The Impact of Irrigation on Poverty Alleviation and Asset Creation in Northern Ethiopia

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Abstract

The objective this study was to evaluate the impact of irrigation program on poverty reduction and asset creation among the users and non-users in the study area. To achieve this objective, both primary and secondary sources were employed to collect the data for the study area. Descriptive statistics and Propensity Score Matching were employed to evaluate the impact of the irrigation program in the study area. The study publicized that among eleven model variables seven of them influence the program participation decisions. The results of the propensity score matching reveals that access to irrigation has a significant effect in increasing the consumption expenditure per adult of irrigation user households. However, the study found that irrigation does not likely to have a significant effect in increasing the size of livestock of beneficiary households.

***Keywords**:* per capita consumption expenditure, propensity score, irrigation, *livestock*

1. Introduction

Ethiopia's recent growth acceleration was accompanied by a substantial declined poverty from 55-60 percent in 2000 to 30.7 percent in 2017. And despite tremendous socioeconomic progress in the last 20 years, Ethiopia remains one of the poorest countries in the world and likewise maintains some of the lowest levels of access to basic services (World Bank, 2017). This report also explained that Ethiopia registers the lowest agricultural yields globally , resulting in a high level of food insecurity and some of the highest burdens of seasonal hunger and malnutrition in Africa. Recent and current droughts, have proved that a large proportion of the population remains extremely vulnerable to climate shocks and other events affecting the harvests and thereby the availability of food (World Bank, 2017).

The variability of the Ethiopian economy growth emanates from high dependence on rain-fed and low productivity subsistence agriculture. This low productivity is aggravated by land degradation and low technology input. This together with low level of water resources utilization and management have been a major source of vulnerability and volatility at the economy wide and households level, particularly rural households. The main challenges, therefore, is to ensure rapid and continued growth in land and labor productivity- thus setting a strong foundation for sustaining growth. The rapidly growing Ethiopian population is an added challenge (MoFED, 2006).

Ethiopia has total renewable surface water resources are estimated at 122 billion cubic meters per year from 12 major river basins and 22 lakes and renewable groundwater resources are estimated to be about 2.6 billion cubic meters (MoWR, 2002). However less than 5 percent (about 200,000 hectares) of the estimated potential 3.7 million hectares of irrigable land in Ethiopia is under irrigation.

Even if Ethiopia has untapped natural resources particularly water resources, the country has not properly benefited from its abundant natural resources conducive to agricultural development, and consequently failed to achieve the desired economic development that would enable its people pull out of the of poverty due to the causes of natural and man-made problems (MoFED, 2006). Besides dependence on rain fed agriculture combined with the erratic nature of rainfall is one of the main causes of widespread food insecurity and poverty in the country. Droughts occur every 3-5 years in northern Ethiopia and every 8-10 years for the whole country, with severe consequences for food production (Haile, 1988 cited in Lire Ersado, 2005).

The regional state of Tigray introduce different irrigation infrastructure in the region and bring sustainable development. Awulachew et al. (2007) explained that Tigray region has to move from rain -fed to irrigation agriculture to feed its people and guarantee food security. Hagos et al. (2009) stated irrigation development has been identified as an important tool to stimulate economic growth and rural development. He also explained the Tigray Regional State have led to concerted efforts to expand irrigation development since 2005 (Hagos et al. 2009).

To alleviate poverty and enhance the food security in region, government introduced different type of irrigation infrastructure to boost the agriculture production and productivity at household levels. In rural areas, these different types irrigation infrastructure have been able to reduce the poverty situation and improving household food security. Irrigation development program played its role in making productivity drought resistance and grow continually by reducing the influence shortage of rain encountered in the last successive years. However, in spite of some indications of improvements on the ground, in the study area there are not adequate studies under-taken to evaluate the impact of irrigation infrastructure investment on poverty reduction and household asset creation. Hence, the objective of this study was to evaluate the impact of irrigation program on poverty reduction and asset creation among the users and non-users in the study area.

2. Study Area and Research Methodology

2.1 Study Area

Tigray region is one of the nine regional states of Ethiopia established in 1993 and located in the northernmost reaches of Ethiopia. The region is astronomically situated between$12^{0}15'$ to $14^{0}57'$ North latitude and $36^{0}27'$- $39^{0}59'$ East longitude with an area of 54,593 km^2. It is bordered by Eritrea in the north, Sudan to the west, Amhara to the south and afar in the east (BoPF,2013/ 2014) .The region is administratively divided in to seven zones□ Western zone, Northwestern zone, Central zone, Eastern zone, South-eastern zone, Mekelle zone and Southern zone, comprising a total of 47 Woredas and 767 Tabias. Each woreda is subdivided in to Tabias", again each "Tabias" is subdivided in to Kushet, which are the lowest units in administrative hierarchy.

According to the 2007 Population and Housing Census, the total population of Tigray was 4,327,342. Based on the base year of 1999 EC projection, the total population for 2012 was estimated to be 4,772,782. (BoPF,2013/ 2014)

The landform of Tigray is complex: composed of highlands (in the range of 2300 to 3200 meters above sea level, (masl), lowland plains (with an altitude range of less than 500 to 1500 masl)1, mountain peaks (as high as 3935 masl) and high to moderate relief hills (1600-2200 masl). On the basis of altitude six major types of agro-ecological zones are identified: upper Dega, Dega, Weyena dega, upper Kola, Lower Kola and Wurch. Kola (lowland) 53 per cent, weyena dega (midland) 39 per cent and dega (high/upper land) 8 per cent where temperature ranges from 12 0c in some highlands to 40 0c. Most parts of the region have an annual temperature between 15 ^{0}c- 17 ^{0}c.

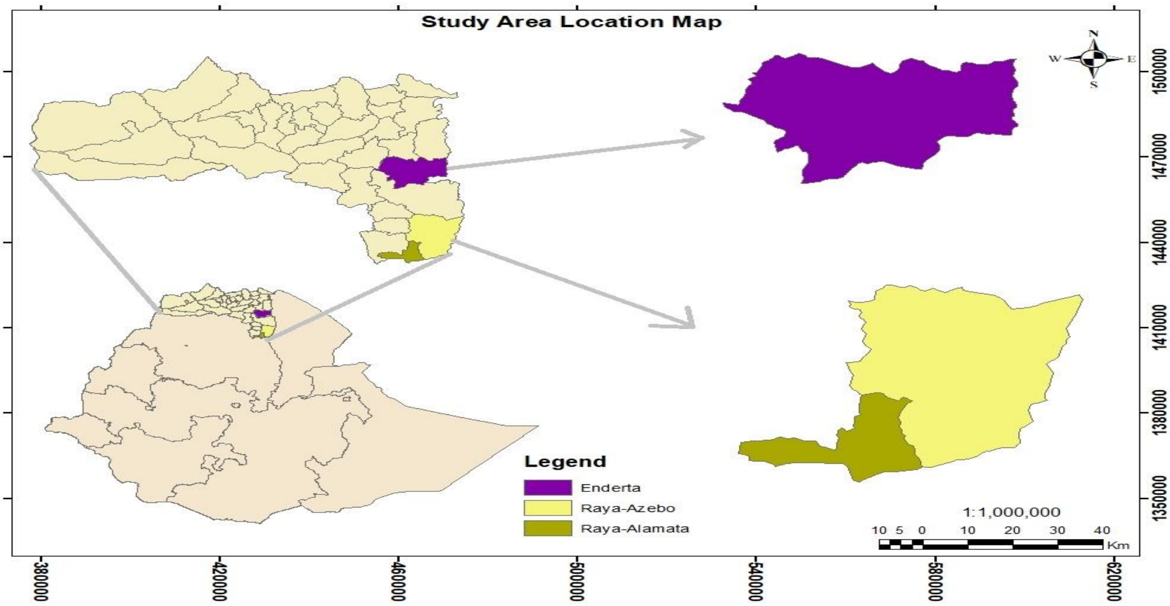

Figure 1. Location map of the study area

The rainfall condition of the region is characterized by erratic and variable both temporally and spatially resulting for the occurrence of frequent drought. The amount of rainfall in the region increase with altitude from East to West and decreases from South to North direction. Average rainfall varies from about 200mm in the northeast lowland to over 1000mm in the south western highlands. In Tigray Agriculture is the main economic stay and means of livelihood to the majority of the rural people. It is characterized by traditional mixed farming as it includes both crop production and livestock rearing, dependent mainly on rainfall. In most areas of the region the crop pattern comprises of cereals (Teff, barely, wheat, maize, and sorghum), pulses, oil seeds, vegetables, spices, fruits. Livestock production is a major component of the agricultural economy of Tigray region and goes to beyond direct production. Sales of livestock and their products provide direct cash income to farmers. Livestock are the living banks of main farmers and have critical role in the agricultural intensification process through provision of drought power and manure for fertilizer and energy (BoPF, 2013/ 2014).

2.2. Research Methodology

2.2.1. Research design

The study adopted a cross-sectional survey research design as its framework to guide the process of data collection. According to Bryman (2008), cross-sectional survey research design is the collection of data mainly using questionnaires or structured interviews to capture quantitative or qualitative data at a single point in time. It also provides information in a short amount of time for administering the survey and collecting the information (Creswell J. 2012). To assess the impact of irrigation on the poverty reduction and on the contribution of enhancing asset resources, quantitative research methodology was used to achieve the objectives of the study.

2.2.2. Selection of study area and households

The data for this study were collected from a household survey conduct in the rural woredas of Rayaalamata, Rayaazebo and Enderta woredas. Multi-stage sampling technique were employed to pick the sample households. Accordingly, in the first stage, they were purposively selected. Due to the presence of irrigation intervention availability and highly affected by recurrent drought were taken into consideration in the selection of woredas to include in the study. In the second stage five tabias were selected purposively from these sample woredas. This is due to the presence of a large number of beneficiary, their accessibility and proximity, the study tabias were chosen. The third stage, using stratified sampling technique; the population under study were grouped into two classes: irrigation beneficiaries and non-beneficiaries. A household list in the selected tabais were obtained from tabia administration. For individual study site the sample size proportional to the whole population of the respective tabias were determined, and hence the samples were self-weighting (Dercon and Hoddinott, 2004). Then from each sample study tabias, irrigation user and non-irrigation user households were selected for the household survey. The sample size for each tabia were determined based on a proportional probability sampling method. Based on this multi stage sampling process a total of 340 households were selected on a random sampling basis from 5 tabias in study areas.

2.2.3. *Data Sources*

A single household was taken as the basic survey unit for the analysis. A household was defined as a number of people (it may be only one person) living and eating together in the same dwelling who share the same budget. Given that the household is a production unit, a farm is defined as all the agricultural activities under the control of the household members (Upton, 1996 cited in Haile, 2008). Both primary and secondary sources were employed to collect the data for the study area.

2.2.4. Methods of analysis

Impact evaluation is an effort to understand whether the changes in well-being are indeed due to program intervention. It tries to determine whether it is possible to identify the program effect and to what extent the measured effect can be attributed to the program. The assessment of the impact of a program (or a development intervention) requires a model of causal inference (Shahidur R. et al, 2010).

An impact evaluation is basically a problem of missing data, because one cannot observe the outcomes of program participants had they not been beneficiaries. The problem of impact evaluation is that treatment assignment is not often random because of the purposive program placement and self-selection into the program. To solve the missing data in the study area a comparison group is used to identify counterfactual of what would have happened without the program. However, having various sources of biases for impact indicators of the study (household expenditures, number of livestock), we do not compare statistically for irrigation users and non-irrigation users. The potential bias may be arise due to the failure of the assumption of unit homogeneity, program placement, heterogeneity, endogenous and self-selection.

Propensity score matching applied to this study for the following reasons. Firstly, there is no baseline data available on irrigation users and non-irrigation users. Secondly, the participants in small-scale irrigation were either purposefully placed or self-selected to participate. Third the available field data were based on a cross-sectional survey. Finally, it was possible to identify some features, in this case sociocultural practices, agro-climatic parameters and physical characteristics, to match the participants and non-participants. Propensity score is defined by Rosenbaum and Rubin (1983) is often used to compare participant outcome with and without treatment in a program evaluation setting. This method was used to reduce bias in estimation of treatment effects with observational data and has become popular method to measure the impact of economic policy interventions (Becker and Ichino, 2002).

Empirical Model Specification

The objective of this study is to evaluate the impact of irrigation on households' food consumption level and livestock assets. If the participation in the irrigation were randomly assigned to farmers, we could assess the impact of irrigation on households' food consumption and asset building by comparing the average consumption of irrigation users and non-irrigation users. In such a case, the average treatment effect (ATE) can be computed as follows:

$$ATE = E\,(Y_{i1} | T_i = 1) - E\,(Y_{i0} | T_i = 0).$$

This is based on the assumption that the output levels of the households before irrigation uses (E (Y0|D=1) can reasonably be approximated by the output level of non-irrigation users during data collection (E (Y0|D=0). Otherwise, estimation of ATE using the above equation is not possible since we do not observe E (Y0|D=1) though we do observe E (Y1|D=1) and (E (Y0|D=0). Besides this, ATE has limited relevance to policy purpose because it includes the effect on persons for whom the programme was never intended (Wooldridge, 2002, Heckman et al, 1997). Another problem is that the treated and non-treated groups may not be the same prior to the intervention, so the expected difference between those groups may not be due entirely to program intervention.

The average treatment on the treated effect (ATT) is the most important policy indicator used for program evaluation. We would like to develop an estimate of the average impact of irrigation on those that participate in irrigation program—the average impact of the treatment on the treated (*ATT*). This parameter estimates the average impact among irrigation users in the study area. It is given by:

$$\Delta_{ATT} = [E(\Delta_i | T_i = 1)]$$

Which is equivalent to:

$$E[Y_{1i} - Y_{0i} | T_i = 1] = E[Y_{1i} | T_i = 1] - E[Y_{0i} | T_i = 1]$$

It is obvious that E (Y_{1i}| T =1) can be easily identified from data on programme participants. The term E (Y_{1i}| T =1) describes specific outcomes e.g. consumption and asset building, etc. observable among programme beneficiaries after implementation of the given irrigation programme. On the other hand, the expected value of ($E[Y_{0i}$|T =1), i.e. the counterfactual mean in outcome (potential outcome in case of non-participation) of those who participated in the programme cannot be directly observed.

The difference, $\Delta_i = E\,(Y_{i1} | Ti = 1) - E\,(Y_{i0}) \mid Ti = 0)$, can be estimated, but is potentially a biased estimator of Δ_i. Intuitively, if the treated and control units systematically differ in their characteristics, then in observing only Y_{i0} for the control group we do not correctly estimate Y_{i0} for the treated group. Such bias is of paramount concern in non-experimental studies (Rajeev H. Dehejia, Sadek Wahba, 1998). Therefore, to solve this problem, we estimate the impact of irrigation on consumption and asset building using propensity score matching as a method for estimating the counterfactual outcome for participants (Rosenbaum and Rubin 1983).

Let P(X) = Pr (Ti = 1 | X) be the probability of participating in the irrigation program. They show that the dimensionality of the matching problem can be significantly reduced by using the propensity score (the conditional probability of participation given the observed covariates). Propensity score matching constructs a statistical comparison group by matching observations on irrigation participant to observations on non-participant with similar values of P(X). The validity of PSM for impact evaluation depends on two important assumptions (Paul J. Gertler et al, 2011).

(a) Conditional independence Assumption

It states that given a set of observable covariates X that are not affected by treatment, potential outcomes Y are independent of treatment assignment. It implies that conditional on *X* nonparticipants have the same mean outcomes as participants would have if they did not receive the program. Conditional independence implies

$$(Y_{1i}, Y_{0i}) \perp T_i \;|X_i$$

Where

Y_{1i} Represent outcomes for participants and Y_{0i} outcomes for nonparticipants

If one is only interested in the mean impact for the treated, then the assumption of unconfoundedness can be weakened by focusing on potential outcomes in the non-participation state (Imbens, 2004). 21This weaker version can be explained as follows.

$$Y_{0i} \perp T_i \;|X_i$$

In other terms, the outcome in the counterfactual state is independent of participation, given the observable characteristics. Thus, conditional on the observables, outcomes for the non-treated (the comparison group) represent what the participants would have experienced had they not participated in the program.

(b) The *common support* or *overlap condition*: $0 < P(T_i = 1|X_i) < 1$.

This condition ensures that treatment observations have comparison observations "nearby" in the propensity score distribution. For matching to be feasible, there must be individuals in the comparison group with the same values of the covariates as the participant of interest. This requires an *overlap* in the distribution of observables between the treated and the comparison groups. 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. For estimating the ATT, this assumption can be relaxed to $P(Ti = 1|Xi) < 1$.

Therefore, treatment units will therefore have to be similar to non-treatment units in terms of observed characteristics unaffected by participation; thus, some non-treatment units may have to be dropped to ensure comparability. If conditional independence and the common support in *P*(*X*) across participants and non-participants are satisfied, the PSM estimator for the ATT can be specified as the mean difference in *Y* over the common support, weighting the comparison units by the propensity score distribution of participants. A typical cross-section estimator can be specified as follows:

$$ATT = E_{P(X)|T=1}\{E[Y_1|T = 1, P(X)] - E[Y_0|T = 0, P(X)]\}$$

To calculate the program treatment effect, one must first calculate the propensity score *P*(*X*) on the basis all observed covariates *X* that jointly affect participation and the outcome of interest. Following (Imben, 2004), the following steps conducted to construct the propensity score matching for the study.

First, the samples of participants and nonparticipants should be pooled, and then participation *T* should be estimated on all the observed covariates *X* in the data that are likely to determine participation. When one is interested only in comparing outcomes for those participating ($T = 1$) with those not participating ($T = 0$), this estimate can be constructed from a logit model of program participation. Therefore, to create a propensity score in this study, the first step is to use a logit regression with treatment as the outcome variable and the potential confounders as explanatory variables. After the participation equation is estimated, the predicted values of *T* from the participation equation can be derived. The predicted outcome represents the estimated probability of participation or propensity score. Each sampled participant and non-participant had an estimated propensity score, $P\hat{}(X|T = 1) = P\hat{}(X)$.

Second, once a propensity score has been calculated for each observation, one must ensure that there is overlap in the range of propensity scores across treatment and comparison groups (called "common support"). As mentioned earlier, some of the nonparticipant observations may have to be dropped because they fall outside the common support. In addition to overlapping, the propensity score should have a similar distribution ("balance") in the irrigation users and non-irrigation users groups. Next Different matching criteria can be used to assign participants to non-participants on the basis of the propensity score. There are different matching estimators, the most commonly used are the nearest neighbor, kernel matching, and radius matching. Each matching estimator varies depending on the definition of a closeness criterion used.

The nearest neighbor method matches irrigation users with non-irrigation users of each household having the nearby propensity score. Caliper matching which means that an individual from the comparison (non-irrigation users) group was also tested as a matching partner for a treated individual that lies within a given caliper (propensity score range) and is closest in terms of propensity score and The kernel-based matching (KM) method uses a weighted average of all farmers in the adopter group to construct a counterfactual.

3. Results and Discussion

3.1. Results of Descriptive Statics of Study Variables

Table 1 presents a summary of variables used in the logit regression. Some characteristics of the sample population, with a comparison between the irrigation users with the non-irrigation users in study. Chi-square and t-statistic test were used to test whether they are statistically significance. The t-test is used to test the significance of the mean values of continuous variables of two groups of irrigation users with non-irrigators while chi-square is used to test the significance of the mean values of the potential discrete (dummy) explanatory variables.

The proportion of male headed households in the irrigators sample is significantly higher than the non-irrigators sample at 1 % significant level, implying that male-headed households have a higher chance of accessing the irrigation service in the study area. irrigation naturally it demand a day to day physical activities and this may be put pressure for female to get an access. Moreover, the chi-square test shows that there is a statistically significant difference in the application of fertilizer and extension service between the irrigation users and non-irrigation user's households at 1% and 10% significant level respectively.

The study further shows that the mean separation test indicates that there is a statistically significant difference in landholding size between irrigation users compared to non-irrigators at 1% significant level. The landholding size of non-irrigation users have higher than the irrigated household. The results illustrated that small land holdings for irrigators implying that the intensive nature of irrigation farming is such that irrigators have to operate less land, while the non-irrigators need to put more land under cultivation to cater for the extensive and risky nature of dry-land farming.

Table 1: descriptive analysis of the sample households

Variable	Irrigation users	Non irrigation users	Difference	T value
Family size	4.38	3.86	0.52	3.3298***
Age of heads	47.08	44.35	2.73	2.3636**
Credit access	54.41	50.54	3.87	2.4847
Extension service	57.35	53.23	4.12	2.8597 *
Fertilizer	85.71	51.08	34.63	45.5554***
Size of Cultivated land	0.50	0.64	-0.14	-3.4676**
Education level of the head	70.78	51.61	19.17	12.9271***
Gender	83.77	70.97	12.8	7.7368***
Number of oxen	2.16	1.70	0.46	3.7437***
Improved seeds	46.75	40.86	5.89	1.1902
Dependence ratio	0.31	0.33	-0.02	-0.6475

Note: *** significant at $p<0.01$, ** significant at $p<0.05$, * significant at $p<0.1$

Besides, there is a statistically significant difference in household size of the irrigation users compared with no- irrigation users at 1% significant level. The result indicated that irrigation activities demand more labor. Whereas a there is a statistically significant difference in oxen holding between the irrigation users and non-irrigated farm households in the study area at 1% level of significance. However, there is no a statistically significant difference in dependence ratio of the irrigation users compared with no- irrigation users at 1% significant level.

The improved seed users result shows that the mean value for irrigation user and non-irrigation user was 46.75 percent and 40.86 percent respectively. Whereas the mean value credit access for irrigation user and non-irrigation user was 54.41 percent and 50.54 percent respectively. However, the chi –square test indicated that there is no statistical association between the irrigation users compared with non-irrigation users in accessibility of credit and improved seeds.

The mean age of irrigation users and non-irrigation users are 47.08 and 44.35 respectively. The results indicated that majority of the farmers are in their energetic years of age. There is significant difference in the distribution of household head age of the sampled respondents between irrigation users and non-irrigation users at 5% significant level in study area. In terms of literacy status, 70.78 per cent of irrigator household heads are literate compared to 51.61 per cent of non-irrigators. There are statistically significant differences between the irrigation users compared with non-irrigation respect to household literacy level at 1% significant level. .

3.2. Determinate of irrigation participation

Based on the irrigation program and information about household participation in the irrigation program (participated and non-participated households) the propensity scores (i.e. the conditional probability of a households' participation in the irrigation programme) were estimated. The first step is to apply a logit regression model (0, 1) used to estimate to determine the conditional probability of participating in the irrigation program for each household with treatment as the outcome variable and the potential confounders as explanatory variables was used to predict propensity score for all sample households. In estimating propensity score, important pre-intervention observable covariates that are expected to affect both access to irrigation and consumption per capita and size of live stocks were included. The nature of data in the logit model included both continuous and binary variables. The following variables are considered in the irrigation infrastructure: Family size, age of heads, gender of heads, access of credit, extension services, fertilizer uses, improved seed, oxen, head of literacy level, size of cultivated land, and dependence ratio.

Before proceeding to impact estimation, multicollinearity between variables was checked and there was no indication of multicollinearity problem between the variables that were considered in the estimation of the propensity scores. Variance inflation factor (VIF) was applied to test for the presence of strong multicollinearity problem among the explanatory variables. There was no explanatory variable dropped from the estimation model since no serious problem of multicollinearity was detected from the VIF results. The results of the logit estimation of irrigation determinants provided are shown in Table 2.

Table 2: logit regression result: probability of being participants in irrigation

Variable	Irrigation users			
	Coefficient	Odd ratio	Z-value	P>z
Family size	0.1878952	1.206707	1.79	0.074*
Age of heads	0.0084933	1.008529	1.52	0.130
Credit access	0.3947981	1.484084	1.49	0.135
Extension service	-0.5889507	.5549092	-1.95	0.051*
Fertilizer	1.695188	5.44767	5.16	0.000***
Size of Cultivated land	-1.956125	.1414053	-4.67	0.000***
Education level of the head	0.8757608	2.400701	3.05	0.002***
Gender	0.5262622	1.692594	1.52	0.130
Number of oxen	0.5028831	1.653482	3.64	0.000***
Improved seeds	0.6567427	1.9285	2.37	0.018**
Dependence ratio	-0.3192785	0.7266731	-0.50	0.618
Constant	-3.389645	.0337207	-4.07	0.000***
Logistic regression	No of obs	340		
	LR chi2(11)	106.62		
	Prob > chi2	0.000		
	Pseudo R2	0.2277		
	Log likelihood	-180.85335		

Note: *** significant at P<0.01, ** significant at P<0.05, * Significant at P<0.1

The results shown that the coefficients of most of the variables have expected signs. As indicating in table (2), family size, and fertilizer uses, education level, improved seeds and oxen were more significantly influenced households to participate in irrigation program. However, extension service and Size of cultivated land are negatively affect a households to participate in irrigation. The logit result estimates that family size and head of literacy are the major determinants of household to participate in cannel river diversion at household level. However variables such as gender of heads and access of credit are less important variables that determine farmers' participate to in all types of irrigation.

3.2. Propensity score estimation for households

Rosenbaum and Rubin [1985] have revealed that issues with the same propensity score have, on average, the same potential outcomes, so comparing treated and untreated subjects with the same propensity score gives an unbiased estimate of the effect of treatment. Scholars use the PSM to remove the difference in the covariates' distributions between the treated and the control groups (Imbens, 2004). Once a propensity score has been computed for each observation, the next step is to sub classify them into different strata such that these blocks are balanced on propensity scores. It must be checked that there is an overlap in the range of propensity scores across treatment and comparison groups. Besides overlapping, the propensity score should have a balance in the irrigation users and non-irrigation users. (Imbens, 2004) revealed that common support should ensure that the mean propensity score is equivalent in the treatment and comparison groups within each of the five quintiles. Since the propensity score corrects for all predictors using a simple variable and the five blocks can remove 90% of bias due to raw comparison, stratifying the propensity score into five blocks can generally remove much of the difference due to the non-overlap of all observed covariates between the treated group and the control (Mingxiang Li, 2012).

Minima and Maxima Comparison is used in this study in order to minimize the bias of the matching. The main principle of this method is to remove all observations whose propensity score is smaller than the minimum and larger than the maximum in the opposite group. The propensity score of the study lies within the interval [0.0141961, 0.9061729] in the non-irrigation group and within [0.0599154, 0.9605926] in the irrigation group. Hence, with the minima and maxima criterion', the common support is given by [0.05991539, 0.96059256] .Observations which lie outside this region are discarded from analysis.

The t- test and the test for standardize bias (SB) are widely used techniques to ensure the balance of the strata (Rosenbaum & Rubin, 1985). Balanced strata between the treated and the matched control group ensure the minimal distance in the marginal distributions of the covariates.

Figure 2 display the common support distributions of the estimated propensity scores for the irrigation and non-irrigation groups. There is an overlap in the distribution of the propensity score of both irrigation (treated) group and non-irrigation group. The upper halves of the histograms shows the propensity score distribution for the irrigators while the bottom halves refers to of the no irrigators.

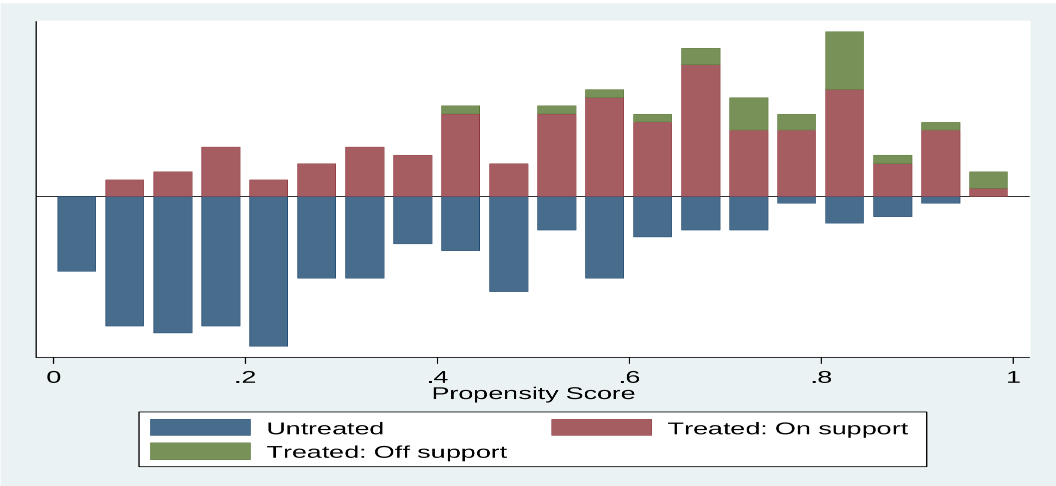

Figure 2: common support distributions of the estimated propensity scores for the irrigation and non-irrigation groups.

Based on the theoretical and previous research work, I stratified the observation data into five blocks after calculating the propensity scores. I conducted the t-test within each block to detect any significant difference of propensity scores between the treated and control groups. Therefore, the t- test reveals that the difference of propensity score between the treated and control groups is statistically insignificant.

To estimate ATT accurately, one should match the irrigation users and non-irrigation users precisely on the basis of the propensity score. The matching quality depends on the closeness of the match or distance measure to determine whether an individual is a good match. Irrigation households and non- irrigation households were matched based on their propensity scores using the nearest neighbor matching (NNM) and kernel matching methods and radius matching . Those methods identify the closest match among irrigation households and non-irrigation households and then compute the effect of irrigation as a mean difference of household consumption between the two households. After choosing a matching or weighting strategy, it is important to evaluate how well the treatment and comparison groups are balanced in the matched or weighted samples.

Table 3: Performance of different matching estimators

Matching estimator	Performance criteria				
	Balancing property	Pseudo-R2	Mean	P value	Matched sample size
Nearest neighbor matching					
Replacement	11	0.021	7	0.686	330
Caliper matching					
Radius 0.1	11	0.011	5.1	0.954	330
Kernel matching					
Band width of 0.1	11	0.012	5.6	0.938	330

The bias between the irrigation and non-irrigation user's households before and after matching is calculated for each variable and the change in this bias is stated in table 3. Overall, the quality of the match is good based on the distance of the standardized bias of the covariates before and after matching.

3.2.1. The impact of irrigation on consumption and livestock resources of the households

After assessing the quality of matching based on propensity score overlap and covariate balance, the next step is to analyze the output table of the matching method. Table 4 reports the estimates of the average per capita consumption expenditure and the size of livestock effects using nearest neighbor matching (NNM), kernel based matching (KBM) and radius matching methods. Of the 340 sample, 154 are treated (irrigation users) and 186 are non-treated (non- irrigation users). Due to imposing common support in this study, 12 observations are discarded from non- irrigation users. Therefore, 174 non-irrigation households' cases are used to match with the irrigation users (154).

The results illustrated that irrigation positively and significantly affect consumption level of households. The treated household's consumptions expenditure per adult equivalent was much more than that of the non-treated households. Using nearest neighboring matching estimator, it was found that, on average, the program has increased the consumption expenditure of the irrigation users households by ETB 1564.19 per adult compare with the non-irrigation household in the study area and this impact was highly significant(at 1 percent probability level).

Table 4: presents the average treatment effect of irrigation on the treated (ATT)

Outcome variable	Matching method	No of irrigation users	No of non-irrigation users	ATT	t-value
Total consumption expenditure	Nearest neighboring	154	63	1564.19	3.319***
	Kernel	154	174	1422.73	3.151***
	Radius	132	154	1507.44	2.864***
size livestock in TLU	Nearest neighboring	154	63	0.350	0.575
	Kernel	154	174	0.497	1.179
	Radius	132	154	0.49	0.845

Note: *** significant at $p<0.01$, ** significant at $p<0.05$, * significant at $p<0.1$

Based on the kernel matching method, the average treatment effect gain as a result of access to irrigation was estimated at ETB 1422.727 and it is statistically significant at one percent. Similarly, using radius matching, 132 irrigation user households were matched to 154 non- irrigation user households. The average adult equivalent consumption expenditure for the irrigation was about ETB 1507.44 consume higher than that of the non-irrigation households. This implies that irrigation users were more likely to consume more food as compared to the non-irrigation user households. Thus, all matching methods indicate that irrigations play a great role in the improvement of livelihoods as well as poverty reduction in the study area. These differences can be explained by the fact that household's access to irrigation has enabled farmers to harvest twice a year and raise cash crop and diversify their cropping patterns. Therefore having access irrigation for beneficiary households helps to increase their production, diversified the crop pattern and income and this in turn improved the household consumption expenditure and wellbeing. This result is consistent with the findings of previous studies (Haile, 2008; Tsegazeab G and Surajit G., 2016, Susanto Kumar Beero and A. Narayanamoorthy, 2014).

On the other hand, the result of all matching methods as indicated in the table 4 , there was no statistically significant difference in livestock resources between the irrigation user and non-irrigation households at the 5% level even though is it positive. This result is consistent with the finding s of previous study of（Woldegebrial Zeweld et al., 2015). They found that Ethiopia government introduce zero grazing strategies to protect the land degradation and have made intensive campaigns for area enclosures and conservation agriculture. Introduction of these practices might enable the relatively better-off households to destock their animals. The frequent droughts and shortage of animal feed in the areas might also contribute to reducing the quantity of animals and the focus on intensive animal husbandry.

Conclusion

The Tigary Regional state has been expanding and prioritize different irrigation projects as a means for reducing poverty and attaining food security at household level. Therefore, the main objective of this study was to evaluate the impact of irrigation on poverty reduction and livestock resources at household levels. This study employed propensity score matching methods to analyze the empirical data that were gathered from irrigation users and non-irrigation users households in the study area. From this research finding, it could be concluded that irrigation had a positive increases in total household consumption are estimated for households who have access to irrigation in study area. However, the impact of the livestock resources is no statistically difference although it is positive.

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