Small-scale irrigation and its effect on food security of rural households in North-West Ethiopia: A comparative analysis

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ABSTRACT

Agriculture is a limiting factor for food security in Ethiopia as more than 80% of the population depends on it for livelihoods. In many parts of the country, the frequency and distribution of rainfall and the principal source of water for crop production are getting more unreliable and inadequate and frequent droughts, make irrigation farming indispensable. Despite the high potential for irrigation, the study area remained to be one of the food insecure districts in the region and currently it is supported by the productive safety net program. Information is also missing on the extent to which households who have access to irrigation produce more than those who depend on rainfed agriculture. The study contributes to a comparative analysis of the effect of small scale irrigation. The aim of the study was to analyze the effect of small scale irrigation on the food security of rural households. Data were collected from 185 randomly selected rural households in the Goncha-SisoEnesie district of northwest Ethiopia. Descriptive analysis, household food balance model and binary logit regression were employed as tools of data analysis. The result revealed that out of all sampled households, 74% were food secured and 26% were not. The gap in food calorie availability was high ranging from 753-6659 kcal/adult equivalent/day in the study area. Out of 84 irrigation users, 84.5% of them were food secured; whereas only 65.3% of the total 101 non-irrigation users were food secured. In this study, household size, farmland size, access to irrigation, access to credit services, and income from rainfed crop production were the determinant factors of household food security. Small scale irrigation had a direct and indirect positive effect on enhancing household food security status. Thus, the concerned development partners and policymakers should consider the promotion and expansion of irrigated farming in the area.

Keywords: Small-scale irrigation, Food security, Household income, Household food balance, Binary logit model, Northwest Ethiopia.
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INTRODUCTION

Ethiopia is an agrarian country, where agriculture is the leading sector as a source of income, employment for more than 80% of the population, source of foreign exchange and national economic growth. The country's economy is determined by the performance of the agriculture sector. The Ethiopian agricultural production is characterized by smallholder rainfall dependent cultivation practices, where a variety of crops are produced throughout the country that defined the success of the production, yield and welfare outcomes (Chamberlin and Schmidt, 2011). In the past few years, the federal and the regional governments of Ethiopia, and donor agencies have been given attention to promoting small-scale irrigation schemes that were targeted to improve the food security of the smallholder farmers (Abdissa Feyera *et al.*, 2017). Although Ethiopia has an irrigable potential of 3.7 million hectares of land, only less than 5 percent of it has been utilized so far (MoWR, 2002). The dominant agricultural system in the country is a smallholder production of cereals under rainfed condition (World Bank, 2006).

As a strategy of water resource development in Amhara region, irrigated agriculture has become the main intervention to mitigate recurrent drought and rainfall variability in the country (Goncha District Administrative office, 2017). The report from USAID (2000) on its assessment of the Amhara region food security indicated that fourty eight districts out of 105 districts in the region were drought-prone and chronically food insecure. East Gojam zone is one of the zones in the region where food insecurity is a serious issue. Achenef Motbainor *et al.* (2016) reported that 59.2% of households in east Gojam zone were food insecure.The study area, Goncha-Siso-Enesie district, is one of the food insecure districts in east Gojam zone of the Amhara region. The district is currently supported by the productive safety net program. Drought is one of the major disasters in the district caused by deforestation and population growth, responsible for reducing crop and animal yield, malnutrition and starvation in the district (Goncha District Agriculture Office, 2015). There are different reasons for the occurrence of food insecurity and poor living standard in the study area. Among others, inefficient use and depletion of natural resources, recurrent drought and natural hazards, the erratic nature of rainfall, rainfall-dependent agricultural practices, crop and livestock diseases and pests, aggravated soil erosion and decline of crop production and productivity are the main ones (Goncha District Agriculture Office, 2016). Farmers practice rainfed agriculture, which suffers from multiple natural hazards like drought, hailstorm, frost, pests, and diseases, and thereby reduce yields.

Although there is a high potential of irrigation water in the study area, it is not well known to what extent production is better off for households using irrigation than those who are depending on rainfed agriculture. The existing studies regarding the effect of irrigation on households' food security are insufficient and they lack comparative analysis of factors that determine households' food security. Therefore, in the current study, a comparative analysis between irrigation users and non-users (only rainfed producers) was conducted. The extent to which small scale irrigation determines the household food security was assessed. The current status of food security of rural households and the determinants influencing food security of households, besides small scale irrigation, were also identified.

MATERIALS AND METHODS

Description of the study area

Goncha-Siso-Enesie district is one of the 18 districts of East Gojam Administrative Zone of the Amhara Regional State in northwest Ethiopia. The district is located at a distance of 343 km from Addis Ababa, the capital of Ethiopia. The district is bordered by Hulet Eju Enesie district to the west, Enebsie Sar Midir district to the east, Enarj Enawga district to the South, and south Gondar Zone to the North (Figure 1). The District had 37 rural and 2 urban *kebeles*, with total households of 37,209 of which 11,597 of them were female-headed households (Goncha District Economic and Finance Office, 2017).

The agro-ecological situation of the study district is characterized by 12% 'Dega' (highland ranging 2200–3200 m.a.s.l), 48% 'Woinadega' (Midland ranging 1600-2200 m.a.s.l), and 40% 'Kolla' (lowland ranging 1000- 1600 m.a.s.l). The area is classified as 46% plain, 16% undulating and 38% mountainous. The nature of the soil is shallow in depth and bare that makes it vulnerable to soil erosion. The dominant soil type is brown (60%) followed by gray (20%) and red soil (15%). The district covers a total area of 98,385 ha, with a land-use pattern of 46,664.30 ha cultivated 11,698.05 ha grazing, 6,358 ha bushlands, 320 ha forest, and 1846 ha water bodies, 5276 ha barren land, and18520 ha settlement. The district has a unimodal type of rainfall that extends from June through September.

It sometimes receives little precipitation between April and May. The average annual rainfall of the district is 1100-1500 mm but with uneven distribution of rainfall with respect to time and space (Goncha District Administrative Office, 2017).

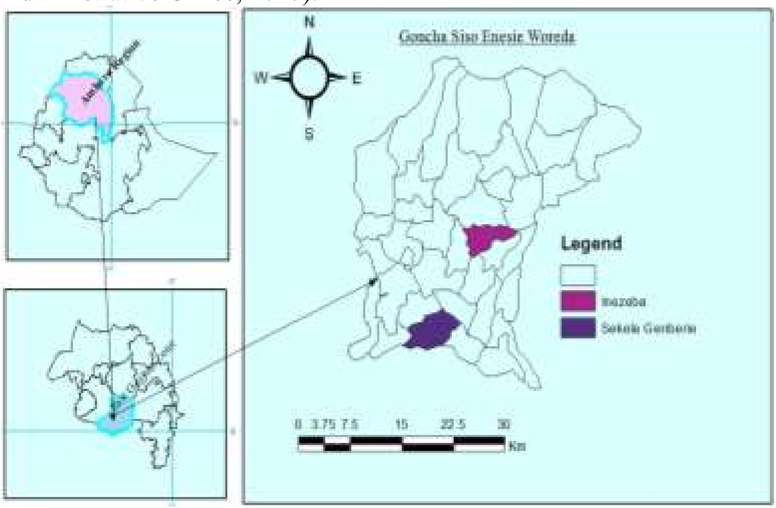

Figure 1. Map of the study area

Sampling techniques and sample size

Multi-stage sampling technique was employed to select the study area, irrigation sites and sample households. In the first stage, the study area, Goncha-Siso-Enesie district, was selected purposively given the experience of the researchers in the area and the fact that the district is among the food insecure, drought-affected districts in the Amhara region. Then,two small scale irrigation schemes were selected from the two rural kebeles (one scheme from each kebele) considering their potential for irrigation production, the recommendation of the district agriculture office and their better performance among others so as to enable the comparison between the food security status of irrigation users and non-users. In the third stage, the total households of the two selected kebeles had been stratified into two groups as irrigation users and non-irrigation users using the list obtained from the local agricultural office. To determine the size of sample for this study, Yamane's (1967) sample size determination formula was used.

Tarro Yamane's formula (1967) is given as: $n= \frac{N}{1+N(e)2}$

Finally, a simple random sampling technique was employed to select 185 households (Table 1).

Table 1. Sample size determination.

Kebele (irrigation scheme)	Sample frame			Sample size		
	Irrigation user	Non-user	Total	Irrigation user	Non-user	Total
Shigeze	250	470	720	24	44	68
Anijeb	750	500	1250	60	57	117
Total	1000	970	1970	84	101	185

Method of data collection

Both primary and secondary sources of data were used. Primary data was collected from sample households (survey), focus group discussion (FGD), key informant interview and transect walk were also conducted.

Method of data analysis and model specification

Both descriptive and econometric data analysis techniques were employed. Descriptive statistical techniques such as mean, percentage, mean difference and standard deviation were used for presenting differences in socioeconomic variables between irrigation users and non-users. The food security status of sampled households in the study area was analyzed using the Household Food Balance Sheet Model (HFBM). The model was initially formulated by Degefa Tolossa (1996) adapted from FAO Regional Food Balance Model and then used by various researchers (Messay Mulugeta, 2010; Getinet Kebede, 2011; Demeku Mesfin *et al.*, 2015). The household food balance sheet equation tries to include all the available cereal and non-cereal food items as stated below.

Household food balance sheet model:

NGA = (GP +GB +FA +GG) – (GS +GU + GV + HL)
NGA= Net grain available
GP= Total grain produced per year per household
GB= Total grain bought per year per household
GA= Total grain obtained from aid per year per household
GG= Total grain obtained as gift from others or remittance per year per household

GS= Quantity grain sold per year per household
GU= Amount of grain reserved for seed per year per household

GV= Total grain given for others per year per household
HL= Post-harvest loss per year per household

In addition, an econometric analysis was employed to examine the determinants of households' food security in the study area. For this analysis, binary logistic regression econometric model was employed to estimate the determinants of the dependent dichotomous variable, food security status of households.

Measuring food security status of sample households

In assessing the food security status of sampled households in the study area, the following steps were followed. First, all stable food sources of cereals and non-cereal grains available to sample households for the past one year (January 2017-December 2017) were collected. Secondly, the collected data was structured in HFBM equation to determine the net food availability situation of the sampled households. Finally, the food energy requirement for each sampled household members was calculated by converting into adult equivalent ratio.

In this study, food security status was measured as the extent of food grain available for home consumption stated in kilocalories per adult equivalent per day. In the end, an attempt was made to convert food grain available for sampled households into dietary calories using EHNRIs food consumption table (Annex 1). By doing this, all sampled households daily dietary status at adult equivalent per day was identified. Then, households who were found to fall above the national minimum daily calorie requirement level, i.e. > 2100 kcal/day/ adult equivalent categorize as food secure and households who fall below the national daily calorie requirement were categorized as food insecure.

The operational form of the logistic regression model is stated as follows (Gujarati, 2004).

$$Pi = E/ y=1/ Xi = \frac{1}{1+e^{-\beta 0+ \beta iXi}} \quad (1)$$

For ease of exposition, we write (1) as:

$$Pi = \frac{1}{1+e^{-Zi}} \quad (2)$$

The probability of a household being food secured is expressed in (2) but, the probability for food insecure is:

$$1\text{-}P = \frac{1}{1+e^{Zi}} \quad (3)$$

Then, it could be written as:

$$\left[\frac{\text{Pi}}{1-\text{Pi}}\right] = \frac{1+e^{Zi}}{1+e^{-Zi}} \quad (4)$$

Equation (4) is referred to as the odds ratio of the probability of a given household food secure to the probability of food insecure.
Taking the natural log of (4) we will get

$$\text{Li} = \text{in}\left[\frac{\text{Pi}}{1-\text{Pi}}\right] = \text{Zi}= \boldsymbol{\beta}\text{o} + \boldsymbol{\beta}\text{iXi} \quad (5)$$

Where Pi will be the probability of food secure range from 0 to 1
Zi = the function of n explanatory variables (X) which determine the level of food security
$\boldsymbol{\beta}$o = the intercept
$\boldsymbol{\beta}$i = represents the coefficient of the equation in the model
Li = is the odds ratio
Xi = independent variables determine households food security

Definition of variables

The definition and measurement of the variables used for the econometric model are summarized in Table 2.

Table 2. Definition of variables, measurements, and expected signs*.

Variables in the model	Variable type	Measurement
Dependent Variable		
Household food security	Dummy	1=food secured; 0= otherwise
Independent Variables		
Sex of the household head	Dummy	1= Male 0 = female
Age of household head	Continuous	Measured in years
Education level of household head	Categorical	lliterate (reference category) If Elementary = 1; 0 = otherwise If Junior = 1; 0=otherwise If Highschool=1; 0=otherwise If college and above=1; 0= otherwise
Total number of family members	Continuous	Measured in the adult equivalent
Livestock holding	Continuous	Measured in TLU

Total cultivated land size	Continuous	Measured in hectares
Use of credit service	Dummy	1= uses credit 0= otherwise
Extension contact	Dummy	1= if has extension contact 0= otherwise
Access to small-scale irrigation	Dummy	1= access to small-scale irrigation; 0= otherwise
Income from rain-fed crop production	Continuous	Measured in ETB (ETB 1 = USD 0.035), ETB = Ethiopian Birr
Use of inputs (fertilizer)	Dummy	1= used inputs 0= otherwise

*Expected sign is + for all independent variables

RESULTS AND DISCUSSION

Descriptive results

Sex of the household head was an important limiting factor in irrigation farm participation. The results show that out of the total 185 respondents, 81.62% were male-headed households whereas the rest 18.38% were female-headed households (Table 3). About 88.1% of irrigation users were male-headed households whereas only 11.9% of the user households were female-headed. This indicates that male-headed households were more likely to participate in irrigation farming than female-headed households. This is because irrigation production needs more labor and female-headed households have labor shortage that makes them to low participation ratio in irrigation farm.

The result shows that from the total 84 sampled irrigation users, 69% were literate and the rest were illiterate. Out of the total 101 sampled non-irrigation user respondents, only 48 (47.5%) were literate and had different levels of education as mentioned above while 53 (52.5%) of non-irrigation respondents were illiterate. The results indicate that irrigation user households have better literacy level as compared to non-user households. This indicates that literate household heads are more likely to receive new technologies and participate in irrigation production than their non-user counterparts.

The mean age of irrigation users and non-user household heads were 41.86 and 45.98 years, with a standard deviation of 8.30 and 11.03, respectively. As a result, the age of the household head had a significant difference between small scale irrigation users and non-users. The mean age of irrigation users was less than the mean age of non-irrigation users. This indicates that being youth might allow households to participate and perform irrigation activities to generate more income than elders. This may also be considered as young households participate in irrigation production using even renting lands than the older ones. The figures corroborate studies reported before (Fekadu Abdisa, 2012) but not others (Abraham Gebrehiwot, 2015).

Table 3. Sampled household characteristics of sex and education level.

		Use of irrigation farming			
		No		**Yes**	
		Number	**%**	**Number**	**%**
Sex of respondent	Female	24	23.8	10	11.9
	Male	77	76.2	74	88.1
Education level of respondent	Illiterate	53	52.5	26	31.0
	Literate	35	34.7	32	38.1
	Grade 1-4	5	5.0	13	15.5
	Grade 5-8	7	6.9	11	13.1
	Grade 9 & above	1	1.0	2	2.4

As indicated in Table 4, the mean family size of irrigation users and non-users was 5.1 and 4.3, respectively with significant mean difference. Engaging in irrigation farm needs more labor and the result shows irrigation users had more family labor than the non-users. As family members were the main source of labor in the study area, households who had more family members were more likely to participate in irrigation farms than households with smaller family size.

The average landholding size of sampled irrigation users was 1.53 and non-users 1.15 hectares. Landholding size was significantly different between irrigation users and non-users ($t=4.32$, $P<0.01$). Irrigation user households had more farmland holding size than their counterparts. Irrigation user households might have the capacity to use rented lands using the income from irrigation agriculture because farmland is the basic production asset in the study area that guarantees the assurance of household food security.

The mean livestock holding size of sampled irrigation users was 5.17 and non-users was 4.21 (measured in TLU, tropical livestock unit). This shows that irrigation user households had more livestock holding size than non-user households. In the study area, livestock was the main source of draught power and income source. In addition, livestock was the main asset of farm households in the study area. A household with more livestock was considered as better off. Households with more cattle especially oxen more likely produced more grain that in turn enabled them to rent more land and take sharecropping from the local poor farmers. Irrigation user households in the study area had more livestock that in turn helped them to plow more land including rented land and sharecrop and contribute for household food security.

Table 4. Summary of household characteristics of continuous variables.

Variables	Use of irrigation	Mean	Standard Deviation	T-test
Age of respondent	Yes	41.86	8.303	2.823**
	No	45.98	11.034	
Family size at adult equivalent	Yes	5.0967	1.18641	3.65***
	No	4.2844	1.72796	
Land holding size	Yes	1.5351	0.55726	4.32***
	No	1.1547	0.62654	
Total livestock unit (TLU)	Yes	5.1706	2.17275	2.71**
	No	4.2126	2.5593	
Distance from market	Yes	10.43	3.671	0.12^{ns}
	No	10.53	6.520	

*** Stands for 1% level of significance, ** for 5%, * for 1% and NS for Not significant

Distance to market is considered as proximity variable for marketing access. Distance to market did not significantly vary between irrigation users and non-user households in sampled kebeles. Because both irrigation users and non-users lived in the same vicinity and were therefore the same distance away from market centers. However, the means of transportation was different between the two groups. About 31% of irrigation users used car and cart and 66.7 % of them also used pack animals to transport their farm produce to the market (Table 5). In contrast, only 7.1% of non-irrigation users transported their farm products to the market center by using car and cart; but the majority of non-irrigation users (about 81%) transported their product using pack animals and 10.1% of them also used human labor.

Although the market center distance was almost similar to both comparison groups, irrigation user households used car and cart more often than non-users for transport. This could be linked to the presence of income difference between the two counterparts as irrigation users gained more income than non-users.

Table 5. Means of transport of sampled households.

Characteristics of sample household		**Use of irrigation farm**			
		Non-irrigation user		**Irrigation user**	
		N	**%**	**N**	**%**
Means of transport	Car	7	7.1	23	27.4
	Cart	2	2.0	3	3.6
	Back animals	80	80.8	56	66.7
	Human labor	10	10.1	2	2.4

Non-farm activities were among the alternative sources of income for rural households. Casual labor, petty trade, masonry, charcoal making, traditional wavering, and blacksmith were the major non-farm activities in the study area. The result (Table 6) indicates that only 9.5% of irrigation user households participated in non-farm income generation activities, whereas a significant number of non-users of irrigation (about 19.8%) participated in non-farm income activities. The survey result indicates that non-irrigation user households participated more in nonfarm income generation activities than irrigation user households. The result also indicates that the average annual income of irrigation user and non-user sampled households was ETB 1,173.81 and 2,821.39, respectively. This shows that non-irrigation user households fetched higher income than their counterparts from the field. Irrigation user household members spend most of their time in irrigation production activity because they had less participation in nonfarm activities than non-user households.

Access to credit is a viable option for rural farm households in order to fulfill agricultural inputs and technologies that improve agricultural production capacity. Access to credit refers to the provision of credit for farm household to enable them to access farm inputs and other technologies such as fertilizer, improved seed, agricultural chemicals, oxen and dewatering pumps. According to the result of this study, sampled households with access to credit and without access to credit had a significant difference in regard to small scale irrigation participation.

Table 6. Summary of households' characteristics of discrete variables.

		Irrigation farming				χ^2
		Yes		No		
		N	%	N	%	
Participation in non-farm activities	Yes	20	19.8	8	9.5	0.052**
	No	81	80.2	76	90.5	
Access to credit	Yes	50	49.5	29	34.5	0.372^{NS}
	No	51	50.5	55	65.5	
Use of fertilizer	Yes	87	86.1	80	95.2	0.038**
	No	14	13.9	4	4.8	
Improved seed	Yes	68	67.3	59	70.2	0.67^{NS}
	No	33	32.7	25	29.8	
Access to extension services	Yes	85	85.0	82	97.6	0.002***
	No	15	15.0	2	2.4	
Extension contact per month	0	19	18.8	2	2.4	
	1	46	45.5	7	8.3	0.003***
	2	32	31.7	23	27.4	
	3	4	4.0	31	36.9	
	4	0	0	21	25.0	
Technical training on farming	Yes	69	68.3	82	97.6	
	No	32	31.7	2	2.4	0.05**

*** Stands for 1% level of significance, ** for 5%, * for 1% and NS for Not significant.

From total sample respondents, 42.7% had access to credit while 57.3% did not use credit. Out of irrigation user respondents, 34.5% had access to credit and 65.5% did not have access. Regarding the credit access, 49.5% of non-irrigation user had access to credit while 50.5% of them were without access to credit. Non-irrigation user respondents had more access to credit as compared to their counterparts. This might be due to the fact that irrigation user households had better income to spend on farm inputs and other household expenditures from own income source. The adoption of new technologies and a new way of doing in rural areas, often depend on farmers' access to extension service. Farmers extension service here includes technical advice, field demonstration and training on agricultural production methods and application of technologies. Extension service provides important information to acquire knowledge and skill to framers in order to improve agricultural productivity and production. Extension service has been delivered via Development Agents (DAs) who were frontline workers in day to day contact with farmers at kebele level. Extension agents working at grassroots offered different extension services for farmers of their respective assigned kebeles. As indicated in table 7, irrigation users and non-users had different access to extension service. Of total irrigation user and non-user respondents, 97.6% and 85.0% had access to extension service, respectively. The assessment result shows that irrigation users had more frequent contact with extension agents than non-users. More than 86% of irrigation users had 2-4 times chance per month extension contact but only 35.7% of non-irrigation users had the same trend of monthly extension contact. This might be due to the fact that irrigation users spent most of their time in their farm site even in the dry season that created a favorable situation to field extension agents to properly deliver their mission as intended. On the other hand, when we see the situation of technical training for farmers at FTC level, irrigation users had more chance than their counterparts and 97.6% of user respondents participated in technical training delivered in farmers training center which is 68.3% for non-user respondents. The food security status of all sampled households obtained from the HFBM calculation indicated that 74.1% (137) household were food secure while 25.9% (48) households were food insecure (Figure 2).

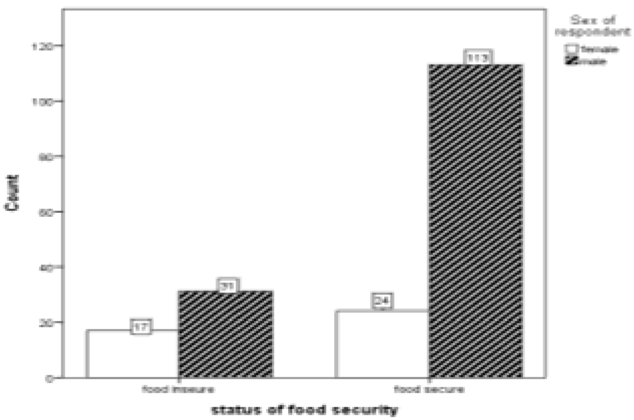

Figure 2. Food security status of households in the study area.

Table 7. Construction of food balance sheet table of the study area.

No. HFBM attributes	Status of food security		Min	Max	Average
	Secure	Insecure			
1. Kilo calories produced	6466	2601	823	17292	5207
2. Kilo calories purchased	130	385	125	3020	197
3. Kilo calories remittance	0	0	0	0.00	0.00
4. Kilo calories food aid	0	0	0	0.00	0.00
Subtotal 1 (1+2+3+4)	6596	2986	1048	20312	5504
5. Grain reserved for seed	563	244	52	2046	488
6. Grain sold	1998	880	93	10332	1756
7. Post-harvest grain loss	440	262	150	676	122
8. Grain given for others	85	0	0	599	23
Subtotal 2 (5+6+7+8)	3086	1386	295	13653	2103
Net kcal availed (subtotal 1-subtotal 2)	3510	1600	753	6659	3015

Food availability in the study area

The average availability of food for food-secure households was 3510 kcal/day/adult equivalent while it was 1600 kcal/day/ adult equivalent for food-insecure households. The result shows that there was a shortage of food energy for a considerable portion of the community in the study area. Besides, the survey result showed that the overall average food energy was 3015 kcal, which was higher than the national minimum recommended value, i.e., 2100 kcal. Moreover, household food energy calorie availability ranged from 753 kcal to 6659 kcal. This indicates that there was big gap in food energy availability among sample households. The main food energy source in the study area was from own production of different food grains that accounted for 94.5% from the total available food calorie during the study time which is followed by domestic purchase that covered 5.5% of a calorie per capita. Food aid and remittance did not contribute because there were no other food aid programs in the two selected kebeles. The government-initiated productive safety net program is the only program supporting the food insecured households in the study area. Food-secure households accommodated 98% of their food from their own production and only 2% from the domestic purchases while food insecure households gained 85% and 15% of their food grain from own production and domestic purchase, respectively. The survey result clearly showed that domestic agricultural food production was the main source of food grain supply. In other words, it substantiates that the local agricultural production situation largely affects the food availability and food security status of the local community of the study area.

Determinants of food security: econometric result

The binary logit model identified four significant variables out of the hypothesized twelve explanatory variables which had the potential to determine household food security in the study area (Table 8). Determinant factors in the study area include access to irrigation (ACCEIRRG), access to credit service (ACCEDT), income from rainfed crop production (RAINFEDINCOM) and household size (HHSIZ).

Table 8. Results of the binary logistic model.

Variables	Coefficient	P>/Z/	dy/dx
SEXHH	0.840 (0.700)	0.230	0.071
AGEHH	-0.163 (0.217)	0.453	-0.011
AGEHHSQR	0.002 (0.002)	0.380	0.000
EDULEVEL	0.015 (0.307)	0.962	0.001
HHSIZ	-0.934*** (0.296)	0.002	-0.064
FARMSIZ	0.276 (0.785)	0.725	0.019
TLU	-0.08 (0.157)	0.611	-0.006
ACCEIRRG	1.611** (0.777)	0.038	0.111
EXTECONT	-0.159 (0.335)	0.636	-0.11
ACCEDT	2.627*** (0.932)	0.005	0.181
RAINFEDINCOM	0.002*** (0.000)	0.000	0.00002
NONFARINCOM	-0.367 (0.844)	0.664	-0.025
USEFERT	0.24 (1.126)	0.831	0.017
Constant	7.675 (5.226)	0.142	
Number of Obs.	184		
LR Chi-square	114.23	Prob > Chi-square = 0.000	
Pseudo R^2	0.54		

Figures in parenthesis are standard errors; *** Stands for 1% level of significance, ** for 5%, * for 1% and NS for Not significant.

Household size

Household food security was significantly negatively related with household size (P<0.01). The model result implies that when household size increased by one adult equivalent, other things remaining constant, the probability of households being food secured decreased by a unit of 0.064. This implies 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. On the other hand, the presence of large family size might increase the non-food expenditure of the household that negatively influences the situation of food availability. A study conducted in rural and urban areas of the Amhara region showed that an increase in one member of a family reduced the the extent of food security of the household by a factor of 2.25 (Mesfin Welderufael, 2014; Getachew Teferi *et al.*, 2018; Adimasu Awoke *et al.* 2019).

Access to irrigation

The model result indicates that this variable positively and significantly affected the food security status of households with a 5% significant level. The model was also used to estimate the relationship between food security status and family involvement in irrigation. Irrigation user households were found to have better food availability as compared to their non-irrigation user counterparts. Irrigation users produced more crop products at least twice a year including in the dry season using irrigation water. In addition, irrigation users might plow a larger farmland size even by renting land and sharecropping from poorer households as they are able to purchase more farm inputs. The result implies that irrigation user households in the study area could diversify their crop products including cash crops like onion and garlic for income and potato and cabbage for consumption. This put them in a better position interms of income and food supply than their counterparts. As shown in the model, being irrigation user household enhances their food security status by a 0.11 unit, keeping other variables constant. Irrigation increases food production and it is an influential factor for improving food security, and provides protection against drought effects, improves employment opportunity and diversifies crops. Previous reports also confirmed a positive and significant relationship between access to irrigation and food security (Abonesh Tesfaye *et al.,* 2008; Woldegebrial Zeweld, 2013; Dereje Mengistie and Desale Kidane, 2016; Tizita Damtew, 2017).

Access to credit service

In this study households' access to credit service was one of the influential institutional factors which determine household food security in the study area. According to the binary logit model, farm credit service had a positive and significant association with household food security, as expected. Having access to credit increaseds food security by a unit of 0.18. The result implies 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. Similar results were reported before in which access to credit and household food security had positive relationships (Ahmed *et al.*, 2014; Alem-meta Assefa and Singh, 2018; Getachew Teferi *et al.*, 2018; Bekele Gebisa *et al.*, 2019).

Income from rainfed crop production

This variable represents the participation of household members in rainfed crop production. The result shows that households were more food secured if they fetched higher income from rain-fed farming. A 1000 birr increase in rainfed crop income enhances the food security of households by a unit of 0.02, keeping other variables constant. Lack of precipitation due to climate change has put rainfed farming in precarious state, lowering the income obtained from rainfed farming. Severity of climate change had impact on rainfed agriculture system of smallholder farmers (Abrham Belay *et al.*, 2017; Sathyan *et al.*, 2018; Melese Gezie, 2019). Rainfed and irrigated production was compared before in Ethiopia, in which irrigation gave more output than the rainfed (Makombe *et al.*, 2007). Marginal productivity of labor and land was four and five times more for irrigated farms than rainfed production.

CONCLUSION

The overall findings of the study indicated that the use of small scale irrigation contributes significantly to improve household food security. Besides access to irrigation, access to credit service, income from rainfed farming and family size were found to significantly influence the food security status of rural households. Households engaged in irrigation farming had more annual income than households who depend on rainfed farming alone. The study revealed that the average food availability of sampled households in the study area was 3015 kcal which was higher than the national average (2100 kcal) with the minimum and maximum value of 753 kcal and 6659 kcal per adult equivalent per day, respectively. The average food availability for food secured households was 3510 kcal and food insecured ones was 1600 kcal. This implies that there was an average of 23.8% calorie deficiency to fulfill the minimum national requirement for food insecured households. Food availability for irrigation user households was found to be higher than that of rain-fed dependent farmers. In general, the finding of the study indicated that small-scale irrigation played significant role in improving household food security. The food security analysis showed that out of food-insecure households, most of them were non-irrigation users. This means that food insecurity occurs within the non-irrigating households than in irrigating households. Thus, promoting small-scale irrigation has a positive influence on ensuring households' food security. Despite the huge potential for small-scale irrigated farming, the area has not been efficiently utilized. As a result, food insecurity is still persistent among the community in the study area. Therefore, scaling up of irrigation agriculture is a viable option in order to achieve household food security in a sustainable manner.

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Competing Interests

The authors declare that they had no competing interests.

REFERENCES

Abdissa Feyera, Tesema Getachew and Yirga Chillot. (2017). Impact analysis of small scale irrigation schemes on household food security the case of Sibu Sire District in Western Oromia, Ethiopia. *Irrigation & Drainage Systems Engineering* **6**:2. DOI: 10.4172/2168-9768.1000187

Abraham Gebrehiwot, Addis Adera and Mesfin Tilahun (2015). The Impact of Small-Scale Irrigation on Income of Rural Farm Households: Evidence from Ahferom Woreda in Tigray, Ethiopia. *International Journal of Business and Economics Research* **4**: 4. doi: 10.11648/j.ijber.20150404.14

Abrham Belay, Recha, J.W., Teshale Woldeamanuel and Morton, J.F. (2017). Smallholder farmers' adaptation to climate change and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia. *Agriculture and Food Security* **6:**24. DOI 10.1186/s40066-017-0100-1

Abonesh Tesfaye, Ayalneh Bogale, Regassa Namara and Dereje Bacha (2008). The impact of small-scale irrigation on household food security: The case of Filtino and Godino irrigation schemes in Ethiopia. *Irrigation and Drainage Systems* **22**:2. https://doi.org/10.1007/s10795-008-9047-5

Achenef Motbainor, Alemayehu Worku and Abera Kumie (2016). Level of food insecurity in East and West Gojjam Zones of Amhara Region, Ethiopia: A Community Based Comprehensive Crosectional Study, Ethiopia.

Adimasu Awoke, Senbetie Toma, Yoseph Halala (2019). Assessment of food insecurity and its determinants in the rural households in Damot Gale Woreda, Wolaita zone, southern Ethiopia. *Agriculture and Food Security* **8**:11. https://doi.org/10.1186/s40066-019-0254-0

Ahmed, F and Dotti, R. (2014). Food security and coping strategies among medium income earners in Maiduguri Metropolis of Borno State, Nigeria. *IOSR Journal of Humanities and Social Science (IOSR-JHSS)* **19**:1-8. DOI: 10.9790/0837-19190108

Alem-meta Assefa and Singh, K.N. (2018). Determinants of food insecurity in the rural farm households in South Wollo Zone of Ethiopia: the case of the Teleyayen subwatershed. *Agricultural and Food Economics* **6**:10. https://doi.org/10.1186/s40100-018-0106-4

Bekele Gebisa Zhou, D, Kidane Assefa and Dessalegn Anshiso (2019). Household income diversification and food security: Evidence from rural and semi-urban areas in Ethiopia. *Sustainability* **11**: 3232. doi:10.3390/su11123232

Chamberlin, J and Schmidt, E. (2011). Ethiopia strategy support program II Working paper, Addis Ababa, Ethiopia.

Degefa Tolossa (1996). Belg Crop Production as a Strategy of Households' Food Security: A Comparative Study of Belg Grower and Non Belg Grower Farmers in Munessa Woreda, Arsi Zone. MA thesis. Addis Ababa university, Addis Ababa, Ethiopia.

Demeku Mesfin, Addisu Damtew and Husen Maru (2015). The status of food availability in the face of climate change and variability in Choke Mountain Watersheds, Central Ethiopia. *Journal of Development and Agricultural Economics* **7**:10. DOI: 10.5897/JDAE2015.0672

Dereje Mengistie and Desale Kidane (2016). Assessment of the Impact of Small-Scale Irrigation on Household Livelihood Improvement at Gubalafto District, North Wollo, Ethiopia. *Agriculture* **6**: 27. doi:10.3390/agriculture6030027

Djangmah, G.M. (2016). Comparative analysis of food security status of farming households in Northern and Eastern region of Ghana. McGill University, Monteral; Quebec, Canada.

EHNRI (Ethiopian Health and Nutrition Research Institute). (1997). Food Composition Table for Use in Ethiopia. Addis Ababa, Ethiopia.

Fekadu Abdisa (2012). Impacts of Small scale Irrigation Schemes on Household Food Security in Western Oromia, Ethiopia. The Case of Sibuire District of Eastern Wolega Zone.MA thesis, Haramaya University, Ethiopia.

Getaneh Kebede. (2011). Impacts of Small scale Irrigation Schemes on Household Income and the Livelihood of Poverty in the Lake Tana Basin of Ethiopia, Cornell University. M.Sc. thesis, Ethiopia.

Getachew Teferi, Degefa Tolossa and Negussie Semie (2018). Food Insecurity of Rural Households in Boset District of Ethiopia: a Suite of Indicators

Analysis. *Agriculture and Food Security* **7**: 65 https://doi.org/10.1186/s40066-018-0217-x

Getinet Kebede. (2011). Linkage small scale irrigation and household food security in drought prone area of North East Ethiopia. A Case study of Aluha Irrigation Scheme in GubalaftoWoreda, North Wollo Zone, Addis Ababa University, M.Sc thesis, Ethiopia.

Goncha District Agriculture Office. (2017). District agriculture sector annual progress report submitted to concerned higher offices, Ethiopia.

Goncha District Administrative Office. (2017). District annual statistical magazine, Ethiopia.

Goncha District Finance and Economic Development Office. (2017). District annual progress report, Ethiopia.

Goncha Distrcit Agriculture Office. (2015). District disaster risk reduction profile for food insecure woreda supported by productive Safety Net program.

Gujarati, D.N. (2004). Basic Econometrics, 4th Edn., Mc-Graw Hill Inc., New York, USA: 1002.

Makombe, G., Dawit Kelemework and Dejene Aredo. (2007). A Comparative Analysis of Rainfed and Irrigated Agricultural Production in Ethiopia. *Irrigation and Drainage Systems* **21**:1. DOI: 10.1007/s10795-007-9018-2

Melese Gezie (2019). Farmer's Response to Climate Change and Variability in Ethiopia: A review. *Cogent Food and Agriculture* **5**: 1. https://doi.org/10.1080/23311932.2019.1613770

Messay Mulugeta. (2010).Food Security Attainment Role of Urban Agriculture: A Case Study from Adama City,Ethiopia. *Ethiopian Journal of Business and Economics* **1**:1.

Ministry of Water Resources (MoWR) (2002). Water sector development program 2002-2016. The Federal Democratic Republic of Ethiopia.

Mesfin Welderufael. (2014). Determinants of households vulnerability to food insecurity in Ethiopia: Econometric Analysis of Rural and Urban Households. *Journal of Economics and Sustainable Development* **5**: 24:70-80.

Sathyan, A.R., Funk, C., Aenis, T and Breuer, L. (2018). Climate vulnerability in rainfed farming: Analysis from Indian Watersheds. *Sustainability* **10**: 3357. doi:10.3390/su10093357

Tizita Damtew (2017). The Effect of Small Scale Irrigation on Household Food Security in Bona-Zuria Woreda, Sidama Zone, Southern Ethiopia. Msc thesis, Hawassa University, Ethiopia.

USAID (2000). Amhara National Regional State Food Security Research Assessment Report. USAID Collaborative Research Support Programs Team.

Woldegebrial Zeweld. (2013). Food security through small scale irrigation: Case study from Northern Ethiopia. M.Sc thesis, European Erasmus Mundus Programme.

World Bank. (2006). Ethiopia: Managing water resources to maximize sustainable growth: A World Bank Water Resource Assistance Strategy for Ethiopia. The World Bank Agriculture and Rural Development Department.

Yamane , T. (1967). Statistics: An Introductory Analysis (2nd ed.). New York: Harper and Row.

Annex 1. Kilocalories per gram of different food types.

Food groups	**Crop type**	**Average kcal per gram**
Cereals	Teff	3.45
	Wheat	
	Maize	
	Barley	
Pulses	Beans	3.5
	Pea	
	Grass pea	
Vegetables	Onion	0.37
	Potato	
	Cabbage	
	Carrot	
Oils and fats	Oil	8.12
	Butter	
Salt/ sugar	SugarSalt	1.78

Source: EHNRI (1997).