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Impact of Small-Scale Irrigation on Rural Households' Income: The Case of Bambasi Woreda, Benishangul Gumuz Region, Ethiopia

Kide Gebru Tesfay[1] and Tsegazeab Gebremariam Yihdego[2]

Lecturer, Department of Economics, College of Business and Economics, Assosa University, P.O. Box 18, Website: www.asu.edu.et

Abstract

In Ethiopia agriculture is the primary determinant of economic growth, and it has the largest economic share to gross domestic product. Investment in small scale irrigation is an important strategy to cultivate the fixed land resource more than two per a year and it makes to reduce associated risks with rainfall variability and to enhance income of the households. The main objective of the study was to examine the impact of small-scale irrigation on rural households' income. The study was used a cross-sectional data obtained from 200 sample households using multi-stage sampling techniques from Bambasi Woreda, Assosa zone, Benishangul Gumuz Region, Ethiopia. Logit and Propensity score matching (PSM) model were used to estimate the determinants and impact of small-scale irrigation on rural households' income. The descriptive statistics analysis was also used for the variables which are not captured by econometrics model. The logistic estimation result revealed that household family size, farm income, numbers of livestock owned and access to agricultural extension service are statistically significant factors and positively determine the probability of households' participation in small scale irrigation. Whereas distance to the market and distance to farm are statistically significantly but negatively affect the probability of households' participate in small scale irrigation. Finally, the four matching algorithms Nearest-Neighbor, Stratification, Radius and Kernel were used to estimate the impact of irrigation on households' income among the treated and control groups. The matching algorithms estimation result shows a positive and significant difference in income between the two groups of households (treated and control groups). In the study area users of small scale irrigation was faced problems mainly like high risk of crop damage and lack of access to credits are among the major ones. In addition, lack of better seeds and inputs, lack of extension support and insufficient of water volume river are also among the problems in the study area.

Key words: - *Bambasi Woreda, Income, Logit, Propensity Score Matching, Small scale irrigation*

1. Introduction

Comprehensively, agriculture is the backbone of the Ethiopian economy by creating of income, employment opportunities and foreign exchange earnings. Nationally, the performance of the main sector agriculture highly determines the economic growth of the country. Hence, approximately 80

percent of the population involves in agricultural activities. Particularly, the main sector agriculture contributed around 41.6 percent to GDP, 60 percent for employment and 80 percent for export earnings (MoFED, 2010). In spite of the achievement of the positive changes of the livelihoods of the rural farm the economy is a subsistence economy in which the farm households failed to smooth their consumption levels and the small holder households are exposed to poverty and food insecurity across various parts of Ethiopia (Mitiku et al., 2001). Further, the households are suffering from different natural and economic activity shocks due the fact that the sector is highly vulnerable to climatic changes and its dependency on the variability of rainfalls.

The fundamental economic instrument of small scale irrigation at country as well as regional level has shown a feasible economic achievements. As a result, the national government has given due emphasis for the expansion irrigation as a key strategy for achieving improved agricultural production, ensuring of household food security and rural poverty reduction as well as means of consumption smoothing. Cognizant, the fact that small scale irrigation has many positive attributes both at private as well as community level of the farm households especially in the world of developing countries (Kumar, 2003; Lipton et al., 2003; Hussain and Hanjra, 2004; Gebregziabher et al., 2009; Bacha et al., 2011).

In similar manner, the Ethiopian government has undertaken various activities to expand irrigation and utilize the underutilized water resource potential both at national as well as regional and local levels of the various corners of the various geographical areas. The Agricultural Development Led Industrialization (ADLI) program considers irrigation development as a key strategy for achieving sustainable development of the country Ethiopia. Thus, to address the subsistence farming problem, the economic performers designed a national strategic plan in 1991, that is the Agricultural Development Led Industrialization (ADLI) that gives a greater focus for irrigation development, cooperative societies and agricultural technologies to answer the high food demand and bring socioeconomic development in the country. Besides, irrigation development, particularly small-scale irrigation is planned to accelerate for maintaining the desired economic growth of the country (MoFED, 2010).

At large, irrigation is an instrumental parameter that consist of the potential to stabilize agricultural production and improve productivity and mitigate the negative impacts of the fluctuating and insufficient rainfall of the country as well as the region. In addition, the principal irrigation development substantiate some of the negative effects of the rapid population growth, poverty severity and food insecurity in which it primarily targets to boost the agricultural yield by producing more than two per year, which in turn minimizes food insecurity gap and poverty depth as well as poverty intensity at household level. Moreover, irrigation helps farmers to overcome rainfall constraint by providing a sustainable supply of water for cultivation and livestock production (FAO, 2003). Irrigation as a program is assigned a prominent role to the development of irrigation in the country for food production. Utilizing water as a

resource helps to feed the frighteningly growing population.

In fact, Ethiopia has a huge potential in terms of surface and ground water availability and lands which is the most cases suitable for irrigation practices and development. However, the contribution of irrigation to the economic growth is not fully fitted with the expectations. Cognizant this fact, the development of the scheme is at its infant stage and the country especially rural households are not as much as beneficiary. Besides, the country's ability to support agriculture through development of irrigation has been recorded as a weak. To this effect, this study has been focused on Bambasi district of Assosa zone of Benishangul Gumuz in which majority of its population was depending on mixed agriculture sector. In turn, in spite of the potential the rural farm households are also suggested as weak in participation to irrigation schemes. Therefore, designing better policy of development projects is appropriate to improve the livelihood of the communities in particular and the country in general. To address this empirical study, the research was motivated to concentrate on the impact of small scale irrigation on rural household income by taking Bambasi woreda as a case study.

This study was answering the following research questions;

- What are the determinant factors for households' decision to participate in small-scale irrigation in the study area?
- What is the impact of small-scale irrigation on rural households' income and consumption expenditure in the study area?
- What are the major challenges to both participant and non - participants of small-scale irrigation in the study area?

Objectives of the study

The general objective of this study is to examine the impact of small-scale irrigation on the rural household income by undertaking Bambasi Woreda as a case study of Benishangul Gumuz region, Western Ethiopia.

The specific objectives are;

- To identify the factors that influences farmers' decision to participate in small-scale irrigation in the study area;
- To determine the impact of small scale irrigation on the rural households' income and consumption expenditure in the study area, and
- To examine the major challenges encountered on the participant and non-participant of the small-scale irrigation systems in the study area;

2. METHODOLOGY OF THE STUDY

2.1 Source of Data Collection

The researchers were used both primary and secondary data's. The primary data was collected in the form of cross-sectional survey data by distributing semi-structured questionnaire methods, and observation. The secondary data was collected by reviewing written official documents of the regional, zonal and woreda level agricultural bureaus.

2.2 Sampling Method and Sample Size

Mutli-stage sampling approaches were employed to collect data from sample respondents. In the first stage, Amba 16, Dabus and Sonka kebeles were selected using purposive sampling techniques out of the total 74 rural kebeles in Bambasi Woreda. Those sample kebeles were

selected based on the availability of small-scale irrigation in the study area. Secondly, the sampling frame was obtained from the expertise of the local administrative officer and was stratified into two groups which are irrigation participants and non-participants. The participants are those households who are the users of irrigation, while the non-participants are those households lived in the same areas but they are not users of irrigation access from the scheme. Finally, 100 sample respondent were selected from each stratums, and totally 200 sample respondents were used to estimate the impact of small scale irrigation on rural household income and consumption expenditure.

2.3 Methods of data analysis

After collecting the data, the study was employed both descriptive statistics and econometrics model in order to interpret the data. The descriptive statistical techniques are tables, means, standard deviation, percentages and frequencies. Those descriptive statistics tools are also used to describe for the variables which are not captured by econometrics models and to strengthen the econometrics estimation results. In the econometric analysis, factors which determine the households' to participate in small scale irrigation are identified by logistic regression model. Moreover, the impact of small scale irrigation on rural household income is analyzed by comparing the participant and non-participant household in the irrigation using propensity score matching (PSM).

Empirical Models

Basically, the study was on impact of small scale irrigation on rural households' income among treated and control groups. Thus, this paper revolves around a specific non-experimental evaluation method called as Propensity-score matching (PSM). PSM employ information by comparing the outcomes differences of the two groups that is how income is differ between the treated and control units, as a result of the intervention of the program. Finally it is possible to estimate the effect of the intervention between the treated and control units. Before, applying the different techniques of propensity score matching focusing on the two basic assumptions of PSM is relevant. Those are conditional independence assumption and assumption of the common support or overlap condition. As a result, once the propensity score is known and the balancing assumption is meeting, the impact of the program or ATT can be estimated on the selected continuous outcome indicators. Therefore, logit model is widely applied than probit model because of its difficulty in its estimation procedure of the probit model than logit model estimation procedure. Thus, based on Gujarati (2004), in estimating the logit model, the dependent variable is participation which takes a value of 1 if the household is participated in a program and 0 otherwise. The mathematical formulation of logit model is given as follows:

$$P_i = \frac{e^{Z_i}}{1+e^{Z_i}} \quad \text{.....} \quad (4)$$

Where, P_i is the probability of participating in irrigation program,

$$Z_i = \beta_0 + \sum \beta_1 X_i \quad (4a)$$

Where, i= 1, 2, 3, - --, n
β0 = intercept and β1 = regression coefficients to be estimated, X_i = pre-intervention characteristic of the household

The probability that a respondents belongs to control group is given by:

$$P_i = \frac{1}{1+e^{Z_i}} \quad (4b)$$

At last, by taking the natural log of the above equation the log of odds ratio can be written as:

$$L_i = \ln\left(\frac{P_i}{1-P_i}\right) = Ln\left(e^{+\sum_{j=1}^{n}\beta_i X_i}\right) = Z_i = \beta_0 + \sum_{j=1}^{n}\beta_i X_i \quad (4c)$$

Where, L_i is the log of the odds ratio in preference of participation in the program which is not merely linear in X_{ji} but also linear in the parameters according to matching theory (Rosenbaum and Robin, 1983; Bryson et al., 2002). In this model the important issue is selecting or preferring to which variable to incorporate and to which type of data is collected and used.

Propensity Score Matching (PSM) Model Specification

The propensity score matching is one of the best methods for evaluating the impacts like development related projects across countries. Similarly, the propensity score matching (PSM) method is one of the non-parametric estimation techniques that could not depend on functional form and distributional assumptions. In practice, the technique is intuitively attractive as it helps in comparing the observed outcomes of technology adopters with the
outcomes of counterfactual non adopters (Heckman *et al.*, 1998). In spite of its heavy d ata requirements, the matching method can produce experimental treatment effect res ults when such data are not feasible and/or available. Besides, it also helps to evaluate programs that require longitudinal datasets using single cross sectional dataset where the base line survey data does not exist.

Hence, the basic idea of the propensity score matching technique is to match observations of adopters and non-adopters according to the predicted propensity of adopting a superior technology (Rosebaum and Rubin 1983: Heckman *et al.*, 1998; Smith and Todd, 2005; Wooldridge, 2005). Therefore, the main attribute of the matching procedure is the reation of the conditions of randomized experiment in order to evaluate a causal effect as in a controlled experiment.

Consider that, G_i denotes a dummy variable such that $G_i = 1$ if the *i*th farmer participate in small scale irrigation and $G_i = 0$ otherwise. Similarly let *Y1i and Y0i* denote potential observed

welfare which is taken by a proxy of income outcomes for participant and non-participant units respectively. Consequently, $\square = Y1i - Y0i$ is the impact of the irrigation on the *i*th farmer, usually called treatment effect. As we observe $Yi = GiY1i + 1(-Gi)Y0i$ rather than $Y1i$ *and* $Y0i$ for the same farmer, we are unable to compute the treatment effect for every unit. The primary treatment effect of interest that can be estimated is therefore the
Average impact of Treatment on the Treated (ATT) given by

$$\tau = E(Y1i - Y0i / Gi = 1) \quad \text{.....(1)}$$

Following Rosenbaum & Rubin (1983), the propensity score can be estimated as

$$P(X) = P(Gi = 1 / X) \quad \text{.....(2)}$$

Assumed the assumptions that (a) $Y1i, Y0i \perp G / X$ *that is,* the potential outcomes are independent of small scale irrigation participation given *X,* this implied that
$E(Y0i / G = ,1\ P(X)) = E(Y0i / G = ,0\ P(X))$ and
(b) $0 < P(X) < 1$, that is, for all *X* there is a positive probability of either participating (*G*= 1) or not participating (*G*= 0), this guarantees every adopter a counterpart in the non-adopter population. Thus, the ATT can then be estimated as:

$$\begin{aligned}\tau &= E(Y_{1i} - Y_{0i} / G_i = 1) \\ &= E[E(Y_{1i} - Y_{0i} / G_i = 1, P(X))] \\ &= E[E(Y_{1i} / G_i = 1, P(X)) - E(Y_{0i} / G_i = 0, P(X))] \quad \text{.....(3)}\end{aligned}$$

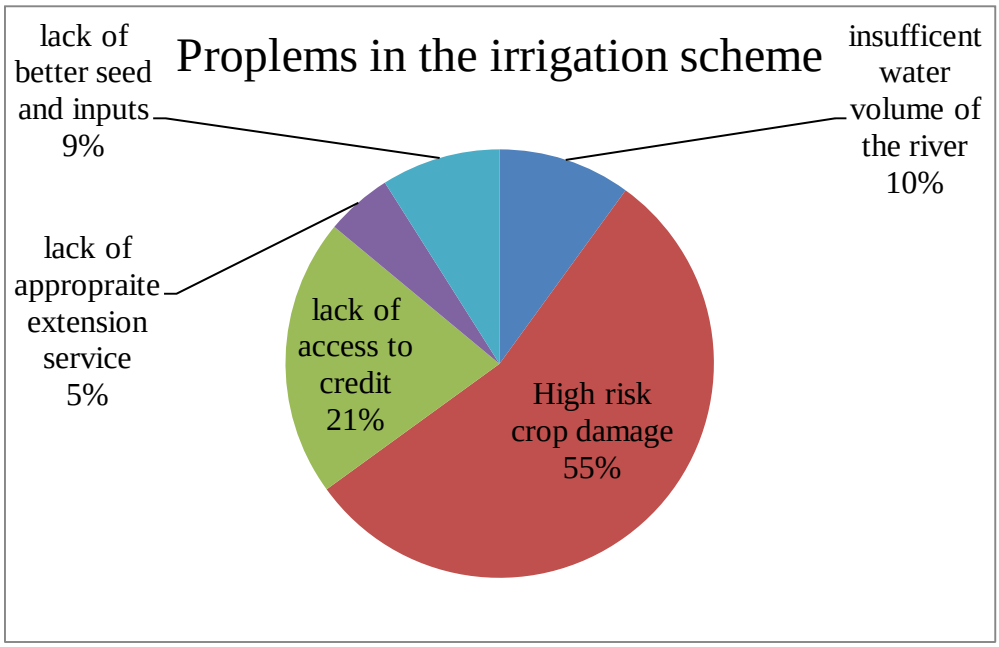
Furthermore, the propensity score is a continuous variable and there is no way to get participant with the same score as its counterfactual(s). Thus, estimation of the propensity score is not sufficient to compute the average treatment effect given by equation (3). But, we need to search for counterfactual(s) that matches with each participant depending on its propensity score. Therefore, different matching methods are adopted in the literature which is advocated by (Smith and Todd, 2005).

So, we use the nearest-neighbor matching method to pick comparison groups. This method
could use a single nearest-neighbor or multiple nearest-neighbors with the closest propensity score to the corresponding participant unit. The method could also be applied with or without replacement where the former allows a given non-user to match with more than one user (Becker and Ichino, 2002; Dehejia and Wahba, 2002). To check the robustness of our result, the impact estimate calculated using the nearest neighbor matching method is compared to the estimates of Kernel, radius and stratification matching method. As argued earlier, the observed outcome variable used as a proxy for the welfare of smallholder rural farmers, in this paper, are irrigation income and household consumption expenditure per adult equivalent per year.

3. Results and Discussion

In this section, the results of the study are presented and discussed pertaining to previously determined specific objectives.

3.1 Basic Problems and Constraints of the irrigation users in the study area



Source: own survey result, 2015
Figure 3.1: Problems in the irrigation scheme

Based on the figure above, high risk crop damage accounts for around 55 percent which reveals as the highest percentage coverage of the problem coverage and then lack of access to credit is 21 percentage which challenges the participation in small scale irrigation.

3.2 The Determinants of Households' Participation to Small-scale Irrigation in Bambasi Woreda

Firstly, logit model was used to estimate the factors that influenced households' decision to participate or not to small scale irrigation scheme. The result of this model is presented in the table 3.1 which shows the odds ratios and marginal effect.

The odds ratio and marginal effect estimation of the logit model result revealed that, household family size, farm income, numbers of livestock own and access to agricultural extension service, market distance and distance to farm of the rural households are statistically significant variables.

Table 3.1: Logistic estimation results for households' participation to small scale irrigation

Variables	Odds Ratio	Std. Err.	P>|z|	mfx	Std. Err	P>|z|
Household head sex*	1.914	1.122	0.268	0.154	0.139	0.268
Household head family size	1.258	.1462	0.048**	0.055	0.028	0.050**
Household head age	.992	.0146	0.590	-0.002	0.004	0.590
Education level of hh head	1.003	.063	0.957	0.0008	0.0148	0.957
Active labor hh family size	.803	.176	0.318	-0.052	0.052	0.320
Farm Income	1.000	.0001	0.000*	0.00005	0.00001	0.000*
Off farm income	1.000	.0003	0.640	0.00004	0.00008	0.639
Land size	.965	.103	0.739	-0.009	0.025	0.739
Distance to mkt	.989	.005	0.042**	-0.003	0.001	0.044**
Access to credit*	1.505	.691	0.373	0.098	0.111	0.378
Access to extension service*	3.408	2.190	0.056***	0.297	0.148	0.044**
Distance to farm	.946	.030	0.078***	-0.013	0.008	0.081***
Tropical Livestock Unite (Tlu)	.773	.073	0.006*	0.061	0.023	0.005*
Number of obs = 200						
LR chi2(13) = 79.59						
Prob > chi2 = 0.0000						
Pseudo R2 = 0.2871						
(*) dy/dx is for discrete change of dummy variable from 0 to 1						
*, ** and *** Significant at 1%, 5%and 10% levels respectively						

Source: Own survey result, 2015

3.3 Impact of Small Scale Irrigation on Rural Households' Income

Small scale irrigation has an impact on rural households' income among users and non uses. The difference between the treated and control groups in the program was easy to estimate using average treatment of the treated (ATT). The estimation results of the four algorithms can be presented in the below table 3.3 and revealed that, there was a difference with regard to income of households among the two groups.

Table 3.3: *ATT results for income of households*

Matching Algorithm	No. Treated	No. Control	ATT	Std. Err	t-value
Nearest Neighbour	100	100	9269.3	2632.9	3.521
Stratification	99	87	5188.3	1107.466	4.685
Radius	100	100	9268.0	2436.1	3.804
Kernel	100	100	9269.3	2447.1	3.788

Source: Own Survey result, 2015

According to the above result, small scale irrigation has a significant impact on households' income in Bambasi Woreda. Since, all the estimated results of the matching algorithm are statistically significant and economically meaningful at 1% of probability of significance. As a result, the estimated ATT result of nearest neighbour, and Kernel matching is 9269.3 Birr whereas, the stratification, and radius matching methods provide ATT values of, 5188.3 Birr, 9268.0 Birr and 9269.3 Birr with a respective t-value of 3.521, 4.685, 3.804

and 3.788. Thus, all of the four matching algorithms are consistent with positive and statistically significant ATTs. Therefore, the theoretical hypothesis of the study is fitted and satisfied as it is.

4. Conclusions and Policy Recommendations

The study was covered the impact of small scale irrigation on rural households income in Bambasi Woreda of Benishangul Gumuz regional state of Ethiopia. A cross sectional primary data collected from 200 sample households (including 100 users of irrigation and 100 non-users of irrigation) was used for analysis in the study. Propensity score matching (PSM) method was employed to estimate the impact of small scale irrigation on rural households' income in the study area. In the first stage of the matching, logit regression model was used to model the probability whether farmers participate in the irrigation or not and to look the main determinants of irrigation participation. The logistic estimation result revealed that, household farm size, farm income, numbers of livestock own and access to agricultural extension service are statistically significant and positively influencing factors which determined households to participate in small scale irrigation. Whereas distance to the market and distance to farm are negative and significantly affect households' to participate in small scale irrigation.

Finally, the matching algorithm estimation results show a positive and significant difference in income between the two groups of households (treated and control groups). The result of the matching algorithm implies that small-scale irrigation has an important influence on rural household income and consumption expenditure. Besides, small scale irrigation plays a great role in contribution to the livelihood households'. In the study area users of irrigation households were faced problems of high risk crop damage and lack of access to credits are among the major one.

As per the finding of the study, the following recommendations are forwarded in order to enhance income of households on the study area. In the study area so far small-scale irrigation schemes non-participant households are basically reasoned out like lack of cultivated land in the irrigation area. Besides, some households are also not utilizing the water for productive activities rather they are ineffective and inefficient in using of the potential water from the river due less capital intensive technology and lack of capital for purchasing of various fruits and vegetable varieties for planting in the area. Thus, government or any concerned body should give attention and provide basic solutions for those households who are not utilizing the irrigation potential. Thus, the responsible body should do small irrigation dam and pumps in return to encourage and initiate for those households who have unavailability of enough land for irrigation. Moreover, households are not using the potential of irrigation even if their land is nearest to the main source of the rivers due the availability of various wild animals which constrains the productivity of the irrigation, less technology holding, and fear of crop damage risks. Therefore, the agricultural expert body should give notice to them concerning awareness creation on the decisive role of small scale irrigation on food security enhancing, poverty reduction, increasing of productivity, and overall livelihood

diversification means of the rural farm households.

In the study area the soil type of land cultivated was infertile which is easily vulnerable to high risk crop damage. Thus, the regional state of government should investigate the acidity of the soil and forward solutions for the households and should also provide damage resistant crops with high yield in various agro-ecological zone of areas.

Further, in the study area the agricultural crops of farmers were affected by epidemic diseases. Thus, the local government has to intervene and provide improved agricultural inputs at reasonable price in a good season. Coincided with this, some farmers still are complaining on the price of fertilizers, better seeds in particular and other agricultural inputs. Therefore, the government should give attention and emphasis on the supply of these inputs at fairness price, on time and in adequate amount. Expansion of access to credit, access to extension service and availability of market place in the study area are crucial in the study area.

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