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The Role of Irrigation in Household Food Security in Upper Blue Nile Basin: The Case of Jedeb Irrigation Scheme, Amhara Region, Ethiopia

Zewdu Siraw

Department of Geography and Environmental Studies, Debre Markose University, Debre MArkos, Ethiopia

Email address:
zewdusiraw@yahoo.com

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Abstract: Food security is the main problem of many developing countries. To improve the food security problem small scale irrigation practice is vital. Demographic characteristics and resource of households as well as Agricultural production were collected using structured questionnaires. The collected data was analyzed using the Statistical Package for Social Sciences (SPSS version 12) and Household food balance model. The findings of this study showed that farmers who have plot on the irrigation scheme were in better condition in terms of production, livestock holding, oxen ownership, and income than their partners with no plot on the scheme in 2008/09. The study also shows that 17.54 % and 40.62 % of irrigation users and non users are found to be food insecure respectively. The regression analysis showed that access to irrigation, income, farm size, house hold size, livestock holding, as well as oxen ownership are the major determinants of household food security in the study area. The study concludes that small-scale irrigation significantly contributed to household food security.

Keywords: Small Scale Irrigation, Food Security, Food Insecurity, Income, Jedeb Irrigation Scheme, Food Balance Model, Income

1. Introduction

In the world of today, food insecurity is a widespread phenomenon despite the fact that food security is considered as an elementary human right [1]. Food security has been a major concern especially in Africa where close to thirty million people are food insecure because of frequent droughts, armed conflict, corruption and the mismanagement of food supplies, environmental degradation and trade policies affecting most African countries [1]. Food insecurity is becoming the most critical issue in the developing world and issue of the development agenda. The biggest proportion of the poor living in a state of acute poverty is found in Africa South of Sahara [2]. Of the 30 poorest countries in the world 22 are in Africa [3]. One serious manifestation of poverty in Sub-Sahara Africa (SSA) is the usual occurrence of food insecurity in the region. In 2000, world leaders committed themselves to the Millennium Development Goals (MDGs). One of its aim was to eradicate poverty and hunger, including "to reduce by half the proportion of people who suffer from hunger" between 1990 and 2015. However, by 2003 the proportion of world population that was undernourished had only decreased from 20% to 17% i.e., from 823 to 820 million people [4]. [4], also predicted that many regions will not reach their MDG targets, particularly sub-Saharan Africa (SSA) where a third of the population is food insecure and there is an actual increase (through population growth) in the number of hungry people. According [3], it is estimated that over 100 million people in Africa are food insecure. More than half of the foods insecure are clustered in seven SSA countries: Chad, Zaire, Uganda, Mozambique, Zambia, Somalia, and of course Ethiopia. In these countries, over 40 percent of the populations are estimated to be food insecure. Accordingly, in Ethiopia food insecurity is seen as the most important feature of development challenges.

The agricultural sector is the backbone of the Ethiopian economy, making multifaceted contributions to the economy. The performance of agriculture, however, in terms of feeding

the country's population, which is growing at about 2.9 per cent per annum, is poor [5]. An estimated 5–6m people are considered chronically food insecure–that is, they require some type of resource transfer (traditionally food aid) to meet their minimal food requirements every year. According to [6], over 50 percent of the Ethiopian population, of whom the majority reside in rural areas, is food insecure in relation to the medically recommended daily intake of 2100 calories per person per day. According to [7], adverse climate changes (such as drought) combined with high human population pressure, environmental, technological and institutional factors, etc, have led to a decline in land holding size per-household, soil erosion and decline in productivity increases the problem of food insecurity.

Over the past three decades, Ethiopia has been challenged by lack of food security. In the country, the trend in growth of domestic food production matched population growth only in the 1960s. The per capita domestic food production has steadily declined over the last three decades [8]. The country is unable to maintain food security of the population although huge number (estimated at 85%) of labor force engaged in the sector. The problem of the sector usually attributed to erratic and/ or insufficient rainfall, high man land ratio, and progressive degradation of the natural resource base especially in highly vulnerable areas of the high lands, which aggravates the incidence of poverty and food insecurity in rural areas. As a result poverty and food shortage have been persistent challenges in rural parts of the country where paradoxically more of the population is engaged in small-scale subsistence oriented farming. In line with this [9] explained that the country suffers from severe food shortage due to chronic droughts. The Machakel district, where Jedeb irrigation site found, is among the poor farming practice and low food production areas in the upper Blue Nile basin. In the district man-made and natural calamities caused low crop yield. Apart from this, the general agricultural production practice of the area is traditional. On the contrary, natural resource degradation and increase in human population is another phenomenon, which contribute for poor living condition and low food production. As a result, there is an increasing decline in the food supply and often resulted in acute decline in food security status of the farming community. To improve household food security different irrigation schemes have been constructed. However, there is no information on the extent to which the so far developed irrigation schemes have been effective in meeting their stated objectives of attaining food self-sufficiency. Hence, there is a need for better understanding of the role played by the constructed irrigation schemes in upper Blue Nile basin taking Jedeb irrigation scheme as a case study. The findings could contribute to improve the performance of small scale irrigation schemes. Therefore, the objectives of the study were: to examine food grain production of the Jedeb irrigation scheme; compare income of irrigation users and non users; assess irrigation contribution to household food security; and identifying the factors that affect household food security status in the study area.

2. Methodology

2.1. Description of the Study Site

Jedeb irrigation scheme is found in Machakle district, in the upper Blue Nile basin of Ethiopia (Figure. 1). The scheme is situated at a distance of about 23kms North-West of Debre Markose town (the capital of East *Gojjam* zone) and about 7kms West of Amanuel town (the capital of *Machakle* district) just along the side of the asphalt road which run from Bahir Dar to Addis Abeba. The source of water for irrigation is the Jedeb River through construction of diversion weir. The Jedeb River originates from the Chokie Mountain in the high lands of Dega Damote as a small spring and enlarges to big Perennial River till it joins the Blue Nile River. The scheme is found in the Woynadega agro climate zone. The irrigation site is one of the areas in the region where irrigation has been practiced for long years. Before the construction of the scheme the local farmers were practicing irrigation through traditional diversion of Jedeb River. From 268 hectares of cultivable command area about 260 hectares was communal grazing land.

2.2. Data Collection and Analysis

For the purpose of this study, the Jedeb irrigation scheme was purposely selected because it is in the area where insufficient and erratic rainfall is a recurrent phenomenon that causes crop failure and food insecurity. The Primary data were collected from primary sources. The conventional household survey is the main method used to collect information from selected sample households. To prepare the questioner, the researcher first visited the study area and discussed informally with elderly individuals, development agents, and agricultural experts. Incorporating the information gathered from these individuals, the questionnaire was designed, and translated in to *Amharic* language for administration. The content of the questionnaires prepared to interview sample households include personal household data, household resources, income sources, asset holding, types and amount of crops produced and other information. Purposive and spatial area random sampling techniques were employed. Firstly, the Jedeb irrigation scheme was selected purposefully. Secondly, using spatial area random sampling technique the sample households were selected from irrigation users and non users. The total irrigation users were 467 household heads and 472 households who have no access to irrigation. The number of sample household heads selected for the questionnaire was determined using [10] sample size determination formula. Based on the formula the total number of respondents were determined to be 121 household units (fifty seven and sixty four irrigation users and non irrigation users respectively). Therefore, the sample size was believed to be representative and can generate reliable information. The difference between sample irrigation user and non-user households was limited only to access to irrigation. Secondary data used in this study were documents collected from different sources

like unpublished and published records and reports from different institutions.

The quantitative data were processed and analyzed using the Statistical Package for Social Sciences (SPSS Version 12). Chi-square analysis was applied to the discrete variables while t-test was applied to the continuous variables. In addition household food balance model was used to analyze food security status of households. Finally multiple regression analysis was used to identify variables significantly affecting household food security. The information obtained from field observations, key informants interview and focus group discussions were analyzed using qualitative description.

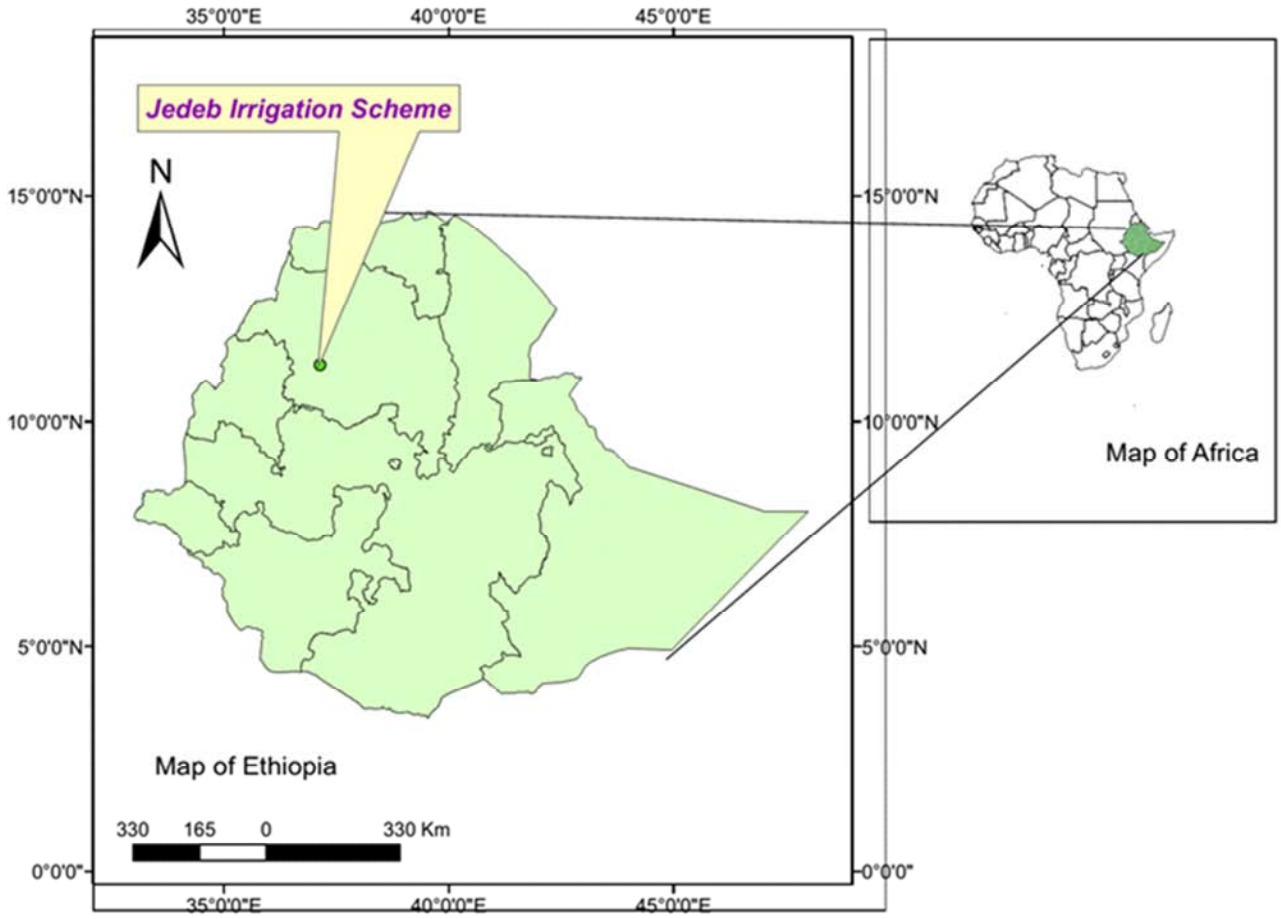

Fig. 1. *Location map of Jedeb Irrigation Scheme.*

3. Results and Discussion

3.1. Demographic Characteristics of Sample Households

The average household size of the sample population was 5.57. Out of the total population, 240 were children below the age of 15 years, 408 were within the age group of 15-64; and 29 were within the age group of greater than 64 years. This constitutes dependency ratio of 65.93 percent, which implies that for 100 persons in the productive age group there were about 65.93 dependents. On the other hand, the average age of household heads for irrigator households was 43.86 and non-irrigator households were 45.31. The average age of the total sample households was 44.63 years.

Table 1. *Education Status of Sample Household heads by Irrigation Status.*

Education status	Irrigation users		Non-irrigation users		Total
	frequency	percent	frequency	percent	
illiterate	25	43.86	23	35.94	48
Read and write	23	40.35	26	40.63	49
1-4	6	10.53	10	15.63	16
5-8	3	5.26	2	3.12	5
above 8	0	0	3	4.68	3
Total	57	100	64	100	121

Source: Survey data, 2010

Table 2. *Income Sources and Means Annual Income of Sample Households in Ethiopian Birr.*

Sources of income	Irrigation users		Non Irrigation -users	
	mean income	St. Dev	mean income	St. Dev
cereals	5046.0351	4293.08116	2600.7969	2345.04916
Root crops and vegetation	1446.3158	1417.539	290.3125	488.798
Livestock & livestock products	1323.8596	1702.68879	320.7500	616.62404
Off farm activities	604.0527	757.26824	715.7969	596.58463
Total	8420.2632	-	3927.5313	-

Source: Survey data, 2010

[11] noted that illiteracy is one of the factors that limit economic, social, physical, technical and educational development in less developed countries. Table one showed that 43.86 % of irrigators and 35.94 % of the non irrigator farmers were illiterate. However, the chi-square test result showed that there was no statistically significant systematic relation between access to irrigation and level of education (chi-square=4.978 and P=0.290).

3.2. Sample Households Income and its Sources

The major cash income sources of households in the study area were sales of cereal crops, root crops and vegetables, livestock and livestock products as well as off farm activities. Off farm activities include labor wage, petty trade, and sale of wood, charcoal, grasses and others. According to Table 2, the mean annual income of irrigation user and non-user households was Birr 8420.2632 and 3927.5313 respectively.

Off farm activities are important means of existence in areas of low agricultural income. The survey result shows that 64.91 per cent and 73.4 per cent of sample households from irrigation and non-irrigation groups have been engaged in different off-farm activities. Off-farm income generating activities help farmers to diversify their income sources and thereby reduce risk of vulnerability to food insecurity. The chi-square test showed that there was statistically significant systematic relation between food security and participation in off-farm activities (chi-square=7.384 and P=0.025). As shown in Table 3 mean annual income of irrigators and the non irrigators was birr8420.26 and 3927.5313 respectively. This result shows a significant difference (T-value=4.319)

This significant difference in income generated by the two sample groups of households is mainly due to high income of irrigation users from irrigated crop production in the dry season. This implies that small scale irrigations are very important means of increasing rural households' income. The study also showed that food secure and insecure households earn mean annual income of 7782.0706 and 1940.0278 birr respectively. The T-test result showed that there was statistically significant difference in mean income of food secure and insecure households with T value of 5.322 and P value of.000.

3.3. Food Grain Production of the Irrigation Scheme

In Jedeb irrigation scheme, different types of crops and vegetables were produced since scheme construction. During the first year of production only 6 hectares of land was cultivated. The crops were maize and potato covered an area of 4 and 2 hectares respectively. During this year the number of irrigators was 24, all were men. Through time the number of irrigators and area cultivated increased to reach 467 irrigators (440 male and 27 female) and 239.2 hectares in 2009. The following table shows crops produced and the size of land cultivated from 2004 to 2009 harvest years. Table 4 shows that more than 90 % of the area of the scheme was used for maize and potato since its construction. It is only small portion of the area was used to produce vegetables and other crops. However, according to the document obtained from Regional Water Resource Bureau the proposed cropping pattern of Jedeb irrigation scheme was 30% for cereals, 10% pulses and 60% vegetables.

Table 3. *Comparison of Annual Income of Irrigation users and Non-users in Ethiopian Birr.*

	Irrigation users	Non- Irrigation users	T-value	df	Sig. (2-tailed)
Mean annual income	8420.26	3927.53	4.319	119	.000*

* Significant at the level of 0.05
Source: Computed from survey data, 2010

Table 4. *Production and Area Cultivated in Jedeb Irrigation Scheme from 2004 to 2009.*

Year	Cultivated land, hectare	Crop type	Production in quintal
2004	6	Maize, potato	552
2005	95.4	Maize, potato	11016
2006	105.1	Maize, Potato, barley, onion	8219
2007	143.49	Potato, Maize, Barely, Onion, Pepper, Red	13027
2008	189.2	Maize, Barley, Potato, Pepper, Onion, Cabbage, Red root, Carrot, chickpea, White onion	25123
2009	239.2	Potato, Pepper, Barley, chickpea, Red onion, Spices, maize	38024

Source: Yewela Kebele Agriculture and rural development office.

Discussion with experts of the district experts revealed that production of maize and potato by most of the farmers at the same irrigation season makes the price of these crops cheap at local markets for most irrigators sale it immediately after harvesting. This influences the income of farmers from sale of irrigated crops. Therefore the experts at district level and other concerned organizations should educate and provide farmers with different seeds of cash crops which are suitable of the agro ecology of the area.

3.4. Household Food Security Status

The household food balance model used in this study is a modified version of the regional food balance model and has been used by [12], [13] and [14] in their analyses of household food security. The model is expressed as:

$$Nij=(Pij + Bij + Fij + Rij) - (Hij + Sij + Mij)$$

Where:

Nij is net food available for household i in year j expressed in kilocalories.

Pij=total grain produced by household i in year j expressed in kilocalories for each grain type;

Bij=total grain purchased by household i in year j expressed in kilocalories;

Fij=total grain obtained through relief food aid or food for work expressed in kilocalories;

Rij=total grain received by household i in year j as gift or remittance expressed in kilocalories;

Hij=total post harvest losses to household i in year j expressed in kilocalories;

Sij=total crop reserved for seed from the home by the household i in year j expressed in kilocalories;

Mij=total marketed grain by household i in year j expressed in kilocalories.

All these data were collected during the household survey conducted in February 2010 except crop reserved for seed and post harvest losses. Post-harvest crop losses (including storage loss) and part of the crop used as seed for the next planting season, were estimated at 10% and 6% respectively following [15], and [16]. Since there was no household reported food aid as a source of food, it is not included in the calculation. Each type of crop is converted in to kilocalories using International Food Security Policy Research Institute [17] and Amhara Region Food Security Bureau table of amount of kilocalories available from 1kg of grain of each crop. The resulting figure shows the amount of total food energy available in kilocalories for the household during the year considered. Then, this figure was divided by the number of adult equivalents for each household and the number of days of a year that gives the per capita kilocalorie available for the household per adult equivalent per day.

Table 5. *Distribution of Households by Ability to Cover the Food Energy Required for Different groups of Months by Irrigation Access.*

No. of Months	Irrigation users		Non-irrigation users		Total	
	frequency	percent	frequency	percent	frequency	percent
Below 6	0	0	6	9.38	6	4.96
6 to 9	0	0	3	4.69	3	2.48
9 to 12	10	17.54	17	26.56	27	22.31
12 and more	47	82.46	39	60.94	85	70.25
Total	57	100	64	100	121	100

Source: Calculated from Field Survey data, 2010

Table 6. *Oxen Ownership by Irrigation Access.*

Oxen owned	Irrigation users		Non-irrigation users		Total	
	frequency	percent	frequency	percent	frequency	percent
No ox	4	7.02	7	10.49	11	9.09
One ox	12	21.05	25	39.06	37	30.58
A pair	15	26.32	19	29.68	34	28.10
3 oxen	12	21.05	6	9.38	18	14.87
Greater than 3	14	24.56	7	10.94	21	17.36
Total	57	100	64	100	121	100

Source: Survey data, 2010

Household adult equivalent (ADEQ) in the study was calculated based on Aliber [18] formula:

$$ADEQ=(A+ 0.5C)^{0.9}$$

Where:

ADEQ is the adult equivalent;

A is the number of adults in a household;

C is the number of children in the family (where every household member below 15 years is a child); and

0.9 is the scale parameter.

The per capita kilocalorie available for the household per adult equivalent per day (here onward referred as simply per capita kilocalorie) was compared to the minimum recommended allowance (2100 kilocalories). Following [19], 2,100 kilo calories per person per day was used as a measure of calories required to enable an adult to live a healthy and moderately active life. Households whose per capita

kilocalorie is less than 2100 are said to be food insecure and those households whose per capita kilocalorie is greater than 2100 kilocalories are said to be food secure.

The result of this computation revealed that 70.25 % of the households in the study area were food secured and 29.75 % were facing food insecure. The mean per capita kilocalorie available to the household per adult equivalent p r day for the entire sample size was found to be 3194.84kcal with standard deviation of 1617.21. A wide range in per capita kilocalorie has been observed with the minimum per capita kilocalorie being 878.00 and the maximum being 9622.70.

Significant variations have been observed between the irrigation users and non irrigation users in per capita kilocalorie availability that irrigator*s* had average per capita kilocalorie of 3863.68, which is higher than the non irrigators average per capita kilocalorie which is 2599.16. The difference in per capita kilocalorie between irrigation users and non user households has been found to be statistically significant with t value of 4.647 and P value of 0.000. The higher amount of mean per capita kilocalorie for irrigation users can be attributed to the production of crops in the dry season on their irrigation plot. On the other hand households who have no access to Jedeb irrigation scheme produce only once a year in the rain season. The analysis showed that 17.54% of irrigation users and 40.62% of non-users were found food insecure.

Table 7. *Result of Multiple Regression Analysis.*

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1181.672	407.220		2.902	.004
	irrigation	418.347	172.982	.130	2.418	.017
	age	-3.562	5.837	-.031	-.610	.543
	house hold size	-73.583	37.142	-.097	-1.981	.046
	education	-166.566	86.012	-.103	-1.937	.055
	farm size	324.503	131.176	.172	2.474	.015
	Livestock	135.350	40.991	.267	3.302	.001
	Oxen	224.493	92.167	.184	2.436	.016
	extension	419.110	228.392	.090	1.835	.069
	credit	84.595	180.341	.023	.469	.640
	off farm	-45.636	188.783	-.013	-.242	.809
	income	.091	.018	.343	4.979	.000

After the computation of the regression analysis six variables among the eleven were found significantly affect food security of the households as shown in Table 8. These variables were access to irrigation, household size, farm size, livestock holding, oxen ownership and income.

The total annual food energy available for the house-hold in kilocalories was also divided by the number of adult equivalents for the household and the minimum recommended allowance of 2100 kilocalories to determine the number of days/ or months the household is able to feed adequately its family members. The result of this analysis in Table 5 shows that 9.38 % of non-irrigation users are able to feed their family members adequately for less than six months of the year. Another 4.69 % of non-users are able to feed adequately for 6 to 9 months. On the other hand, all households from irrigation users could feed all family members adequately for more than nine months of the year. The result shows that only 17.54 % of irrigation users were found food insecure whereas 40.62 % from non-users were found to be food insecure. The finding revealed that farmers who had access to irrigation were in better position in food security status than the non-users.

3.5. Demographic Characteristics and Food Security

Age of the household head is regarded as an important variable with an impact on household food security status; i.e. older household are usually better than younger households (especially newly formed households) in terms of resource endowment. [20] argues that the higher the age of the household head, the more stable the economy of the farm household, because older people have also relatively richer experiences of the social and physical environments as well as greater experience of farming activities. Moreover, older household heads are expected to have better access to land than younger heads, because younger men either have to wait for a land distribution, or have to share land with their families. Thus it was hypothesized that older households are more likely food secure than younger households. The t-test was run to test this hypothesis and the result showed that there was statistically significant difference in mean age of the household heads between households which were food secure and those which were not (t=-2.917; P=0.004). The mean age of the household head for food secure and insecure households was 46.71 (N=85) and 39.97 (N=36) respectively. The result implies that household head age had an impact on household food security. This might be related to the fact that younger household heads have lower amount of farm land and other asset holdings.

Household size is the other important variable with implications to household food security. The statistical analysis showed a significant difference in household size between food secure and food insecure households (t=-2.888; P=0.005). The mean family size for food secure and food insecure households was 5.37 and 6.04 respectively. The result indicated that household size had an impact on food security. Large households have more people to feed as compared to

small households thus, reducing the calorie available per household member increasing the food insecurity in those households. This result is consistent with [8].

Literacy level of the household head is also an important variable mostly presumed to have impact on food security status of the household. The result of the chi-square showed that there was no significant relation between household food security and education level of the household head (chi=5.072, P=0.280). The reason behind this anomaly might be explained by the presence or lack of other important productive resources. This result was supported by [14].

Table 8. *The Association between Food Security and 11 Independent Variables.*

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate
1	.883 (a)	.779	.757	797.37709

Predictors: income, education, off farm, credit, house hold size, extension, age, irrigation, farm size, oxen, livestock

3.6. Households' Economic Resources and Household Food Security

The study examines the existence of any systematic relationship between asset ownership and food security among sample farmers who had access to Jedeb irrigation scheme and who had no. In this regard, the relations between food security and variables such as farm size, livestock holding, oxen ownership, participation in off-farm income generating activities and access to farm inputs (extension service, credit and irrigation access) were examined.

Farm Size

The size of the land in agriculture influences household food security in that the larger the farm land the higher the production [21]. The land holdings size in the study area vary from zero to 3 hectares. The average farm size of the entire sample households was 1.158 hectare. On the other hand the average farm size of irrigation users and non users was 1.160 and 1.156 hectare respectively. The average irrigable land holding of sample irrigation users was 0.186 hectare. The T-test result shows that there was no statistically significant difference in the mean farm size of irrigation users and non users (at t value of 0.24 and P=.981). As it is evidenced from many empirical research findings, access to sufficient farm land is one of the critical factors determining food security. The t-test result showed that the average farmland holding for food secure households was 1.4471ha and the corresponding figure for food insecure households was 0.476ha. This difference in farm size between food secure and food insecure households was found to be statistically significant with t value of 6.624 and P value of 0.000. This result was supported by [8].

Oxen Ownership

In the rural parts of the country, including the study area, ownership of pair of oxen is perceived as a prerequisite for an independent economic activity and is an important economic asset towards which households strive to attain more production; it enables a household to cultivate their land adequately and in time.

The above table shows that only 26.32 % of irrigation users and 29.68 % of non irrigation users owned a pair of oxen, and 45.61 % irrigation users and 20.31 % non users owned more than a pair of oxen. The survey result showed that the average oxen holding per sample irrigation users and non user households were 2.32 and 1.73 respectively. T-test showed that there was statistically significant difference in oxen holding between irrigation users and non users at t value of 2.551 and p=0.012. This reveals that income and additional production obtained from irrigation enable irrigators to maintain large number of oxen. T- test result showed that the average oxen possession for food insecure households was 0.89 and that of the food secure households was found to be 2.48. This difference was found to be statistically significant with t value of 7.478 and P value of.000. This indicates that oxen ownership had an impact on household food security.

Livestock Holding

Livestock contribute significantly to food security, to generate income and are an important mobile means of storing wealth, provide transport and on farm power. Increasing livestock productivity can have a significant impact to achieving food security and alleviating poverty, as it is an important asset especially in the rural smallholders' economy [22]. In line with this, [23] stated that livestock are valued assets for the rural poor and marketing of livestock products is practical and efficient pathway out of poverty. Livestock holding in terms of tropical livestock units for the total sample households was distributed with mean value of 4.0921TLU and standard deviation of 3.16. The household survey shows that the average number of TLU owned by irrigation users and non users per household was 5.2600 and 3.0833 respectively. This difference in mean livestock holding was found to be statistically significant with t value of 3.968 and P value of 0.000. This indicates that irrigation users owned more livestock than the non users. Livestock possession positively affects food security as it is the backbone of the farm economy in mixed farming systems. The average livestock holding for food secured and insecure households was 5.1432 and 1.6661 TLU respectively. This difference was found to be statistically significant with t value of 6.300 and P value of 0.000.

Table 9. *Stepwise Regression result of Food Security and Independent Variables.*

Mode	R	R^2	Adjusted R^2	Std. Error of the Estimate
1	.759 (a)	.576	.572	1057.80335
2	.830 (b)	.688	.683	910.73681
3	.855 (c)	.731	.724	849.38461
4	.865 (d)	.749	.740	824.28578
5	.872 (e)	.761	.751	807.61546

a Predictors: livestock
b Predictors: livestock, income
c Predictors: livestock, income, farm size
d Predictors: livestock, income, farm size, irrigation
e Predictors: livestock, income, farm size, irrigation, oxen

Extension Services

The effectiveness of agricultural inputs in production partly relies upon the availability of sound agricultural extension services at community levels. The household survey data demonstrates that of the total sample households 86 percent have access to extension service, while 14 percent are non users of extension service. Among the farmers visited and advised by development agents 62 % of them have reported that they were visited twice and more per month. This suggests that most of the farmers in the study area have access to extension service. The chi-square test showed that there was statistically significant systematic relationship between access to extension service and food security, with chi-value of 5.089 and P value of.024.

Credit Service

The availability of agricultural credit to the subsistence farmers who have little or no capital or savings to invest in farming is an important component in small farm development programs. The household survey shows that among the total sample households only 26.45 percent of farmers have reported that they have got credit access. Among them 31.25 and 68.75 percents were irrigation users and non users respectively. The Chi-square result showed that there was statistically significant systematic relationship between access to credit and food security, with chi-value of 4.154 and P value of.042.

Access to Irrigation and Food Security

The survey data indicated that about 63 percent of the irrigators produce three times a year and 37 percents produce twice a year on their plot in the irrigation scheme using water from the Jedeb river. While non irrigators produce only in the rainy season. The chi-square test shows that there was statistically significant systematic relationship between access to irrigation and food security, with chi-value of 7.685 and P value of 0.006. This result was supported by [24]. Making the minimum per capita kilocalorie allowance 2400 kilocalories per person per day (which is the global minimum recommended kilocalorie required for an active and healthy life) revealed that about 75.44% (N=43) from irrigation users and 51.56 % (N=33) from non irrigation users were found to be food secure. On the other hand, 24.56 % and 48.44 % of irrigation users and non users were found food insecure respectively. The above findings clearly showed that Jedeb irrigation scheme had played a very important role in improving the food security status of irrigators.

3.7. Determinants of Household Food Security

Household food security can be affected by household demographic factors like age, household size, education level etc and by household access to factors of production like land, livestock, oxen, extension services etc. To analyze the impact of these variables on household food security, multiple regression models was used. The dependent variable (Y) is the household food security status in terms of per capita kilocalorie available in the household. The independent Variables (X) are: Education level of the household head (0=illiterate, 1=read and write, 2=grade 1-4, 3=grade 5- 8 and 4=above grade 8), age of household head (in number), household size (in number), farm size (in hectare), oxen ownership (in number) livestock holding (in TLU), household income (in birr), participation in off-farm activities (1=yes and 0=no), access to extension Service (1=yes and 0=no), access of credit (1=yes and 0=no), and access to irrigation (yes=1, no=0).

The regression result showed that the combined effect of the considered variables show a significant association as it is indicated in Table 9. The coefficient of determination (R^2) was determined to be 0.779 implying that about 77.9% of the variation in food security of the households (average kilocalorie available in household) was explained by the eleven independent variables included in the model. Table 8 showed that household size had a significant and inverse relation with household food security (average available kilocalorie) and was significant at 5% level. However, access to irrigation, farm size, livestock holding, oxen ownership and income of the households had direct relation with food security of the households and were significant at 5% level. The result shows that the other variables included in the regression analysis were found to be statistically insignificant.

In order to show the relative contribution of each variable a stepwise regression analysis was computed. As shown in Table 10 among the eleven independent variables considered, livestock holding stands first which accounted for 57.6% of the variation in household food security. This is because livestock ownership has important direct and indirect contributions. Directly it is a source of food and cash that can be used to buy food and other items needed. Indirectly, it is the asset that can be transformed in to inputs in food production. The second higher (11.2%) contribution for the variation of the dependent variable was made by household income. This means households income increase their ability to buy food grains and the available food in a household. Farm size is the other variable which contributed to the variation of the dependent variable next to income. This is due to the fact that without it food production is nearly impossible for subsistence farm households. Households endowed with large farm size have high food production. Access to irrigation also contributed significantly to the variation since it increases food availability at household level through increasing number of harvesting in a year. The other variable which contributes to the variation in the dependent variable was oxen ownership. This is due to the fact that households with more number of oxen have sufficient drought power and are able to rent in land in addition to their own and thus produce more food crops.

4. Conclusions and Recommendations

The findings of the study showed that there was statistically significant difference in livestock holding, oxen ownership, crop production and income between irrigation users and non user households. It implies that farmers who had plot on the irrigation scheme were in better condition in

terms of production, livestock holding, oxen ownership, and income than their partners with no plot on the scheme. Cash income generated from irrigation farming has been an important source of investment on productive assets of rural households. Therefore it can be concluded that the Jedeb irrigation scheme brought positive impact on production, income and livestock resource and food security status of irrigation users. In addition to access to irrigation, household size, income, livestock holding, oxen ownership as well as farm size were the major factors that determine household food security in the study area. The study, therefore, concludes that the Jedeb irrigation scheme significantly contributed to household food security.

Based on the findings of the study the following points were recommended. Efforts should be made to raise the level of agricultural production and productivity. This can be done only through use of modern agricultural technological inputs such as fertilizers, improved crop varieties and agronomic practices. Therefore, there is a need for an invigorated agricultural research and extension programmes. The ever-increasing population pressure is the major cause behind the problem of food insecurity. Hence, efforts should be geared towards controlling population growth through vigorous family planning education. The other important implication of the study is that government should enhance the availability of off-farm jobs in the area. This is very crucial for poor rural households to supplement their income so that food security agenda of government would be met. The regional government should commit to increase significantly the total agricultural land under irrigation and these activities should consider the negative impacts on the ecosystem. The implication of this is particularly significant given the fact that the study area is endowed with both surface water and groundwater resources that might be tapped to expand irrigated agriculture.

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