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Impact of Small Scale Irrigation on Household Farm Income and Asset Holding: Evidence from Shebedino District, Southern Ethiopia

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Abstract
Irrigation as an agricultural intensification method plays dominant role in increasing agricultural production and productivity. The main objective of this study was to assess impact of small scale irrigation use on household farm income and asset holding. Relevant primary and secondary data were collected to respond to the objectives of the study. The primary data were collected from randomly selected 93 irrigation user households and 103 non-user households drawn based on proportion to population size. Secondary data were collected from review of relevant related literatures. Both descriptive statistics and econometric model were used for analyzing quantitative data of the study. Twelve variables were hypothesized that determine households' probability of participation in irrigation use and seven of them were found significant. The study has found that age, educational level, contact frequency with agricultural development agent, credit access, access to mass media, participation in irrigation related training and livestock ownership were the variables that significantly influence households' use of small scale irrigation. The result of PSM analysis indicate that participation in irrigation use has increased annual household farm income by 19,474.8 ETB for participant households than non-participant households which is significant at 1% level. Similarly, it has increased their physical asset holding which is measured in Ethiopian birr valued 27,502 ETB at 1% statistically significance level. The sensitivity analysis result showed that the impact results estimated by this study were in sensitive to unobserved selection bias. It was concluded that irrigation has positive and significant impact on annual farm income and asset holding of the rural farming households. Therefore, governmental and nongovernmental organizations working on irrigation should promote irrigation in livelihood improvement procedure.
Keywords: Key Words: Asset holding, Farm income, Small scale irrigation

1. Introduction

Irrigation as a method of agricultural intensification plays dominant role in increasing agricultural production and productivity (Abraham *et al.*, 2015). Ethiopia is predominantly an agrarian country with the vast majority of its population directly or indirectly involved in agriculture. Agriculture is the backbone of the country's economy and it is mostly small- scale, rain-fed, traditional and subsistence farming with limited access to technology and institutional support services (Desta, 2012). Ethiopia is alone believed to have the potential of 5.1 million hectares of land that can be developed for irrigation through the river and spring diversion, pump, gravity, pressure, underground water, water harvesting and other mechanisms (Tedros, 2014). Irrigation has key role to stabilize agricultural production and mitigate the negative impacts of variable or insufficient rainfall (Getaneh, 2011. It has also potential to increase both yields and cropping intensity (Awulachew *et al.*, 2010).

In the study area, small-scale irrigation use started in 1986. During this period, irrigation was used only for coffee nursery development, specifically in two *Kebeles*' of the district namely Taramesa and Sadeka *Kebeles*. However, at the present, small-scale irrigation practice took place not only by using concrete canal direct

diversion, but also use of motor pump both from concrete canal and from river diversion, fetching by water sprayer and use of shallow-well system in fifteen potential *Kebeles* of the district. Many households have been engaged in irrigation practices and benefiting from it (SDAO, 2018).

Considerable researches previously conducted in this field in the study area and at large in Ethiopia are focused on food security, livelihood and poverty alleviation. For example, a study conducted by Woldemichael and Tewodros, (2015), Dereje and Desale, (2016) and Mengistu (2008) ignored analysis of impact of small scale irrigation on asset building. The premising gap of these studies is; they drawn dependent sample for their study which focus on one group comparison (before irrigation use and after irrigation use). The approach followed to assess impact with such type of sample is subject to bias as it focuses on comparing before and after cases. Another study conducted by Abonesh *et al*., (2015) on the impact of small scale irrigation on household food security in Ethiopia ignore impact on income brought by the use of irrigation where the study focused only on comparison of average food consumption expenditure of irrigation users and non-users. Moreover, study conducted by Bernard, (2011) on the impact of small scale irrigation schemes on rural livelihoods focused on overview of the socio demographic profile of plot holders followed also the same approach.

Generally the reviewed previous studies didn't follow appropriate impact measurement approach but they simply compare before and after cases. Besides, studies conducted and documented on impact of small scale irrigation on household farm income and asset holding in study area is very much limited. Therefore, this study was conducted to assess impact of small scale irrigation use on household farm income and asset building so as to fill the knowledge gap required and further to contribute the development endeavors of the study area and in zonal, regional and national level where the agro ecological and socio economic conditions are similar.

1.1 Objective of the study

General objective

The general objective of this study was to assess impact of small scale irrigation on household farm income and household asset holding. The specific objectives include

1. To evaluate impact of small scale irrigation use on household farm income
2. To evaluate impact of small scale irrigation use on household asset holding

2. MATERIALS AND METHODS

2.1 Description of the study area

Shebedino *District* is found in Sidama Zone, Southern Nation Nationalities and Peoples Regional State. It is located at 300 km far from Addis Ababa, capital city of the Ethiopia. There are two agro climatic zones in the study area which is *Woyina Dega* (84.4%) and *Dega* (15.6%). Annual range of temperature varies from 16 ^{o}c to 25^{o}c. Annual range of rainfall also varies from 800mm to 1600 mm (DOFED, 2015). The study District has a total area of 276.9sq.km. As per CSA data of 2007 census, the *District* has an estimated total population of 233,922. From these, 118,026 are male and 115,896 are female. The total households of the study area are 37,152. The *District* comprises 35 *Kebele* administrations. Among these, three of them are urban *Kebele*s and 32 of them are rural *Kebeles* (DOFED, 2018).

2.2 Study Design

The research design for this study was social survey type. Mixed approach of quantitative and qualitative method of data collection was employed and the study had two sample groups (irrigation user and nonuser groups).

2.3 Sampling Techniques

Three stage sampling procedure was followed to select the respondent household for the study. In the first stage, the study District was selected purposively due to its high potential to irrigation use. In the second stage, four rural *Kebele* administrations were selected randomly from fifteen irrigation potential *Kebeles* of the study area. In the third stage, in four selected *Kebeles*, households were stratified into two strata (small-scale irrigation users and non-users who have access to irrigation water). Sample size was determined by using simple formula developed by Yemane (1967) at precision level of 7%. Following this, to identify respective sample for each stratum in each *Kebeles*, sample proportion to the population was employed. Based on this, 93 households from irrigation users and 103 households from non-users users were identified. Finally, respondent households were selected by using simple random sampling technique from each stratum.

$$\mathrm{n} = \frac{N}{1+N(\mathrm{e})}2$$
$$= \frac{4615}{1+4615(0.07)2}$$
$$=196$$

2.4 Source and Method of Data Collection

Both primary and secondary sources were used to collect relevant data. The primary data were collected directly from the selected respondents. To collected primary data from the respondents, a well-developed questionnaire was prepared both for qualitative and quantitative data. Before the collection of actual data, the questionnaire was pretested. Relevant literatures were reviewed to collect secondary data.

2.5 Data Analysis

The collected data were analyzed using STATA software version 13 by orderly applying analytical methods. Propensity Score Matching (PSM) model was used to examine the impact of small scale irrigation on farm income and asset holding. Besides, chi-square and independent t-test was used to compare both groups with respect to discrete and continuous variables respectively.

3. Results and Discussions

This section is divided into two subsections. The first sub section provides descriptive analysis of sample households' characteristics while the second sub section presents econometric estimation results followed to identify impact of irrigation on farm income and asset holding.

3.1 Characteristics of Sampled Households

The result presented on Table 1 reveals that the average age of irrigation user and non-user was found to be 45.16 and 43.76 years respectively. The analysis of t-test shows that age has no significant influence on irrigation use. The average family size of the total sample household was 5.43 while it was 5.61 and 5.27 for irrigation users and non-users respectively. This indicates that households that are users of small scale irrigation have more family size than non-user households. The main reason for this may be by its nature irrigation is labor intensive activities, that is why irrigation user households have relatively more number of family size than non-user households. The mean educational attainment of irrigation user households was 4.77 and for that of non-user household was 2.71. The t-test result indicates that there was significant mean difference in educational level between two groups at 1% of significance level which indicates positive influence of education on irrigation use. The mean land holding for irrigation user and non-user group was 0.807 and 0.55. The t-test analysis reveals that there is statistically significant mean difference between the two groups in terms of land holding at 1% significance level indicating the influence of land holding on use of small scale irrigation. Irrigation user and non- user households have to travel 81.1 and 86.84 meters in average from their farmland to the water point respectively. The result of t-test analysis reveals that there is no statistically significant difference between two groups in terms of distance from their farmland to the water point. The monthly average number of contacts respondents made with agricultural development agent in a month was 2.64 times and while it was 3.53 for irrigation users and 1.83 for non-users. The analysis of t test indicate that, there was statistically significant difference in number of number of contact made by irrigation user and non-user households with development agents at 1% of statistical significance level. It was found the average numbers of livestock holding of irrigation user household was 2.59 and it was 1.73 for non-user households. The t-test result that there is a statistical significant difference in livestock holding between irrigation users and non-user households at 1% significance level.

Table 1: Characteristics of respondents (Continuous variable)

Variables	Irrigation	Mean	t-value
Age	Users	45.16	1.1
	Non users	43.76	
Education	Users	4.77	3.98***
	Non users	2.71	
Family size	Users	5.61	1.48
	Non users	5.27	
Land holding	Users	0.8	4.95***
	Non users	0.55	
Distance farm plot from water point(m)	Users	81.1	0.32
	Non users	86.84	
Contact with agricultural development agent	Users	3.53	5.68***
	Non users	1.83	
Livestock(TLU)	Users	2.59	5.11***
	Non users	1.73	

Source: Own computation *** means significant at 1%

The result presented on Table 2 shows that 3.87 % irrigation users were male headed households while 16.13 % of them were female headed households. On the other hand, from total sampled non-user households

74.76 % and 25.24% of them were male and female headed households respectively. The chi square analysis shows that sex of the respondent household head have no influence on irrigation participation. The survey result depicts that 68.82% and 74.76% of irrigation users and non-users respectively have suitable slope for irrigation. The chi square shows that slope has no influence on irrigation use. The result obtained from household survey reveals that about 30.61 % of them accessed credit from different formal organizations while the rest 69.39% of them haven't accessed credit from these institutions. Among irrigation user households about 46.24% of them accessed credit while more than half of them haven't accessed it. Only 16.5% of irrigation non users accessed credit from the lending institutions. The result of Chi square test analysis indicate that access to credit influenced irrigation use at 1% significance level. Moreover, among total sampled households, about 51.02% of them have access to media while 48.98% of them have no access. About 61.29% of irrigation users and 41.75% irrigation non-users have access to media. The chi square test shows that access to media have positive influence on use of irrigation at 1% significance level. Furthermore, it was found that about half of the respondents participated in irrigation use related training where 65.59% of the irrigation users and 36.89% of the non-users followed training accordingly. The Chi square analysis reveals that participation in irrigation use related training influence irrigation use positively at 1% significance level.

Table 2: Characteristics of respondents (Discrete variables)

Variable	Irrigation users		Irrigation non-users		Total		Chi^2 value
	Freq	%	Freq.	%	Freq.	%	
Sex							**2.45**
Male	78	83.87	77	74.76	155	79.08	
Female	15	16.13	26	25.24	41	20.92	
Total	93	100	103	100	196	100	
Farm land slope for irrigation							**0.85**
Suitable	64	68.82	77	74.76	141	71.94	
Not suitable	29	31.18	26	25.24	55	28.06	
Total	93	100	103	100	230	100	
Access to credit							**20.33*** **
Yes	43	46.24	17	16.5	60	30.61	
No	50	53.76	86	83.5	136	69.39	
Total	93	100	103	100	196	100	
Access to media							**7.46*** **
Yes	57	61.29	43	41.75	100	51.02	
No	36	38.71	60	58.25	96	48.98	
Total	93	100	103	100	196	100	
Participation in irrigation training							
Yes	61	65.59	38	36.89	99	50.51	**16.1*** **
No	32	34.41	65	63.11	97	49.49	
Total	93	100	103	100	196	100	

Source: Own computation *** means significant at 1%

3. 2 Econometric Analysis

This part presents econometric analysis followed to examine impact of irrigation use on farm income and asset holding of household. It illustrates the estimation of propensity scores, defining common support region, choosing matching algorism, testing matching quality, calculating average treatment effect on treated and sensitivity analysis.

3.2.1 Estimation of propensity score

This section presents the result of logistic regression, the first step in propensity score matching, to estimate propensity score for matching irrigation user with non-user households. The existence of multicolinearity problem between explanatory variables of the study was tested by using Variance Inflation factor (VI) for continuous explanatory variables and Contingency Coefficient (CC) for discrete explanatory variables. The test of both analyses indicates that there is no multicolinreatiy problem between independent variables of the study. Therefore, all explanatory variables were used in the impact analysis procedure. The existence of problem of heteroscedasticity was tested using Breusch-Pagen test. This test resulted in the existence of heteroscedasticity problem as it was significant at 1% probability level, chi ^{2} values of 78.35, suggesting the need for standard error robust. Hence, robust standard error was conducted accordingly. The logistic regression result revealed that among twelve hypothesized variables, seven were found to be significant while the rest five variables were not significant in influencing probability of participation in irrigation use. Based on this age, educational level, and

contact frequency with agricultural development agent, credit access, access to mass media, participation in irrigation use related training and livestock ownership were variables identified by logistic regression model that influence households' probability of participation in irrigation use.

Table 3: Households' propensity of participation is small scale irrigation use

IRRPART	Coefficient	Odds Ratio	Std. Err.	Z	p-value
SX	-0.1761964	0.838453	0.4529053	-0.39	0.697
AGE	0.0478341	1.048997	0.0262915	1.82	0.069*
FMSZ	0.0107475	1.010805	0.1150239	0.09	0.926
EDULVL	0.1697668	1.185028	0.0617457	2.75	0.006***
LANDSIZE	0.6629278	1.940465	0.5567159	1.19	0.234
FARMDST	-0.000892	0.999108	0.00158	-0.56	0.572
SLOPE	-0.100917	0.904008	0.4284701	-0.24	0.814
CREDTACC	0.7460684	2.108693	0.4400824	1.70	0.090*
CONTFREQ	0.214892	1.239728	0.0838863	2.56	0.010**
MASSMED	0.773823	2.168039	0.3637404	2.13	0.033**
IRRTRAIN	1.055789	2.874243	0.3682157	2.87	0.004***
TLU	0.2528589	1.287702	0.1898259	1.33	0.10*
_cons	-5.497234	0.004098	1.351333	-4.07	0.000

***, ** and * means significant at 1%, 5% and 10% respectively. Sample size (N) =196 Pseudo R^2= 0.28 LR chi2(12) = 76.02P rob> chi2 =0.000. Log likelihood = - 97.593253

Source: Own computation

It was found that education level, contact with agricultural development agent and participation in irrigation use related training affect households' probability of participation in irrigation use positively and significantly at 1% significance level. A positive relationship between education and irrigation use may highlight that more educated people are more adopter of technology than others and able to understand and apply different sort of irrigation technology in their farm. This finding is consistent with Kebede (2011) and Muez (2014). A positive relationship between contact with agricultural development agent and irrigation use indicate that farmers who have more contact with development agent have more information on how to use irrigation than those who have no or less contact. Furthermore, a positive relationship between irrigation use and participation in irrigation use related training indicate that households who frequently follows training may have better skill and knowledge on the irrigation system.

A positive relationship between irrigation use and access to media shows that those households who had access to mass media have relatively better information access from the media on irrigation use methodology and even way forwards on how to access information from agriculture information centers also. Furthermore, it was found that age, access to credit and livestock ownership affect household probability of participation in irrigation use significantly and positively at 10% significance level. A relationship between age and irrigation use indicate that as age increases, farming experience increases in the same manner and farmers able to accumulate more knowledge and skill on how to use irrigation. A relationship between irrigation use and livestock ownership indicate the fact that in rural economy livestock is a means of income besides their other benefits that helps farmers to purchase farm implements for irrigation use. This is consistence with the finding of (Berihun *et al*., 2014).

Moreover, the result of logistic regression also indicate that access to credit affect household's probability of participation in irrigation use significantly and positively at 10% statistically significance level. The odds ratio of logistic regression model of access to credit indicates that favor of probability of participation in irrigation by a factor of 2.1 for those households who have access to credit. A positive relationship between the two variables indicate that access to credit is very important in that it helps farmers to acquire all the necessary inputs in right quantities and qualities for the irrigation practices at the right time. This is consistence with the finding of (FAO, 2008).

3.2.2 Identifying common support region

The propensity scores vary between 0.0564124-0.9822864 for irrigation users with mean score of 0.656892. Whereas the score varies between 0.0354646-0.906419 for non-user household with mean score of 0.309. The common support then lies between 0.0564124-0.906419. This means that household whose propensity score less than minimum (0.0564124) and larger than maximum (0.906419) are not considered for matching. Based on this procedure, 25 households (18 from irrigation users group and 7 from non- users group) were discarded from the study in impact assessment procedure.

Table 4: Distribution of estimated propensity score of households

Group	Observation	Mean	Std. Dev.	Min	Max
All household	196	0.4744898	0.2936385	0.0354646	0.9822864
Irrigation participant	93	0.656892	0.2604525	0.0564124	0.9822864
Non participant	103	0.3097966	0.2125269	0.0354646	0.906419

Source: Own computation

Figure 1 below shows the distribution of propensity score and common support region. The bottom halves of the histogram show the propensity score distribution of irrigation non user households and the upper halves shows the propensity score distribution of irrigation user households. The green colored (treated on support) and the red colored (untreated on support) indicates the observations in the irrigation user group and non-user group that have a suitable comparison respectively, whereas the orange colored (treated off support) and the blue colored (untreated off support) indicates the observations in the irrigation user and non- user group that do not have a suitable comparison respectively.

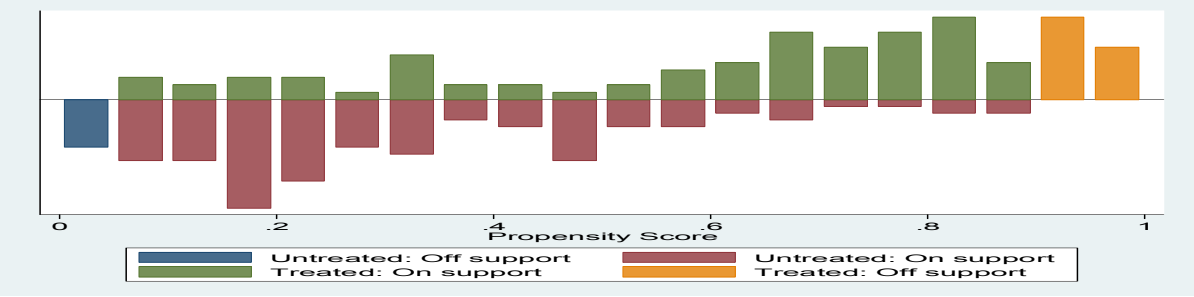

Figure 1: Propensity score distribution and common support region for propensity score
Source: Own computation

3.2.3 Matching irrigation users with non-users household

Following identification of common support region, different matching estimators (algorisms) were tried to match irrigation user with non-user households' in common support region. The final choice of matching algorism was guided by three criteria as suggested by Caliendo and Kopeinig (2008); namely equal mean test (balancing test), pseudo R^2 and size of matched sample (see Table 5). Matching algorism which balances all explanatory variables of groups (result in insignificant mean differences between irrigation users and non-users), bear low pseudo R^2 value and results in large sample size is preferable (Deheja and Wahba, 2002). Based on those criteria, kernel with bandwidth of 0.25 was found to be best estimator for this study. Therefore, impact analysis procedure was followed and discussed by using kernel with bandwidth of 0.25.

Table 5: Performance criteria of matching algorism

Matching Algorisms	Balancing test*	Performance criteria	
		Pseudo-R^2	Matched sample size
Nearest Neighbor			
Nearest Neighbor 1	12	0.039	171
Nearest Neighbor 2	10	0.049	171
Nearest Neighbor 3	11	0.046	171
Nearest Neighbor 4	11	0.039	171
Nearest Neighbor 5	10	0.044	171
Radius			
Radius 0.01	5	0.214	171
Radius 0.1	5	0.214	171
Radius 0.25	5	0.214	171
Radius 0.5	5	0.214	171
Caliper			
Caliper 0.01	12	0.049	120
Caliper 0.1	12	0.039	171
Caliper 0.25	12	0.039	171
Caliper 0.5	12	0.039	171
Kernel			
Kernel (bw 0.01)	11	0.054	120
Kernel (bw 0.1)	10	0.042	171
Kernel(bw 0.25)	12	0.036	171
Kernel (bw 0.5)	10	0.078	171

Source: Own computation

3.2.5 Average treatment effect on the treated

In this section, the study provides evidence as to whether or not the irrigation use has brought significant changes on household farm income and asset holding. The estimation result presented on Table 6 provides a supportive evidence of statistically significant effect of irrigation use on farm income and asset holding of household measured in Ethiopian Birr. It has been found, that on average, participation in irrigation use has increased annual household farm income by 19,474.8 birr for participant households than non-participant households which is significant at 1% level. Similarly, it has increased their physical asset holding which is measured in Ethiopian birr valued 27,502.4 ETB at 1% statistically significance level. The finding of this study was consistence with Kinfe *et al*., (2012**),** Bernard (2012), Ayele *et al*., (2013), Dereje and Desale (2016) and Woldegebriel, (2015).

Table 6: Average Treatment Effect on the Treated

Outcome variable	Mean of irrigation users	Mean of irrigation non-users	Mean Difference	t-stat
Farm income	31618.4933	12143.6409	19474.8524	7.72***
Physical asset	48203.5733	20701.1102	27502.4632	6.45***

*** means significant at 1% significance level

Source: Own computation

3.2.6 Sensitivity analysis

Deciding which variables should be included in a statistical model is one of the unsolved and probably most debatable issues in observational study (Abera, 2015). Relevant but omitted variables but which is relevant to the matching irrigation users with non-user households cause bias in outcome of intervention. The standard response to this knowledge has been to include additional control variables under the belief that the inclusion of every additional variable serves to reduce the potential threat from omitted variable bias. However, reality is more complicated, and the control variable strategy does not protect from omitted variable bias (Rosenbaum, 2002).

To reduce the above problem, sensitivity analysis has got a great attention on this day. Recently, it becomes an increasingly important topic in the applied evaluation literatures (Caliendo and Kopeinig, 2008). In order to check for unobservable biases, using Rosenbaum Bounding approach sensitivity analysis was performed on the computed outcome variables with respect to deviation from the conditional independence assumption (Caliendo and Kopeinig, 2005). The basic question to be answered here is whether the finding about treatment effects may be affected by unobserved factors (hidden bias) or not.

Based on this, sensitivity analysis was conducted for outcome variable (farm income and physical asset). Table 7 presents the critical level of $e^{\gamma}=1$ (first row), over which the causal inference of significant irrigation use outcomes (impact) must be questioned. The first column of the table shows those outcome variables which bear statistical differences between irrigation users and non-users in impact estimate. The rest of the values which correspond to each row of the significant outcome variables are p-critical values (or the upper bound of Wilcox on significance level -Sig+) at different critical value of e^{γ} (Rosenbaum, 2002).

The results show that inference for the impact of irrigation use does not change, even though the participant and non-participant households were allowed to differ in their odds of being treated up $e^{\gamma}=7.25$ in terms of unobserved covariates. That means for all outcome variables estimated, at various level of critical value of e^{γ}, the p- critical values are significant which further indicate that the study has considered important covariates that affected both participation and outcome variables. Thus, it is possible to conclude that impact estimates (ATT) of this study for each outcome variables were insensitive to unobserved selection bias.

Table 7: Result of sensitivity analysis using Rosenbaum bounding approach

Outcome	$e^{\gamma}=1$	$e^{\gamma}=2.25$	$e^{\gamma}=3.5$	$e^{\gamma}=4.75$	$e^{\gamma}=6$	$e^{\gamma}=7.25$
Physical asset	$2.1e^{-11}$	0.00003	0.00184	0.012986	0.040577	0.085212
Farm income	$2.6e^{-14}$	2.6e-07	0.000029	0.000278	0.001063	0.002598

Source: Own computation

Note: e^{γ} (Gamma) = log odds of differential due to unobserved factors where Wilcoxon significance level for each significant outcome variable is calculated

4. Conclusions and Recommendations

The study has found out that participation in irrigation use has increased annual household farm income by 19,474.8 birr for participant households than non-participant households which were significant at 1% level. Similarly, it has increased their physical asset holding which is measured in Ethiopian birr valued 27502.4 ETB at 1% statistically significance level. Hence it was concluded that irrigation has positive and significant impact on annual farm income and asset holding of the rural farming households. Based on the findings of study, the following recommendations were forwarded.

- Micro Finance Institutions in the study area are expected to expand their provision of loans to purchase water pump and other important equipment and agricultural inputs.
- Governmental and non-governmental organizations should more promote irrigation for the livelihood

improvement of the rural; farming households.

- Agricultural Development Agents, other NGOs experts working on irrigation could give more support particularly for those who are non-participant households by providing more irrigation use related relevant trainings.
- District Agricultural and Natural resource development office particularly agricultural extension department could increase awareness of the households by using mass media focusing on provision of ideal irrigation use information.

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