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Full Length Research Paper

Impact of small scale irrigation on household's food security in *Fentale* District, East *Showa Zone* of Oromia National Regional State, Ethiopia

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The study analyzed the impact of small-scale irrigation on household food security. Multi- stage random sampling technique was used to select sample households. Data was collected from two groups (from 80 households' participants in irrigation and from 80 households' non participants in irrigation). Data was analyzed using descriptive and econometric techniques. Logit and Propensity score matching probability model was used to analyzed the data. The result of the model indicated that, participation in small-scale irrigation was positively influenced by education status of household head, distance from local market and frequency of extension contact and negatively influenced by livestock holding, irrigation water source, dependency ratio and non-farm income. The result of average treatment effect showed that, daily calorie intake of households participants in irrigation increased approximately by 28 percent than non participant irrigation households. Participation in small-scale irrigation increased the calorie intake by 908.29 kilo calorie per adult equivalent per day or increased by 28.52% over those households non participant in irrigation. These showed that the intervention in small scale irrigation was positive and there is a statically significant mean difference between the participants and non participants. The result revealed that, development of small scale irrigation for pastoral and agro pastorals households can make a significant contribution towards increased food security. Therefore, the study recommends that, continuous investment in small scale irrigation system should be encouraged to promote small scale irrigation development in similar lowland areas of Ethiopia to ensure pastoral and agro pastorals household food security.

Keywords: Household food security, propensity score matching, Logit, small-scale irrigation, daily calorie intake.

Organization of the study

Clearly showing the organization structure of the study is an interesting part of research paper to explain the sequence of the research work. Therefore, this research paper has five chapters. Background, statement of the problem, objectives, significance, scope and limitation. Whereas, chapter two is research methodology; chapter three deals with result and discussions, chapter four is summary, conclusion and recommendation, chapter five and six are reference and appendix respectively.

INTRODUCTION

Background and Justification

In Ethiopia nearly one third of the population lives below the poverty line and a vast majority depends on subsistence agriculture. Consequently, chronic and acute food insecurity is prevalent among rural populations and smallholder farmers, agro pastorals and pastorals. The main causes are heavy reliance of agriculture on rain fed,

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recurrent droughts, climate change and unbalanced growth rate of the population annually beyond agricultural production growth (UNICEF, 2014; MoFED, 2012;Seleshi and Merrey, 2014).

In Ethiopia, pastoralists and agro pastoralists were estimated to be about 10 to 13 % of total population and live in arid and semi-arid area. Drought and climate changes threaten the sustainability of pastoral and agro pastoral traditional practices (Jeffrey, S. *et al*., 2011). As a result, livestock production is not able to support the food demand of pastoral community. For instance around 1.8 million pastoralists, agro pastoralists and smallholder farmers affected by El Niño and need support in 2015 (UNICEF, 2014). Similarly, FAO (2016) reports reveal that; in Ethiopia pastoralists are the first and hardest hit by drought in 2015. This implies, the household food security of the pastoral community is not realized in the absence of proper agricultural development and efficient utilization of its water resource for irrigation.

Different writers postulate that; irrigation is a viable strategy to raise crop yields and achieve food security in third world nations. For instance, Valipour (2015) point out that irrigation play an important role to reduce poverty in the world through improvement of production, enhancement of employment opportunities and stabilization of income and consumption. Similarly Seleshi (2010) state that irrigation creates livelihood options and increase food resilience for smallholder farmers by raising production and productivity, thereby achieving food self-sufficiency. Generally, irrigation also allows poor people to increase their production and enhance opportunities to reduce vulnerability caused by the seasonality of agricultural production. Considering this fact the government of Ethiopia has been giving special emphasis to enhance irrigated agriculture in lowland area in order to improve the livelihood and ensure food security (MoA, 2011).

Accordingly, at East *Showa* zone of "Oromia national region state; *Fentale* irrigation project" was established in 2009 for agro pastoralists. The project has the capacity to irrigate a total of 3,700 hectors (FDSEP, 2013). However, despite the fact that government established irrigation system in the area, the impact of small-scale irrigation on household food security was theoretically and empirically not an in-depth study. Most previous study concentrated on well experienced agrarian area and explains the effect of irrigation in terms of income. They did not look at irrigation in terms of nutritional security. Therefore, this study was done with the objective to analyze the impact of irrigation on household food security in *Fentale* district to provide baseline information for policy maker for further support and investment on smallholder irrigation development.

Objective of the Study

The main objective of this research was to analyze the impact of small-scale irrigation on household food security.

Specific objectives of this study are:-

- To analyze the impact of small scale irrigation on households food security in the study area
- To identify factors that determines household's participation in irrigation in the study area.

Significance of the Study

The finding of this study can be used to provide baseline information for policy makers on status of agro pastoralist's food security in the study area. On top of this, the research work also provides information for researchers interested to study in other similar research theme.

Scope and Limitation of the Study

The study analyzed the impact of small-scale irrigation on household food security in case of agro pastoralist farm community. It is limited to *Fentale* district, east *Showa* zone of Oromia national regional state. This study does not represent the whole population of the region and it is limited to one year survey data. Since assessing household food security status was a difficult issue, maximum effort was made to gather reliable information by convincing farm households to address the objective of the study.

Concept and terminology used in the study

Household food security

Household food security refers to the ability of a household to produce and/or purchase the food needed by all household members to meet their dietary requirements to achieve and maintain an optimal nutritional need.

Small Scale Irrigation

In this study, small-scale irrigation is a type of irrigation practiced in small plot of land that is controlled and managed by smallholder (agro-pastoralists) households.

Propensity Scores Matching

Propensity Scores Matching is a tool that creates a comparison group with the treatment group based on factors that influenced people's propensity to participate in irrigation.

Dependent and outcome variable

Dependent variable is variable influenced by independent variables. In this study participation in small-scale irrigation is dependent variable which is affected by the independent variable. It is dummy values1 for household participants in irrigation and 0 otherwise.

The outcome variable is a daily calorie intake per adult equivalent (AE). Daily calorie intake is the amount of total

calories consummation of each sample households per day per AE and then compared with recommended Kcal per AE per day (2200kcal) set by the Ethiopia Government (FSS, 2002).

Participants are households who have access to irrigation farm by ownership, rented/shared in/out or gifted.

Non participant is a household who have no access to involve in irrigation farm.

METHODOLOGY

Description of the Study Area

Location of the study site

The study was conducted in *Fentale* district, Oromia national regional state. *Fentale* district is located in the Great Rift Valley East of East Showa Zone of Oromia national regional State. The district is situated at 193 km east of Addis Ababa on the main high way joining Ethiopia and Djibouti (FDSEPD, 2013).

Climate of study area

The climate of Fentale area has a typical characteristics and falls under hot-semi arid. The mean annual temperature and mean annual rainfall of *Fentale* district varied between 18^0c and 39^0c and its mean annual rainfall is 350mm-470mm. Rainfall of the area is very erratic and scarce occurring two or three times yearly (Yohannes, 2011).

Farming system and land use pattern

The major economic activity in the study area was livestock based subsistence farming. Cattle, goat, sheep and camel are the dominant livestock species. Crop cultivation has never been practiced until 1950 by the native inhabitants in the area. Since 2009, pastorals were shifted to semi crop production in the district following development of irrigation infrastructure. Crops like Maize, Teff, Onion, Tomato and wheat were newly introduced and practice in the area. Maize is the largest cultivable crop followed by onion and tomato (FDSEPD, 2013).

Research Methods and Methodology

Sampling and Sample size

A multi-stage random sampling technique was employed to select sample households. In the first stage, from six-irrigation user *kebele*, three *kebele* were purposively selected. In the second stage respondents were selected and stratified into two strata called irrigation users and non-users. Then from each stratum 80 sample respondents were selected randomly by simple random sampling technique. Finally, 160 household heads were interviewed. To determine the required sample size, the study employed a formula developed by Yamane (1967).

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

where, n= sample size for the study, N= total number of household head, e= margin of errors.

Types of data collected and data sources

Quantitative and qualitative data types were collected from primary and secondary data sources. Primary data was collected from respondents. Whereas, secondary data was reviewed and organized from published and unpublished materials.

Methods of data collection

Semi-structured questionnaire and focused group discussion were used for data collection. To observe the relevance of the questionnaire, the questionnaire was pre-tested based on the real situation before the actual survey was carried out. After all primary data was collected by semi structured questionnaire, focus group discussion was held with 5-7 household to supplement the primary data.

Methods of data analysis and model used

Descriptive statistics, Logit and propensity score matching probability model was used to analyze the data. The propensity score is defined as the probability of receiving treatment based on measured covariates:

$$E(x) = P(D=1 \mid X)$$

where E(x) is the abbreviation for propensity score, P is a probability, D=1 a treatment indicator with values 0 for control and 1 for treatment, the "|" symbol stands for conditional on (predicted), and *X* is a set of observed covariates. To analyze the impact of small scale irrigation on household food security average treatment effect (ATT) was used. ATT is the difference between the outcome of treated and the outcome of treated observations if they had not been treated (counterfactual) computed as:

$$\text{ATT} = E(Yi^T - Yi^C \mid D = 1) = E(Yi^T \mid D = 1) - E(Yi^C \mid D = 1)$$

where D is treatment sample respondents

RESULT AND DISCUSSION

This chapter deals with the analysis of the survey data and interpretation of the study results. Such as, demogra-

phic and social economic related to sampled household discussed using descriptive statistics and econometric result.

Descriptive results

3.1.1. Household demographic characteristics

Under this subtopic, the demographic characteristic of the surveyed households was discussed and summarized in Table 1. It shows that education level showed a significant difference between participants and non-participants. Whereas, sex and non-farm income sources of the households did not show significant difference between the two groups.

3.1.2. Scio economic characteristics

Table 2 summarized the socio economic and institutional characteristic of the surveyed household. It shows that among the presented features; dependency ratio, total livestock holding, distance from irrigation water source, distance from local market, and frequency of extension contact is a significant difference for participants and non-participants.

Descriptive statistics of outcome variables

The descriptive statistics of participants and non-participants group in Table 3 showed that, the mean calorie intake per adult equivalent of participants were more than that of calorie intake per adult equivalent of non-participants household (3206.47 versus 1998.53kcl respectively). As indicated that the mean difference in calorie intake per adult equivalent between the participants and the non-participants households were 1207.94 kcl. The t-test also showed that statistically significant difference at 1% probability level.

Econometric Results

The study data was checked for the occurrence of Multicollinearity problem using VIF before going to analysis. The mean VIF result of continuous variable is 1.09 which shows that there is no sign of the presence of multicollinearity among the explanatory variables included in the model (Appendix Table 4). According to Gujarati (2004), it is essential to omit variable with Variance Inflation Factor (VIF) value exceeds 10 that happens if R^2 exceeds 0.90 and show high correlation between variables.

Factors that determines household's participation in irrigation

Logit results of participation in irrigation

The estimated logistic regression model indicated that seven of the ten explanatory variables significantly influenced participation in irrigation. The results in Table 4 reveal significant and insignificant covariates of irrigation participation.

Education status: significantly and positively influenced irrigation participation. These result agreed with the result of Kinfe et al., (2012) who found that education plays a key role in the household decision for technology adoption or participation.

Dependency ratio of household: it influenced irrigation participation negatively 10% probability level. This is probably due to time and labor shortage of household. This result was also agree with Abera (2015) who found that household members holdings with high dependency ratios might not be able to participate in programs due to time, labor and/or financial constraints.

Distance from irrigation water source: Had a negative impact on irrigation participation at 1% probability level. The possible explanation is that; as a household far from irrigation water source, access to get enough water for irrigation is reduce as a result of cost of operation of labor and time is increase and reduce participation in irrigation. The result confirmed the study of Sinyolo et al., (2014) who found that distance of farmer's homestead from the irrigation scheme had a negative influence on the farmer being an irrigator.

Livestock holding: significantly and negatively affect participation irrigation at 10% probability level. This is probably due to the difficulty of combine large livestock with a small field of cultivation. This study consists of the hypothesis and study conducted by Dadi et al., (2011) and Abdi, (2015). However, against the study of Abera, (2015) found that households with larger livestock holding may have money to spend on any possible costs to use irrigation.

Nonfarm income source: significantly and positively affected participation in irrigation at 5% probability level. The possible reason is that, household involve nonfarm income source not participant in irrigation. This may be because of lack of time and skill. The result of this study is against study of Hundush (2014), who found that households who participate in non-farm more probably encouraged participating and adopting irrigation systems because of the money that they earn from non-farm.

Frequency of extension contact: Significantly and positively influenced participation in irrigation. The odd ratio of 1.57 indicates that, other factor being constant, a unit contact of household with extension agent, increase participation in irrigation by the odds of 1.57. This is probably due to irrigation participation provide technical support or advice from extension worker. This result confirm with the study of (Sinyolo et al., 2014), found that farmers who directly contact with extension agent participate in irrigation than those who do not contact.

Table 1. Descriptive statistics of for dummy variables

Participation in irrigation		Participant percentage	Non-participant percentage	Total percentage	X^2 – value
Variables					
Sex	Male	90.00.	88.80	89.40	0.65
	Female	10.00	11.30	10.60	
Total		100.00	100.00	100.00	
Education status	Not read and write	58.75	81.25	70.00	9.64***
	Read and write	41.25	18.75	30.00	
Total		100.00	100.00	100.00	
Nonfarm income source	yes	10.00	13.75	11.87	0.53
	no	90.00	86.25	88.12	
Total		100.00	100.00	100.00	

Source: own results (2016)
***, means significant at 1%

Table 2. Descriptive statistics continues variables.

Variables	Participant HH		Non-participant HH		
	Mean	SD	Mean	SD	**t-value**
Age (in year)	38.14	10.37	39.91	10.84	**1.05**
Dependency ratio in the household (%) (%)	86.46	63.54	104.12	76.22	**2.61*** **
Livestock holding in TLU	6.19	4.20	8.64	6.67	**2.76*** **
Distance from irrigation water source in (km).	1.30	0.81	1.916	0.968	**5.14*** **
Distance from nearest market in(km)	26.57	5.02	25.06	5.81	**1.76***
Labor availability per men equivalent in hh	2.52	0.89	2.61	0.98	**0.62**
Frequency of extension contact with household head per month	1.95	1.85	1.12	1.16	**3.37*** **

Source: own results, 2016
*and *** means significant at 10% and 1% probability level respectively.

Table 3. shows that, the descriptive result of the outcome variable (calorie intake/AE per day.

Variables	Combined Mean	Participant Households	Non-participant Households	Mean Difference	T-test
Calorie intake/adult equiv.	2602.50	3206.47	1998.53	1207.94	7.51***

Source: Own estimation result (2016). *** means significant at 1%, probability level.

Table 4. Logit results of participation in irrigation.

Variables	Coefficients	Standard errors	odds ratio
Sexhh	-0.499	0.390	0.606
Agehh	0.011	0.019	1.011
Edustatushh	1.035**	1.367	2.815
Dependratio	-.0.005*	0.002	0.994
Laborav	-0.117	0.203	0.889
Distirrgwater	-1.015***	0.100	0.362
Livstockhold	-0.079*	0.038	0.923
Nonfarm	-1.487**	0.154	0.225
Freqextncont.	0.451***	0.215	1.571
Distlocmrkt	0.087**	0.041	1.091
Constant	0.125	1.663	1.133
N	160		
LRchi2 (10)	58.40		
Prob>chi^2	0.000		
Log likelihood	-81.702		
Pseudo R^2	0.263		

Source: Own survey result (2016). ***, ** and * means significant at the 1%, 5% and 10% probability levels, respectively.

Table 5. ATT of outcome variable.

Outcome variables	Treated	Control	Difference	SE	t-value
Kilo calorie intake per adult equivalent per day	3183.91	2275.61	908.29	227.50	3.99***

The bootstrapped SE obtained after 100 replications
**' ***Significant at 5% probability level.

Distance from local market: Significantly and positively influenced irrigation participation at 5% probability level. The possible explanation is household far from market has less probability to invest or engage in other source of livelihood. This result is against the study of Sinyolo et al. (2014), which suggests that the better the household head had the market they are more probable to participate in irrigation practices.

SUMMARY

The aim of this study is to analyze the impact of small-scale irrigation on household food security. For this study a total of 160 sample respondents were selected from the two strata (irrigation participant and non participant) randomly through simple random sampling technique.

Descriptive statistics and econometric model was used to analyze the result of this study. To test the significance of the two groups, chi-square and t-test were applied.

The result of descriptive statistics clearly showed that those household participants in irrigation differ in terms of household characteristics and institutional factors then non participant in irrigation. The two groups differ in terms of educational status, distance from irrigation water source, dependency ratio and the frequency of extension contact (Table 1 and 2). Similarly, the descriptive statistics of outcome variable clearly showed that those households that participate in irrigation are by far better calorie intake per adult equivalent than non participant households. A t-test was used to compare the mean of the two groups by using different determinants of small-scale irrigation and statistically significant result is obtained (Table 3). The result revealed that households participant in irrigation farm are in a better position when compared to those that are non-participant in irrigation farm in terms of food security (Table 3).

In the same way the result of logit model shows education statatus, frequcy extention contact, and distance from local market positively affect participation in irrigation. While, dependacy ratio, livestock holding,

distance from irrigation water source and non farm income source affect participation in irrigation negativily (Table 4).

Education level of household head positively affects farmers' decision to participate in small-scale irrigation. As a result, educated household heads are in a better position to use irrigation. Therefore enhancing the educational status of the agro pastoralists through formal and informal (Capacity building, experience sharing with model farmer and prepare farmer field days) recommended.

Household with less labor force in family members less to use irrigation farming. This is because of irrigation use more labor forces. Therefore, Introducing labor saving technology (use less horsepower tractor and herbicide chemical) and improving the working habit of the household's will be advisable to reduce labor shortage in the households.

Distance from irrigation water source lead the household for addition cost of operation labor and time as a result participation of household in small-scale irrigation reduced. Thus, expansion of irrigation structure is a recommendable solution to improve participation in irrigation in the study area.

Having more livestock affect participation in irrigation negatively. This is because of the difficulty to rear large number of livestock in small area of cultivated land. Therefore using more productive livestock is advisable to reducing number. To do so government and extension personnel should change the attitude of agro pastoralist through different training advisable. Also providing access for agro pastoralist household to get improved livestock through artificial simulation is advisable.

Nonfarm income source of household, affect participation in irrigation negatively. Thus, it is well if farmer household look into different livelihood option to do so in capacity building and forming entrepreneur household will be advisable. Frequency of extension contact, positively affect participation in irrigation because irrigation provide technical support and advice from extension worker. Thus, enhancing contact of development worker through providing incentive to extension worker is advisable by giving short and long-term training.

CONCLUSION AND RECOMMENDATIONS

From the result of this study, participation in small scale irrigation increase daily calorie intake by 908.29 Kilo calorie per adult equivalent per day or increased by 28.52 percent than non participant households in irrigation. These show that intervention in small scale irrigation is a key factor in making agro pastoral food self- sufficient. Hence, giving more attention and support for small scale irrigation development at agro pastoral areas has improved household food security. Generally, access to small scale irrigation development allows agro pastoral opportunity to increase their farm productivity and reduce chronic and acute food insecurity in the study area. Therefore, the study recommends that continuous investment on small scale irrigation development should be encouraged to promote small scale irrigation development in similar lowland areas of Ethiopia to support and ensure pastoral and agro pastoral household food security.

Further Study

The study considers few points from the broad and complex issue of the effect of small-scale irrigation and only considered the positive impact of small-scale irrigation. However, the negative effect of irrigation on the households and on envaroment was not addressed in this study. Therefore, further study will be needed to address the negative effect of small-scale irrigation in the study area.

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7. APPENDICES

Appendix Table 1. Conversion factor of tropical livestock unit (TLU).

Livestock Category	TLU	Livestock Category	TLU
Ox	1	Horse	1.1
Cow	1	Sheep (adult)	0.13
Woyefen	0.34	Sheep (young)	0.06
Heifer	0.75	Goat (adult)	0.13
Calf	0.25	Goat (young)	0.06
Donkey (adult)	0.7	Hen	0.013
Donkey (young)	0.35		

Source: Storck, et al., 1991

Appendix Table 2. Conversion factor for adult equivalent (AE).

Age group	Male	Female
0-1	0.33	0.33
1-2	0.46	0.46
2-3	0.54	0.54
3-5	0.62	0.62
5-7	0.74	0.7
7-10	0.84	0.72
10-12	0.88	0.78
12-14	0.96	0.84
14-16	1.06	0.86
16-18	1.14	0.86
18-30	1.04	0.8
30-60	1	0.82
+60	0.84	0.74

Source: Storck, et al., 1991.

Appendix Table 3. Conversion of food items consumed by sample household.

Food type	Kcl/kg	Food type	Kcl/kg
Maize	0.33	Sugar	0.88
Wheat	0.46	Tomato	0.96
Teff	0.54	Cabbage	1.06
Bean	0.62	Onion	1.14
Potato	0.74	Milk	1.04
Tea	0.84	Butter	1
Coffee		Oil	0.84

Source: Storck, et al., 1991

Appendix Table 4. Multicollinearity test for continuous explanatory variables.

Variable	**VIF**
Labor / man equiv.	1.16
Age	1.12
Depend ratio	1.12
Distlocalmrkt	1.10
Distirrigation	1.06
Ferqextncontact	1.05
Livstokhold	1.05
Mean VIF	**1.09**

Source: own result, 2016