

The Impact of Small Scale Irrigation on Crop Production and Income of Households: The Case of North Achefer Woreda, Amhara Regional State, Ethiopia

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Abstract
This study analyzed the impact of small scale irrigation on crop production and income of households in North AchefeRWoreda, Amhara Regional State. It was conducted in the 5 selected Kebeles namely; Ambeshen, Yismala, Shobila, Chimba and Womberiabarkanta. Cross-sectional survey was employed to collect data from 175 respondents, in which 75 were irrigation users and 100 were non-users. The study has employed logit model to identify determinants of small scale irrigation participation and propensity score matching method to analyze the impact of small scale irrigation on crop production and household income. The result of logit regression indicated that livestock holding, fertilizer usage and training are identified as determinants of small scale irrigation in the study area. Propensity score estimation technique (kernel matching with band length 0.5) revealed that irrigation users are better in crop production by 6.01 quintals, and generate more income by birr 12,630.40 compared to non-users per year. The findings of the study highlight that small scale irrigation is important in increasing crop production and income of households. Finally, this paper recommended irrigation non-users should be addressed and motivated to participate in irrigation to increase production and income of households.
Keywords: Small scale irrigation, crop production, household income, PSM model

1. INTRODUCTION

In Sub-Saharan Africa countries, agriculture provides a relatively large share of the gross domestic product (GDP), however the productivity in the sector lags considerably behind compared to other continents, as well as the region's potential. On average, about 65% of Africa's labor force is employed in agriculture, yet the sector accounts for about 32% of GDP, reflecting relatively low productivity (AGRA, 2013). In Ethiopia, agriculture has a large share both in terms of GDP and employment, it accounted for 43% of GDP and employs 85% of the total labor force, and also the sector generates over 70% export values (UNDP, 2013).

Despite its importance for the national economy, the sector is largely based on subsistence farming, and heavily dependent on erratic rainfall. The distribution of rainfall also varies from region to region. As a result, the production capacity varies from region to region. Irrigation development is one of the many components in the agricultural sector that has been promoted in most areas of the country in order to increase and diversify agricultural production so that income.The study assessed the impact of small scale irrigation on crop production and income of households in the case of North AchefeRWoreda, Amhara Region, in aiming to have some contribution to the country development in general and the study area in particular. The study identifies determinants of small scale irrigation participation and analyzes the impact of small scale irrigation in the total crop production and income of households.

This paper is organized in five sections. The second section presents the theoretical and empirical literature on irrigation development and its impact on generating income, followed by section three which provide information about data set and the methodology. Section four presents the major findings and a discussion of the result. And finally, section five presents conclusion and recommendations.

2. LITERATURE REVIEW

Traditional irrigation in Ethiopia has long history. The traditional small-scale irrigation is in general, simple river diversions it is practiced in Ethiopia since ancient times producing subsistence food crops. This traditional small scale irrigation is subject to frequent damage by flood. Private concessionaires who operated farms for growing commercial crops such as cotton, sugarcane and horticultural crops started the first formal irrigation schemes in the late 1950s in the upper and lower Awash Valley. However, modern irrigation systems were started in the 1960s with the objective of producing industrial crops in Awash Valley. During this time, irrigated agriculture was expanded in all parts of the Awash Valley and in the Lower Rift Valley. The Awash Valley saw the biggest expansion in view of the water regulation afforded by the construction of the Koka dam and reservoir that regulated flows with benefits of flood control, hydropower and assured irrigation water supply (Agerie, 2013).
The potential of irrigation water in Ethiopia is quite high and its drainage pattern is of great importance to its

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neighboring countries. From the total run off 110 billion m3 about 90% flows down to neighbors through eleven major rivers. From the total potential area, the area irrigated is low and the reasons on the past regime is due to lack of fund, data on different factors of natural resources, infrastructure, skill, research and suitable policy and hydro-politics of the region (Agerie, 2013). The development of irrigation and agricultural water management in Ethiopia holds significant potential to improve productivity and reduce vulnerability to the climactic volatility in the country. The achievement shows that of construction of small scale irrigation, which covers about 2.4 million hectares at the end of the first Growth and Transformation Plan (GTP), and planned to increase by 75% (MoA, 2015).

3. DATA AND METHODOLOGY

Both primary and secondary data were used in this study. Primary data for the study was collected from selected sample households through questionnaire. Secondary data was also collected from Central Statistics Agency (CSA), Ministry of Finance and Cooperation, Ministry of Agriculture, Bureau of Agriculture and Rural Development, Woreda Agriculture and Rural Development office, and WoredaTrade and Transport Office.

In determining the number of samples (sample size) the researcher used a formula developed by (Kothari, 2004) to determine finite population. i.e.:

$$n = \frac{z^2 .p.q.N}{e^2 (N-1) + z^2 .p.q} \quad \ldots\ldots (1)$$

Therefore, the researcher collected data from 175 samples of households from a total of 1650 population. From 175 sample households 75 were from treatment group (irrigation user) and 100 were from control group (irrigation non-user).

An impact evaluation is essentially a problem of missing data, because one cannot observe the outcomes of program participants had they not been beneficiaries. Without information on the counterfactual, the next best alternative is to compare outcomes of treated individuals or households with those of a comparison group that has not been treated. In doing so, one attempts to pick a comparison group that is very similar to the treated group, such that those who received treatment would have had outcomes similar to those in the comparison group in absence of treatment (Khandker, et al 2010).

There are different methods of impact evaluation techniques which vary by their underlying assumptions to resolve selection bias in estimating the program effect, in this case irrigation. Among methods include: Randomized evaluations, Matching methods specifically propensity score matching (PSM), Double-difference (DD) methods, Instrumental variable (IV) methods, Regression discontinuity (RD) design and pipeline methods, Distributional impacts, Structural and other modeling approaches (Khandker, et al 2010).

In studying the impact of small scale irrigation on crop production and income of households the researcher used propensity score match approach. PSM methods compare treatment effects across participant and matched nonparticipant units, with the matching conducted on a range of observed characteristics.

PSM methods therefore assume that selection bias is based only on observed characteristics; they cannot account for unobserved factors affecting participation. The approach tries to capture the effects of different observed covariateson participation in a single propensity score or index. Then, outcomes of participating and nonparticipating households with similar propensity scores are compared to obtain the program effect. Households which have no match will be dropped, because of no basis exists for comparison (Khandker, et al 2010).

PSM constructs a statistical comparison group that is based on a model of the probability of participating in the treatment T conditional on observed characteristics X, or the propensity score:

$P(X) = Pr(T = 1|X)$. …………………………………………………… (2)

The necessary assumptions for identification of the program effect are: conditional independence and presence of a common support.

Conditional independence states that given a set of observable covariates X that are not affected by treatment; potential outcomes Y are independent of treatment assignment T. If Yi^Trepresent outcomes for participants and Yi^Coutcomes for nonparticipants, conditional independence implies:

$(Y_i^T, Y_i^C) \perp T_i|X_i$…………………………………………………….. (3)

Conditional independence is a strong assumption and is not a directly testable criterion; it depends on specific features of the program itself. If unobserved characteristics determine program participation, conditional independence will be violated, and PSM is not an appropriate method.

Common support or overlap condition: $0 < P(Ti = 1|Xi) < 1$. According to (Heckman, LaLonde, and Smith 1999), as cited by (Khandker, et al 2010); this condition ensures that treatment observations have comparison observations “nearby” in the propensity score distribution. Specifically, the effectiveness of PSM also depends on having a large and roughly equal number of participant and nonparticipant observations so that a substantial region of common support can be found.

If the household uses irrigation T = 1, if the households do not use irrigation T = 0

T = Yi (1) – Yi (0). ………………………………………………………. (4)

Let $Y_i^T$the amount of income by treatment group (irrigation user individuals), and $Y_i^C$the amount of income by controlled group (non-irrigation users), then the difference in income between treated and controlled group will be seen as:

$\Delta i = Y_i^T - Y_i^C$ ………………………………………………………….. (5)

To study the impact of small scale irrigation on crop production and income of households, in principle any discrete choice model can be used. For the binary treatment case, where we estimate the probability of participation versus nonparticipation, logit and probit models usually yield similar results. Hence, the choice is not too critical, even though the logit distribution has more density mass in the bounds (Caliendo and Kopeinig, 2008).According to (Rosenbaum & Rubin, 1983; D'Agostino, 1998), as cited by (Stone and Tang, 2013), a common approach for modeling the treatment selection process or estimating propensity scores is logistic regression (LR) with treatment group assignment (1=T, 0=C) as the dichotomous outcome and a set of measured covariates as predictors. Based on the estimated model, predicted probabilities for being assigned to the treatment group (propensity score estimates) may be obtained for both the treatment group and potential control group members. Therefore, in studying the impact of small scale irrigation on crop production and income of households, logit model was used to identify determinants of small scale irrigation participationand to estimate propensity scores.

Limitation of propensity score matching

PSM has two clear disadvantages relative to experimental techniques. The first is the need to make the CIA. In the case of random assignment, properly conducted, we can be confident that the treated and non-treated populations are similar on both observable and unobservable characteristics. This is not true in the case of PSM, which takes account of selection on observables only. Second, whereas PSM can only estimate treatment effects where there is support for the treated individuals among the non-treated population, random assignment ensures that there is common support across the whole sample. These considerations make experimental techniques unambiguously superior to PSM. However, practical considerations are also important in the design and execution of program evaluations and, in some circumstances; these practical considerations favor PSM over random assignment (Bryson, et al, 2002).

4. RESULTS AND DISCUSSION

4.1Econometric Analysis

In this part the result of multicollinearity and model specification tests, determinants of small scale irrigation participation, estimation of propensity score, checking for overlap and common support, matching algorithm, matching quality indicators, ATT and sensitivity analyses were presented.

4.1.1 Tests in the analysis

In the construction of econometric model, variables that provide the same information may be included. Therefore, here before estimating the propensity score matching, multicollinearity and model specification tests were conducted. Thus variance inflation factors (VIF) for continuous variables and pair wise correlation for dummy variables were used. As can be seen from table 4.8, the VIF was far less than 10. This proved that there was no multicollinearity problem. The result also from pair wise correlation showed no multicollinearity problem as it was by less than 0.75 (see table 4.9).

Table 1 Collinearity diagnostics for continuous independent variables

Variable	VIF	SQRT VIF	Tolerance	R_Squared
Age	1.42	1.19	0.7038	0.2962
Family size	1.23	1.11	0.8153	0.1847
Market	1.1	1.05	0.9132	0.0868
Land holding	1.96	1.4	0.509	0.491
Livestock	1.49	1.22	0.6702	0.3298
Fertilizer	1.21	1.1	0.8269	0.1731

Mean VIF 1.40

Table 2 Collinearity diagnostics for categorical independent variables

	Sex	Edu	Training	Off farm	Credit
Sex	1				
Edu	0.0544	1			
Training	0.0544	0.512	1		
Off farm	-0.0831	0.1077	0.0429	1	
Credit	-0.0738	-0.2021	-0.0923	0.0272	1

Source: from own computation, 2016

Model specification was checked using link test. The test result showed a p- value of 0.709, which is insignificant. As can be seen from table 3, the test failed to reject the hypothesis that the model is correctly specified.

Table 3 model specification test

treat	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
_hat	1.024179	0.1823682	5.62	0.000	0.6667443	1.381614
_hatsq	0.0324869	0.0869177	0.37	0.709	-0.137869	0.2028425
_cons	-0.036605	0.2114787	-0.17	0.863	-0.451096	0.3778853

Source: from own computation, 2016

4.1.2 Determinants of participation in small scale irrigation

In understanding the determinants of participation in small scale irrigation logistic regression was used. As we can see in the table 4 from all explanatory variables, irrigation training situation of the household, livestock holding size of the household and the amount of fertilizer used are found to be significant at 1% and 5% significant level. These variables had positive relationship with small scale irrigation participation as expected. On the other hand other covariates are found to be insignificant in the model.

From institutional service characteristic variables, irrigation training affects the participation of households in small scale irrigation at 1% significant level with expected positive sign. The odds ratio 8.87 from table 4 tells us, households who took irrigation training have a probability to participate in small scale irrigation 8.87 times better than those who didn't take the training, keeping other variables constant. This is because of training as a mechanism of awareness creation helps farmers to know the importance of irrigation. So that, irrigation training made farmers to be aware and participate in small scale irrigation.

From socio-economic characteristic variables, livestock holding size affects small scale irrigation participation of households positively as expected at 5% significant level. The odds ratio 1.2 from table 4 tells us, an increase a one unit livestock in TLU increases 1.2 times the participation of households in small scale irrigation, keeping other variables constant. Farmers having large livestock holding indicate that, they have more drought power for agricultural practices. Irrigation as an agricultural activity uses livestock's power. Therefore livestock holding size of the household matters for the participation of small scale irrigation.

Another variable which affects small scale irrigation participation significantly is the amount of fertilizer used. Agricultural inputs in this case fertilizer, plays an important role in increasing productivities so as production. As it observed from the result of logit estimation on table 4 the amount of fertilizer used positively affects small scale irrigation at 1% significant level. The odds ratio 1.4 from table 4 indicates, in keeping other variables constant, an increase in the amount of fertilizer used in one quintal increases the participation of small scale irrigationby 1.4 times.

Table 4 logit estimated result with odds ratio

treat	Odds Ratio	Std. Err.	Z	P>z	[95% Conf.	Interval]
sexHH	0.084735	0.150269	-1.39	0.164	0.002622	2.738922
ageHH	0.968178	0.022246	-1.41	0.159	0.925543	1.012777
eduHH	0.902187	0.486859	-0.19	0.849	0.313293	2.598016
famsize	1.015905	0.126981	0.13	0.900	0.795168	1.297917
dismkt	0.974831	0.111527	-0.22	0.824	0.779015	1.219867
fland	1.355684	0.408395	1.01	0.312	0.751168	2.446694
livest	1.21125**	0.096	2.42	0.016	1.036979	1.414808
fert	1.376661***	0.132523	3.32	0.001	1.139953	1.66252
irrtrain	8.874267***	5.377209	3.6	0.000	2.706211	29.1007
poffarm	1.236629	0.613624	0.43	0.669	0.467592	3.270481
cred	1.353328	0.59052	0.69	0.488	0.575419	3.182893
_cons	0.148795	0.31909	-0.89	0.374	0.002224	9.953802

Source: own computation, 2016, *** 1% level of significance, ** 5% level of significance

As presented in table 2 from the appendix the estimated result of the logit model had a Chi2 = 0.000 and a pseudo R^2 = 0.2676. It indicates how well the explanatory variables explain the participation.

4.1.3 Estimation of propensity score

In analyzing the impact of small scale irrigation on crop production and households' income propensity score matching was used. It was done using the "pscore" command in STATA to predict a propensity score between the two groups (see table 5).

Table 5 Summary of matching score by groups

Treat	mean	Sd	min	max
control	0.2925258	0.2268361	0.0108867	0.8685149
treatment	0.6099656	0.2371782	0.0446117	0.9874125
Total	0.4285714	0.2793197	0.0108867	0.9874125

Source: from own computation, 2016

4.1.4 Checking for overlap and common support

The propensity score rangesfrom 0.0108867 to 0.9874125 with a mean of 0.4285714. The propensity score for small scale irrigation users fall in the range of 0.0446117 and 0.9874125 with a mean of 0.6099656. While the propensity score for non-irrigation users' ranges from 0.0108867 to 0.8685149 with a mean 0.2925258. The common support and overlap region for both control and treatment groups lies between 0.0108867 and 0.8685149. Having common support and overlap region tells us the two comparison groups can make matching. Accordingly, 14 households (shown by green color) from the treatment group were dropped from analysis of average treatment effects.

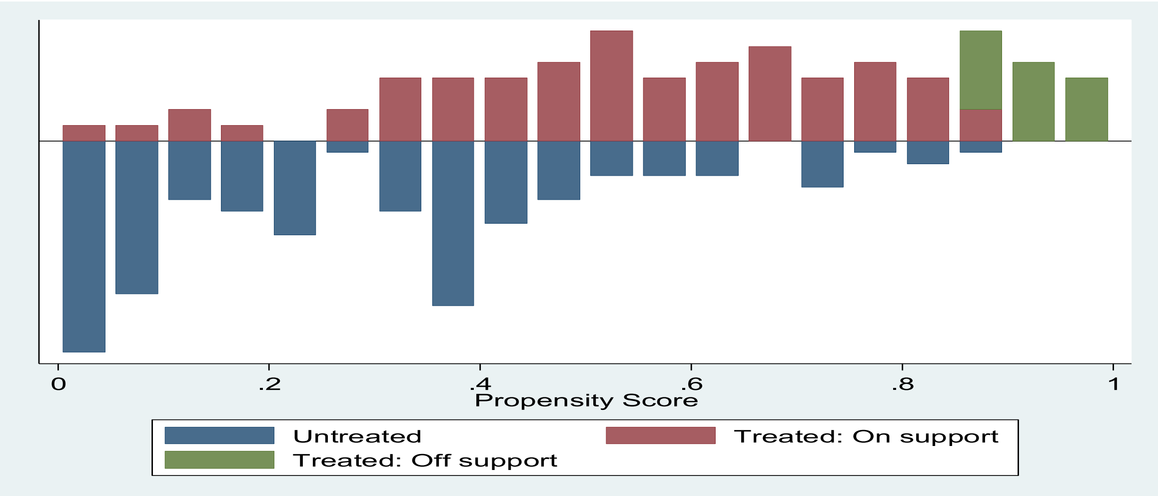

Figure 1 ps-graph for propensity scores

Source: Own Computation, 2016

4.1.5 Matching Algorithm

Once the common support region identified, the next step is searching the appropriate matching algorithms. The appropriate matching algorithm should be selected by observing three criteria in the result that are: the balancing test, the reduction in standard, pseudo-R2 and matched sample size (Rosenbaum and Rubin, 1983). A matching algorithm which balances the most explanatory variables, results in a low pseudo-R2 value, reduces more standard bias and also results in large matched sample size should be selected. As we see from table 6 the kernel matching algorithm (band width 0.5) was found appropriate matching algorithm for the data presented for this study.

Table 6 Matching algorithms comparison

No	Matching algorithm	Reduced bias	Psedo-R^2	Matched sample size
1	Nearest Neighboring (1)	11.2	0.059	139
2	Nearest Neighboring (2)	12.1	0.037	159
3	Nearest Neighboring (3)	5.2	0.015	159
4	Radius Caliper (1)	7.6	0.01	161
5	Radius Caliper (2)	10.1	0.019	161
6	Radius Caliper (3)	17.8	0.11	161
7	Kernel Matching (1)	8.3	0.011	161
8	Kernel Matching (2)	7.9	0.012	161
9	**Kernel Matching (3)**	**17.4**	**0.059**	**161**

Source: from own computation, 2016

1. Nearest Neighboring with 1 closest neighbor without replacement and common support
2. Nearest Neighboring with 1 closest neighbor with replacement and common support
3. Nearest Neighboring with 5 closest neighbors with replacement and common support
4. Radius Matching with 0.1 caliper and common support
5. Radius Matching with 0.25 caliper and common support
6. Radius Matching with 0.5 caliper and common support

7. Kernel Matching with band width 0.1 and common support
8. Kernel Matching with band width 0.25 and common support
9.**Kernel Matching with band width 0.5 and common support**

4.1.6 Matching quality indicators

After appropriate algorithm selection, by using different procedures the propensity score and the covariates should be checked with the selected algorithm. The result showed that there were five variables statically significant at 1% significance level before matching, but there were no variable which was significant after matching. In addition, the result also indicated that after matching the value of pseudo R2 reduced from 0.268 to 0.059, the likelihood ratio reduced from 63.98 to 9.97 and chi2 test resulted insignificant (see table 7). Therefore, the result revealed that both treated and control groups had an identical distribution in the covariates after matching and the impact of small scale irrigation could be easily evaluated since participants and non-participants were similar in their pre-intervention observable characteristics.

Table 7 ps-test result summary

Sample	Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	%Var
Unmatched	0.268	63.98	0.000	40.2	24.9	132.5*	0.89	0
Matched	0.059	9.97	0.533	14.7	17.4	57.6*	0.76	17

Source: from own computation, 2016

4.1.7 Average Treatment on Treated (ATT)

Below here is discussed the impact of small scale irrigation on crop production and income of households. These were estimated by average treatment effect on treated (ATT) by the selected appropriate algorithm, Kernel matching with band width 0.5 and common support.

The impact of small scale irrigation on crop production

The estimated results of the average treatment effect on the treated (ATT) of the outcome variable crop production by using propensity score matching (PSM) techniques that are: nearest neighbor matching(NNM), radius caliper matching(RM) and, kernel matching (KM) with different measurements and the common support revealed that small scale irrigation had a positive and significant impact on crop production. By kernel matching with band width 0.5 and common support, which was selected by matching quality indicators the impact of small scale irrigation on crop production, was estimated in table 8.

Table 8 estimated ATT of total crop production

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
Production	Unmatched	54.573333	38.79	15.783333	3.1832793	4.96
	ATT	50.262295	44.246925	6.0153702	3.4634723	1.74

Source: own computation, 2016

As from table 8 indicated the average total crop production of small scale irrigation users was 50.26 quintal and 44.25 quintal for non-users. This showed there was a 6.01 quintal crop production difference between users and non-users as a result of small scale irrigation participation. Therefore, this result shows small scale irrigation has a positive significant impact on crop production. This result is consistent with the study conducted by Ohikere, etal (2012), in Nigeria.

The impact of small scale irrigation on household income

The estimated results of the average treatment effect on the treated (ATT) of the outcome variable household income by using propensity score matching (PSM) techniques that are: nearest neighbor matching(NNM), radius caliper matching(RM) and, kernel matching (KM) with different measurements and the common support revealed that small scale irrigation had a positive and significant impact on household income. By kernel matching with band width 0.5 and common support, which was selected by matching quality indicators the impact of small scale irrigation on household income, was estimated in table 9.

Table 9 estimated ATT of household income

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
Income	Unmatched	51087.127	29925.068	21162.059	2973.57	7.12
	ATT	46739.541	34109.14	12630.402	3454.0649	3.66

Source: own computation, 2016

As from table 9 indicated the average income of households of small scale irrigation users was 46,769 ETB and 34,109 ETB for non-users. This showed there was a 12,630 ETB income difference between users and non-users as a result of small scale irrigation participation. Therefore, this result shows small scale irrigation has a positive significant impact on income of households. The result is in line with Desta (2004), Getaneh (2011), Agerie (2013), and Hadush (2014) conducted in Ethiopia.

Bootstrap is an appropriate way to check the stability of the results. Therefore, the result was checked by boots rap and showed that the impact of small scale irrigation on crop production and income of households are stable.

4.1.8 Sensitivity Analysis

The validity of matching estimators for impact evaluation depends on the primary assumption which is the Conditional Independence Assumption (CIA) also known as un-confoundedness (Rosenbaum and Rubin, 1983). CIA states that the treatment assignment conditional on observed Covariates (X) is independent of the post intervention outcome. This assumption implies that the counterfactual outcome in the treated group is the same as the observed outcomes for the control group. The CIA assumption requires that the set of explanatory variables/Covariates (X) should include all the variables that together influence the outcome with and without treatment. The need of doing sensitivity analysis is to made diagnosis on how robust the estimated ATT are with respect to possible deviations from these conditions. This is because any unobservable factor affecting treatment leads to biased ATT. Thus, the sensitivity of matching estimates to unobserved heterogeneity was tested using the Rosenbaum bounds method (r-bound) in STATA.

Accordingly, the Rosenbaum bound (r-bounds) sensitivity analysis results by kernel matching band width (0.5) matching algorithm estimator showed that the impacts of small scale irrigation on crop production and income of households is not sensitive, even up to γ =13 which is a very high value. It is significant at 1 % significance level (see table 10). Therefore, we can conclude that the average treatment effects estimated in both crop production and income of households are highly robust (insensitive) to the presence of unobserved characteristics.

Table 10 sensitivity analysis test for the estimated ATT (Rosenbaum bounds to outcome variables)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	0	0	0.5	0.5	0.5	0.5
2	4.60E-10	0	0.5	0.5	-4.10E-07	0.5
3	2.90E-07	0	-4.10E-07	0.5	-4.10E-07	1
4	7.50E-06	0	-4.10E-07	0.5	-4.10E-07	1
5	0.000054	0	-4.10E-07	1	-4.10E-07	1
6	0.000203	0	-4.10E-07	1	-4.10E-07	1
7	0.000532	0	-4.10E-07	1	-4.10E-07	1
8	0.0011	0	-4.10E-07	1	-4.10E-07	1
9	0.001946	0	-4.10E-07	1	-4.10E-07	1
10	0.003085	0	-4.10E-07	1	-4.10E-07	1
11	0.004512	0	-4.10E-07	1	-4.10E-07	1
12	0.00621	0	-4.10E-07	1	-4.10E-07	1
13	0.008155	0	-4.10E-07	1	-4.10E-07	1
14	0.010319	0	-4.10E-07	1	-4.10E-07	1
15	0.012674	0	-4.10E-07	1	-4.10E-07	1

* gamma - log odds of differential assignment due to unobserved factors
sig+ - upper bound significance level
sig- - lower bound significance level
t-hat+ - upper bound Hodges-Lehmann point estimate
t-hat- - lower bound Hodges-Lehmann point estimate
CI+ - upper bound confidence interval (a= .95)
CI- - lower bound confidence interval (a= .95)
Source: from own computation, 2016

5. CONCLUION AND RECOMENDATION

5.1 Conclusion

Accordingly, the objective of this study was to analyze the impact of small scale irrigation on crop production and households' income. To achieve this objective, five kebeles in the woreda were selected based on their potential to irrigation. Data was gathered from 175 households (75 from irrigation users and 100 from non-users) by semi- structured questionnaire. For the purpose of identifying major problems focus group discussions were made. In addition secondary data from the Woreda Office of Agriculture and Zone Agriculture Department were collected.

In analyzing the data obtained both descriptive and econometric analyses methods were used with the help of STATA. Accordingly, the propensity score matching techniques estimation result also showed that small scale irrigation has positive and significant impacts on the income of households and total crop production. The average treatment effect (ATT) estimation revealed that, the mean difference of household income and total crop production of small scale irrigation users and non-users is 12630.40 birr and 6.01 quintal, respectively.

5.2 Recommendation

The study revealed that, small scale irrigation has a positive and significant impact on crop production and income of households in North AcheferWoreda, Amhara region. Based on the findings of this study the following recommendations are forwarded. Education is assumed to be sharpening human being for better life. Literate households are better in adopting small scale irrigation than illiterate ones. Therefore there should be a focus on both formal and informal education to literate farmers. Before running any activity, awareness creation for that particular program is a very important issue. Irrigation training made difference in participation of small scale irrigation. Farmers who took irrigation training were better in participating small scale irrigation than from those who did not took training. As a result irrigation training should be provided for farmers to increase their participation in small scale irrigation so as to boost their production and income. Livestock holding had a positive significant impact on small scale irrigation participation. Livestock as a source of power is essential for households to participate in small scale irrigation. So in addition to farming activities households should focus on livestock raring.

Land as a factor of production is important to do any agriculture activities. Farm land holding size matters in participating small scale irrigation. Households with more farm holding size had more probability to participate in small scale irrigation. Therefore youths should be provided farm land to be motivated in participation of small scale irrigation.

The amount of fertilizer used had influence on the productivity and production of crop production. The more you used the more you get production. But the focus for fertilizer supply for rain fed production by far better than from irrigation production. Therefore accessing fertilizer through the year for both rain fed and irrigation production should be a preliminary task to motivate small scale irrigation. Finally, as seen from the result, small scale irrigation has a positive impact on crop production and income of households. Therefore irrigation non-users should be addressed and motivated to participate in irrigation to increase production and income of households.

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