. Different authors such as [13] stressed that supplementary irrigation has been practiced by smallholder farmers of Ethiopia for centuries to solve their livelihood challenges. This study, thus, assessed the impact of irrigated

water use on households' income in South Wollo Zone, Amhara Regional state, Ethiopia using cross-sectional survey data.

## 2. Statement of the Problem

Agriculture is the main sector that is used as a source of income for rural households in Ethiopia. However, it is manifested by multidimensional problems such as rainfall variability, climate change, a skilled workforce, and lack of awareness about using irrigated water sources, etc. On the other hand, Ethiopia is endowed with ample water resources with 12 river basins that provide an estimated annual runoff of 125 billion m<sup>3</sup> and 22 natural and artificial lakes, and the groundwater potential varies from 2.6 to 13.5 billion m<sup>3</sup> per year, which makes an average of 1,575m<sup>3</sup> of physically available water per person per year, a relatively large volume [14].

Moreover, Ethiopia has at least 5.3 million hectares (5.3 Mha) of irrigation potential; 3.7 Mha from gravity-fed surface water, 1.1 Mha from groundwater and 0.5 Mha from rainwater harvesting [15]. According to the United Nations Development Group [16], impact is defined as changes in people's lives. This might include changes in knowledge, skill, behavior, health or living conditions for children, adults, families or communities. Such changes are positive or negative long-term effects on identifiable population groups produced by a development intervention, directly or indirectly, intended or unintended.

One third of the population in Africa is already living in drought-prone areas and 220 million are exposed to drought each year [17]. The Horn of Africa is identified as being the most vulnerable to the impact of climate change, particularly drought. The agricultural sector accounted for 37 percent of Ethiopian GDP, and employed 72 percent of the labor force [Ibid]. So, one can easily understand that "water-centered dev't" is the key to growth and transformation of the country. The growth and change plan (GTP2) also considers enhancing the use of a country's water resources [18].

However, currently, in Ethiopia, the irrigation subsector is not significantly contributing to the national economy [19].

According to their reports, the main factors are no consistent and reliable inventory data, lack of agreed reports in common consensus and well-studied documented reports with regards to water and irrigation-related potentials and implementations.

Irrigation use in Ethiopia dates back several centuries, and continues to be an integral part of Ethiopian agriculture. In Ethiopia, modern irrigation began in the 1950s through private and government-owned schemes in the middle Awash Valley where big sugar, fruit and cotton state farms are found [20]. In Ethiopia, irrigation development is a priority for agricultural transformation.

In Ethiopia, there are diversified climate ranging from semi-arid desert type in the lowlands to humid and warm

(temperate) type in the southwest [21] also described high interand intra-annual rainfall variability in Ethiopia; complex topographical and geographical features of the country [22].

According to [23] “a theoretical analysis of Economic Incentive Policies encouraging agricultural water conservation,” to measure, among other variables, the relationship between changes in water supplied and revenue; [24] uses several different models including a Cobb-Douglas production function and Heckscher-Ohlin trading model to analyze the value of water in agriculture; [25] uses a quadratic function composed of several crop input prices, output prices and water prices; [26] research finding indicates, an increase in irrigated crop acreage as well as an increase in water-intensive crop acreage leads to an increase in demand for irrigation water and [27] and [28] work in which marginal revenue is determined and used to find the value of irrigation water.

To overcome the challenge, it is crucial to shift and expand irrigation agriculture. According to [29] narration, irrigation can be defined as an artificial application of water to soil for the purpose of supplying the moisture essential in the plant root zone to prevent stress that may cause reduced yield or poor quality of harvest crops. Likewise, irrigation farming increases the income of smallholder farmers at household level in particular and national level at large [30]. It is Developed by farmers themselves, non-governmental organizations (NGOs) or governments.

Bacha D, et al., [31] examined the impact of small-scale irrigation on household poverty in central Ethiopia, using a propensity score matching and a FGT (Foster–Greer–Thorbecke) model. Based on the findings, they reported that land productivity, credit utilization, mean off-farm income, asset ownership, extension support, resilience to poverty and mean food and non-food consumption expenditures were significantly higher for irrigators than non-irrigators.

According to [32] concerned to assess the impact of small-scale irrigation schemes on household income in Bahir Dar Zuria Woreda, Ethiopia by using Heckmaan selection model (two-staged), identified the factors that affect households to participate in irrigation. The probit model indicated that owning irrigation land, having a pumping motor and dissatisfaction with the existing irrigation schemes are the most influencing factors that influence irrigation participation.

Poor practices of irrigation management discourage efforts to improve livelihoods, and expose people and the environment to risks. According to [33] irrigation projects have been failing mainly because of insufficient participation by beneficiaries and insecurity of land tenure. Socioeconomic, cultural, religious and gender-related issues pose a problem with full and equal participation by beneficiaries [34]. The poor performance of irrigation in the country, systematic and holistic evaluation of irrigation management in general and of small-scale irrigation in particular is lacking [35].

Besides, the occurrence of irrigated water is not uniform because it depends on various environmental and geological

factors in Amhara region, Ethiopia. The South Wollo Zone is not exceptional in facing such kinds of daunting irrigated water and agricultural production spillovers. According to this study surveyed data, less than 25% of households are engaged on irrigated water agriculture production.

This study, therefore, filled previous study gaps using an instrumental variable model and propensity score matching models that employ cross-sectional survey data. It also used a binary logistic regression model to identify major significant factors that affect smallholder farmers' irrigated water use and its effect on their income in the South Wollo zone, Ethiopia.

### 3. General Objectives

The general objectives of this study analyzed the smallholder farmer's irrigated water use and its effect on household's income in South Wollo zone Administration, Amhara regional State, Ethiopia

#### 3.1. Specific Objective

This study's specific objectives include:

1. Identify factors affecting smallholder farmer's irrigated water use
2. Assess the effect of irrigated water use on agricultural production
3. Compute smallholder farmers irrigated water use efficiency in Woreda
4. Evaluate the impact of irrigated water use on increasing agricultural income

#### 3.2. Research Question

The following research questions were included:

1. What are the major effects of irrigated water use on agriculture production?
2. Do smallholder farmers efficiently use groundwater resources?
3. What are the major significant factors that influence farmer's irrigated water use
4. What is the impact of irrigated water use on small holder farmer's agriculture income?

### 4. Significance and Justification

Irrigated agriculture can fill the existing food and income gap for rural households. However, there is no advanced irrigated agricultural production in the South Wollo zone, Ethiopia. This study, thus, assessed and evaluated the impact of irrigated water use on a household's income. This is due to the fact that in South Wollo, amhara regional state, Ethiopia, agriculture is depending on variable rainfall and irrigated water is not so much used to increase agriculture productivity. This study will help with expanding irrigated water use improves small-scale the holder farmers in the South Wollo zone,

Ethiopia. It will also become an input for data source for further research and help to improve agriculture productivity extension services.

## 5. Scope and Limitation of the Study

This study covered major Woredas in the South Wollo zone, particularly the North West of South Wollo in Amahra regional state called 'Borena', Ethiopia. Namely, this study purposely selected study areas, such as, Wogeda, Borena woreda, Kelala, Saiynt and Legambo woreda administration. This study was limited by respondent's response and data collector's knowledge gaps. Data collectors and respondents' misinterpretation of questions; unwillingness to fill in data; and stata, and spss software data entry errors limited these research findings. However, researchers have reduced limitations by using various techniques of research alternatives that can increase data reliability.

## 6. Organization of the Study

This study consists of five chapters. The first chapter includes background information, statement of a problem, objectives and research questions etc. The second chapter reviewed theoretical and empirical literature. The third chapter is research methodology and fourth chapter discusses data results and analysis. The final chapter concludes and suggests a recommendation.

## 7. Methodology

This research employed a descriptive type of research design using cross-sectional survey data.

A triangulation method, which consists of both qualitative and quantitative methods, will be applied in the course of this study.

Data source: both primary & secondary sources, whereas the sample population were smallholder farmers, who engage in agriculture production in South Wollo zone. The sample target will be smallholder farmers, who use irrigated water resources in Kelala, Wogedie, borena, Legambo and Sayint District.

### 7.1. Sampling Techniques and Sample Size

The sample population was smallholder farmers, who engaged in irrigated agricultural production in the South Wollo zone. Whereas, the sample target was smallholder farmers, who use irrigated water resources in Kelala, Wogedie, borena, Legambo and Sayint District. Purposive sampling techniques are used to select sample districts or woredas, such as Kelala, Wogedie, Borena & Sayint and Legambo Woreda South Wollo Zone.

Rationality, Woredas have similar agro ecological zones.

Similarly, sample kebeles and households were selected using proportional sampling techniques.

Finally, random sampling techniques were used to withdraw sample households. According to a sample work report (2012), the population in Wogedie, Kelala, Sayint, Dessie Zuria, Borena are 168,000, 180,000, 169,000 and 185,000 in order. This study determined sample kebele and sample smallholder farmers. (Yamane, 1967) to determine the required sample size at 95% confidence level, degree of variability = 0.5% (0.05 level of significance) and level of exactness = 9%. Based on this formula, this study collected data from 120 sample respondents who participated in irrigated and non-irrigated agriculture in South Wollo Zone, Ethiopia.

### 7.2. Data Collection and Data Analysis Methods

This study employed structured questionnaire. This study collect data from each woreda and checked its validity and reliability before analysis and discussion. The collected data analyzed using qualitative and quantitative methods. The qualitative methods rationality began to apply grounding theory. Quantitative methods used econometric models such as binary logistic regression model, IVM & PSM. Descriptive and inferential statistics and test were checked and computed using STATA 14 latest software version.

This study also used Binary logistic regression employed to identify the major significant factors that will significantly Influence farmer's irrigated water use for agricultural production

In this proposal, smallholder farmers were asked whether they consume water resources for irrigation or not. The farmer's response was replied to either "Yes" or "No", a typical case of qualitative dichotomous variable.

The most commonly relevant and used qualitative response models are the logit model, which corresponds to a logistic distribution function, and the Probit Model (Gujarati, 2004). This study, thus, used a logit model due to its iterative and easy interpretation for binary response variables.

These logistic regression models specify a functional relation between the probabilities of smallholder farmers irrigating water consumption for agriculture and the various explanatory variables.

Independent variables that affect smallholder farmers' irrigated water consumption for agriculture will be described both quantitatively and qualitatively.

The logit distribution function for the farmers' irrigated water use is specified as:

$$P_i = \frac{1}{1+e^{-Z_i}} \quad (1)$$

Where,

$P_i$ : is the probability of smallholder farmers water use for agriculture production

$Z_i$ : is a function of n- explanatory variables (x) and expressed as: income, family size, education level, and etc.....



$$Z_i = \beta_0 + \beta_{i1} + \beta_{i2} + \dots + \beta_{in} + e_i \quad (2)$$

Where:

$\beta_0$ : is the intercept.

$\beta_1, \beta_2, \dots, \beta_n$  are the coefficients of the equation in the model.

The slopes tell how the log-odds in favor of smallholder farmers irrigated water used for agricultural production was

$P_i$  is not only non-linear in  $X$  but also in the  $\beta_i$ 's, which can be written as:

$$P_i = \frac{1}{1 + e^{-(\beta_0 + \beta_{i1} + \beta_{i2} + \dots + \beta_{in} + e_i)}} \quad (3)$$

This means that we cannot use the OLS procedure to estimate the parameters. But this problem is more apparent than real because this equation is intrinsically linear, which can be shown as follows.

If  $P_i$  is the probability of smallholders' farmers water consumption for agricultural production,

Whereas,  $(1 - P_i)$  is the probability of smallholder farmers are not consuming water can be written as:

$$1 - P_i = \frac{1}{1 + e^{-(Z_i)}} \quad (4)$$

We can take the ratio of the probability of irrigated water consumer and non-consumer farmers:

$$\frac{P_i}{1 - P_i} = \frac{1 + e^{Z_i}}{1 + e^{-Z_i}} \quad (5)$$

It is the ratio of the probability that the farmer will consume irrigated water for agriculture to the probability that he/she will not consume it.

Finally, taking the natural log of equation 5 we get:

$$L_i = \ln \frac{P_i}{1 - P_i} = Z_i = \beta_0 + \beta_{i1} + \beta_{i2} + \dots + \beta_{in} + e_i \quad (6)$$

Thus, if the stochastic disturbance term ( $U_i$ ) is introduced, the logit model becomes:

$$Z_i = \beta_0 + \beta_{i1} + \beta_{i2} + \dots + \beta_{in} + e_i \quad (7)$$

Predicted logit of smallholder farmer's irrigated water use for agriculture production ( $Y_i$ ) i.e

$$Y_i = \beta_0 + \beta_1 \text{ age} + \beta_2 \text{ sex} + \beta_3 \text{ educ} + \beta_4 \text{ familysize} + \beta_5 \text{ dependency} + \beta_6 \text{ culture} + \beta_7 \text{ behaviours} + \beta_8 \text{ landsize} + \beta_9 \text{ awareness} + \beta_{10} \text{ extension service} + \beta_{11} \text{ income} + \beta_{12} \text{ credit} + e_i$$

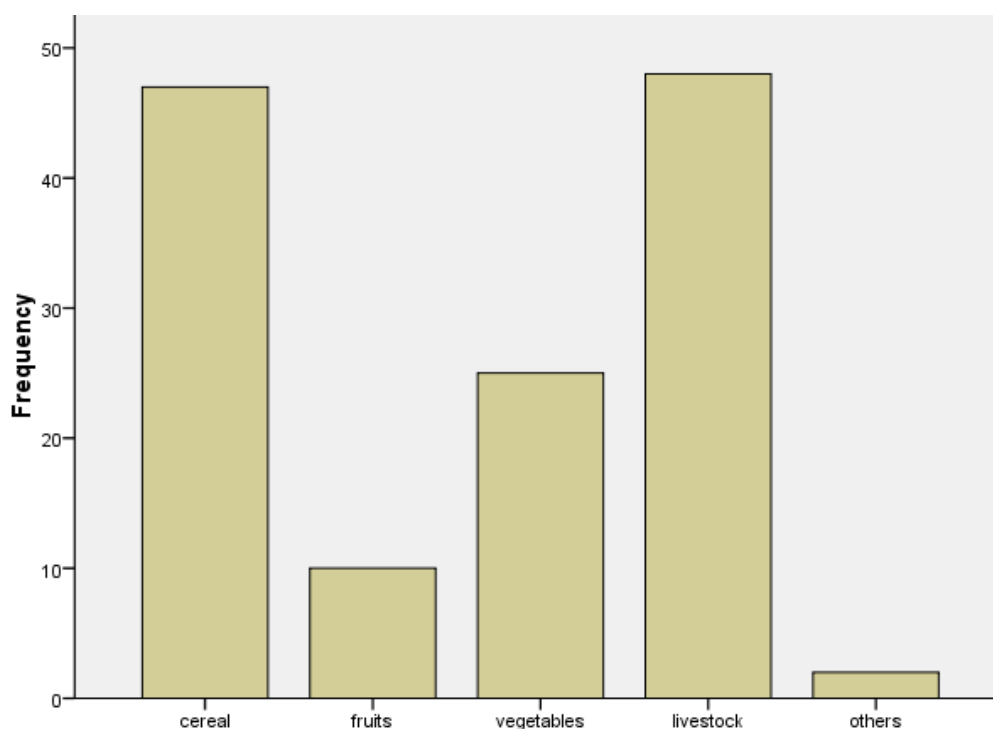
#### Instrumental Variable Model (IVM)

Smallholder farmer's agricultural production and level of income separately became dependent factors ( $Y_i$ ). However, this research classified factors into two categories. Endogenous factors ( $X_i$ ), which were directly associated and determined in the model. Endogenous factors ( $X_i$ ) consist of family size, education level, income, attitude, willingness, behavior, culture etc. In this study, exogenous factors ( $Z_i$ ) include institutional proxies, geographical settings, water source, distance, land size, price, and technology etc. determined by the model. Endogenous factors ( $X_i$ ) consist of family size, education level, income, attitude, willingness, behavior, culture etc. In this study, exogenous factors ( $Z_i$ ) include institutional proxies, geographical settings, water source, distance, land size, price, technology etc.

## 8. Finding and Discussion

Agriculture is the main sector in the Amhara regional state, particularly, in Wollo Zone, Ethiopia. However, climate variability and temperature changes have challenged the sector to increase its productivity every year. Smallholder farmers, despite having a small land size compared to family size and demand for agricultural production, still depend on variable seasonal rainfall and can't fulfill the minimum income requirement for survival. As a result, most smallholders were found below the income poverty line. This study result showed that alternative irrigated water sources could enhance and improve rural household's livelihoods in the study area. This study statistical evidence showed out of total participants, 35.6%, 36.4% and 18.9% used irrigated water for cereal, livestock and vegetable production respectively.

Irrigated agricultural activities are in fact varied across agricultural zone and thereby rely on the smallholder's preference to engage in the sector. This study identified different types of agricultural activities of which farmers used irrigated water sources. Among major irrigated agriculture activities, smallholder farmers participated in cereals, fruits, vegetables, livestock agriculture and others. Out of these activities, the majority of farmers produce cereal, vegetables and livestock using irrigated water sources in south wollo zone respectively.

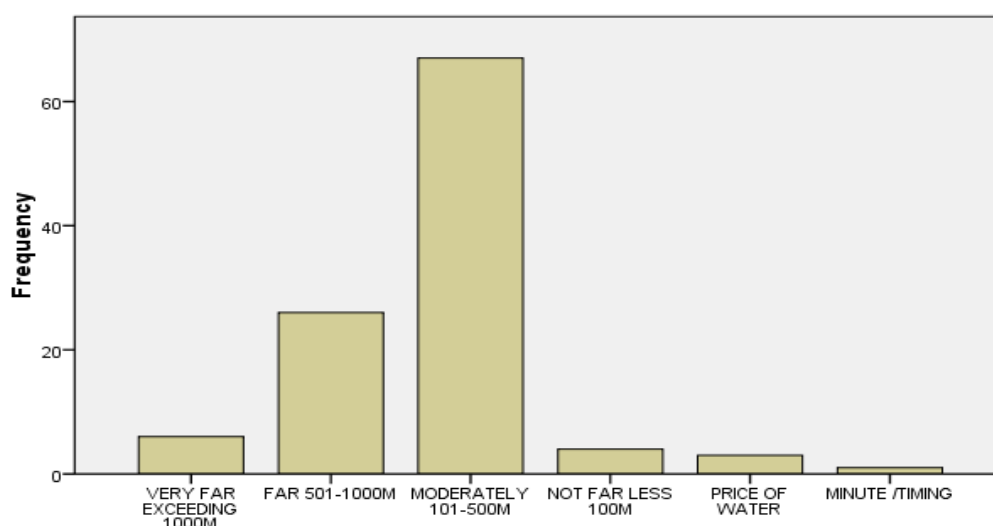


Source: Data survey, 2022

**Figure 1.** Types of Irrigated Agriculture in South Wollo Zone.

Farmers' irrigated water use demand, water quantity, and distance from the source, as well as technological accessibility and price determine irrigated activities in the south wall zone. This study result below in a figure indicated that smallholder farmer's accessibility of irrigated water source

was found far distance and then affected expansion of irrigated water use for agricultural production. However, most respondents replied that the irrigated water source was moderate, which is 101-500m, a far distance from irrigated land for agriculture.



**Figure 2.** Distance of Irrigated Water Source from Irrigated Land.

Irrigated water source and quantity determine irrigated agricultural activities in the South Wollo Zone. Irrigated infrastructure and technology to supply water for irrigation activi-

ties are still influencing farmers to expand irrigated land use in the study area. Agriculture Extension and non-integrated smallholder farmers' participation along with land neighbors

also affected irrigated water use and affecting its distance from the water sources, such as river, groundwater, etc.

Logistic regression				Number of obs		=	132
				LR chi2(5)		=	7.75
				Prob > chi2		=	0.1706
Log likelihood = -75.357525				Pseudo R2		=	0.6489
-----							
variable	dy/dx	Std. Err.	z	P> z	[	95% C.I.	]
-----+-----							
HHsex	.0014511	.11432	0.01	0.990	-.222617	.225519	1.19697
HHage	-.0012332	.00427	-0.29	0.773	-.009601	.007135	42.6742
HHfamsiz	-.0211606	.01801	-1.17	0.240	-.056459	.014138	4.18182
HHMarist	-.2143685	.11061	-1.94	0.053	-.431158	.002421	1.91667
HHeduc	-.045522	.03616	-1.26	0.208	-.116389	.025345	2.43182

**Figure 3.** Factor Affecting Smallholder Farmer Decision to Use Irrigated Water Source In South Wollo Zone, Ethiopia.

Smallholder farmers' decision to use irrigated water for agricultural production was affected by multidimensional factors. This study used households' decision to use irrigated water for agriculture was dependent on a variable. Whereas, availability of irrigated water, availability of irrigated land,

land size and irrigated land use for agricultural types were explanatory variables. Out of the mentioned variables, farmers' willingness to use irrigated land for significantly affected by their decision to use irrigated water for agricultural production at 95 percent confidence level in the south wollo zone.

Logistic regression							Number of obs	=	120
							LR chi2(4)	=	39.47
							Prob > chi2	=	0.0000
Log likelihood = -60.144961							Pseudo R2	=	0.8471
-----									
variable	dy/dx	Std. Err.	z	P> z	[	95% C.I.	]	X	
-----+-----									
IRRWAGRI	.109168	.06317	1.73	0.084	-.014641	.232977		2.05	
IRRILAND*	.6055772	.08722	6.94	0.000	.434634	.77652		.766667	
LANSIZE	.0075211	.26314	0.03	0.977	-.50823	.523272		.2985	
IRRLNDUS	-.030686	.03676	-0.83	0.404	-.102738	.041366		2.475	
-----									
(*) dy/dx is for discrete change of dummy variable from 0 to 1									

Source: Data Survey 2022/23

**Figure 4.** Factors Affecting Smallholder's Irrigated Agriculture production.

As is indicated in figure 4 above, agricultural water use agricultural decision by farmers requires continuous agricultural extension and capacity building services to enhance their irrigated agricultural productivity. Despite although there is accessibility of irrigated water sources like small rivers,

farmers were not sensitive and willing to use it for agricultural production instead. They kept seasonal rainfall. Because they believed that irrigation makes their land lose its nature and fertility for seasonal production. It is therefore fundamental to improve farmers' awareness to use sources called irrigated

water, to improve their income as well as their livelihoods.

Treatment-effects estimation		Number of obs	=	121
Estimator	: propensity-score matching	Matches: requested	=	1
Outcome model: matching		min	=	1
Treatment model: logit		max	=	3
-----				
		AI Robust		
HHINCOM		Coef.	Std. Err.	z P> z  [95% Conf. Interval]
-----+-----				
ATE				
HHIRRU				
(Yes vs No)		7641.873	1510.26	5.06 0.000 4681.818 10601.93

Source: Survey Data, 2023

**Figure 5.** Impacts of Irrigated Water Use on Smallholder's Household's Income.

Seasonal agriculture is a major source of households' livelihoods in the study area. Irrigated water and land use varies across each agro-ecological zone. Smallholder farmers use small plots of land for agricultural production. Along with the demand of farmers and the availability of water sources, irrigated water use and land size productivity were determined but differently for different agricultural uses. This study logistic regression model result shows that household irrigated water use is significantly affected by their level of income at 95 confidence levels. In other words, a smallholder farmer's income, which used irrigated water sources, was more than that of users of non-irrigated water users. However, the number of smallholder farmers who use irrigated water is not much greater than the non-irrigated users. Productivity is determined.

## 9. Conclusion

Agriculture is the largest consumer of water and total evapotranspiration from global agricultural land could double in the next 50 years if trends in food consumption and current practices of production continue. There is an imminent need to improve water use efficiency or, more importantly, water productivity. It is highly determining the rural economy in Ethiopia. Agriculture production mainly depends on seasonal variable rainfall. As a result, farmers are not aware enough to use irrigated water as an alternative to irrigated agricultural production. This study, thus, evaluated the impact of irrigated water use's effect on household's income in the South Wall Zone. It employed a descriptive type of research design using cross sectionally surveyed data from the selected Woredas.

This study employed a propensity score matching model that used to evaluate irrigated water use for agricultural income. This study result found smallholder farmers used irrigated water for cereal, vegetable, and fruit production. However, land size, lack of technology and price-rising rises affected agricultural water use for agricultural production. Moreover, irrigated water is far distances from irrigated land agricultural were one of the factors that challenged smallholder farmer's agricultural production. Logistic regression model results revealed that among the major factors Irrigated land size were found significantly affecting smallholder farmers' irrigated water use at the 95 confidence level in South Wollo Zone, Amhara regional state, Ethiopia.

## 10. Recommendation

Improving water use efficiency or enhancing agricultural water productivity is a critical response to growing water scarcity, including the need to leave enough water in rivers and lakes to sustain ecosystems and to meet the growing demands of cities and industries. Water is an economic good which is valued using valuation and non-valuation techniques. Ethiopia has abundant water resources. However, it is not yet exploited and used for irrigated agricultural production. In Amhara regional state, particularly in the South wollo zone, agriculture shares the largest percentage of its income and becomes the main source of livelihood. Nevertheless, agriculture is still on and affected by seasonal and variable rainfall and by climate change. Smallholder irrigated agriculture is not yet ensuring the rural household's food security. Irrigated agriculture and irrigated water use



are significantly interlinked to achieve food security. This study findings confirmed that irrigated water user households These substantially improved their livelihoods and income compared to non-irrigated water users. It is, thus, important to use irrigated agriculture to improve rural households' income in the South Wollo, zone, Amhara regional states and, at large, in Ethiopia.

## Conflicts of Interest

This author declare that no conflict of interest.

## Appendix

**Table 1.** Sample woredas and participants in south wollo zone, Amhara region, Ethiopia.

Study Area	Number of Kebele	Sample Kebele	Sample Households	Non Irrigation Participant	Non Irrigated User
Borena Woreda	35	4	75	38	38
Kelala	31	3	50	25	25
Legambo	32	3	50	25	25
Sayint	35	4	75	37	37
Wogedie	34	3	50	25	25
Total			300	150	150

**Table 2.** Major types of irrigated agricultures in south wollo zone, Ethiopia.

Types of Agriculture	Frequency	Percent
cereal	47	35.6
fruits	10	7.6
vegetables	25	18.9
livestock	48	36.4
others	2	1.5
Total	132	100.0

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