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The Role of Soil Conservation on Net Value of Crop Income of Farmers: Evidence from Low Rainfall Areas of West Belessa Woreda, North Gondar Zone

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Abstract:

The study was conducted to measure the impact of soil conservation on net value of crop income for conserved plots, to evaluate crop income difference from that of non-conserved plots and to evaluate the real significance of adopting soil conservation activities on farm plots. For this purpose, the study selected two kebeles by using purposive and stratified random sampling techniques. Hence, cross sectional data on socio-economic level variables to plot specific characteristics including soil conservation status was generated from 176 conserved and 176 non-conserved plots in terms of questionnaire survey and secondary data. The study used descriptive statistics (frequency, percentages, mean, standard deviation, and mean difference), inferential statistics (chi-square and independent sample t-test) and propensity score matching method to control for self-selection and program selection bias. The research finding suggests the existence of a significant positive impact of soil conservation on net value of crop income in West Belessa woreda. From the study, soil conservation measures increased net value of crop income by about ETB 164 for stratification and ETB 299 for kernel matching methods on average to conserved plots compared to the non-conserved plots. Thus, based on the result it is possible to conclude that average net value of crop income of farmers with conserved plots is significantly higher than those with non-conserved plots.

Key words: West Belessa woreda, soil conservation, propensity score matching, average treatment effect on the treated

1. Introduction

The Ethiopian economy is mainly based on agriculture which accommodates in 2008/09, 85% of the population in terms of employment and livelihood. It accounts for 43% of the country's gross domestic product (GDP), 80% of the export earnings and about 75% of Ethiopia's industry is engaged in processing of farm products (Tsegay, 2010). Having this fact, economic development of the country is heavily dependent on the performance of the agricultural sector. However, low productivity characterizes Ethiopian agriculture. The low productivity of the agricultural sector has made it difficult to attain food self-sufficiency at a national level (Tadesse and Belay, 2004).

Land degradation is one of the major causes of low and in many places declining agricultura productivity and continuing food insecurity and rural poverty in Ethiopia in general and in the northern highlands in particular (IFPRI, WUR and EEPFE, 2005). According to Schmidt and Fanaye (2010), land degradation problem is further aggravated by limited use of sustainable land management practices. This results in lowering of soil organic matter in already poor soils, a depletion of nutrients that have contributed to a stagnation or decline of crop production.

In recognition of these challenges, there has been a great deal of effort to address land degradation problems in Ethiopia. For example, Growth Transformation Plan (GTP), launched in 2011, Comprehensive Africa Agriculture Development Program (CAADP) and Plan for Accelerated and Sustained Development to End Poverty (PASDEP) from 2005/06 – 2009/10 are some the efforts undertaken in addressing land degradation problem in Ethiopia.

However, evidences show that agricultural sector is growing by 9% which is less than the overall growth of 11.4% (MOFED, 2010/11). Thus, while introducing soil and moisture (water) conservation technologies to improve the productivity of agricultural sector, the relationship between soil conservation and crop production should be studied.

In line with these arguments, this study dealt with some basic questions involving role of soil conservation on net value of crop income of farmers in low rainfall areas of West Belessa woreda, North Gondar zone. Particularly, the study tried to answer:

- Is there significant difference between plots with soil conservation and plots without soil conservation measures in terms of net value of crop income to farmers in low rainfall areas?

- What is the impact of soil conservation activities on net value of crop income? Does it really have a positive impact? Will it underlines the importance of careful geographical targeting when promoting and scaling up soil conservation technologies?

2. Description of study area

West Belessa Woreda

West Belessa woreda is one of the 20 woreda and 3 town administrations in Amhara region of Ethiopia which is named after former province of Belessa. Based on the 2010/11 DoFED report, the woreda has a total population of around 157,713 of whom 80,397 are men and 77,316 are women and in addition 5.4% of the total population is urban and the rest 94.6% is rural inhabitants.

West Belessa woreda is one of the nine (9) food insecure woredas in North Gondar zone with low rainfall below 700 mm per annum. To alleviate food insecurity problem of the woreda as a strategy the local government is currently running huge soil conservation works on vast farm plots of farmers in different areas of the woreda.

3. Data analysis procedure

3.1 Descriptive statistics

In this study, descriptive statistics was used to present the characteristics of sample units, i.e., to compare and contrast different categories of sample units (individuals) with respect to the desired characteristics In addition, it was used to the association between different household and plot characteristics with adoption of soil conservation measures. For these reasons frequency, percentages, and means were used.

Furthermore, inferential statistics was used to study relationships between variables using t-test and chi-square.

3.2 Propensity Score Matching

Here, the main goal of the study is to identify the average treatment effect of soil conservation on the treated plots (ATT). Let C_{hp} denotes a dummy variable such that $C_{hp} = 1$ if the h^{th} household adopting soil conservation on plot p and $C_{hp} = 0$, otherwise. And, W_{hp} is observed characteristics of the household; Y_{hp1} and Y_{hp0} denote potential observed value of net crop income for conserved and non-conserved units respectively.

ATT (τ) is given by:

$$\tau = E\left(Y_{hp1} - Y_{hp0} \mid C_{hp} = 1\right)$$

$$= E\left(Y_{hp1} \mid C_{hp} = 1\right) - E\left(Y_{hp0} \mid C_{hp} = 1\right) \qquad (1)$$

The evaluation problem is that we only observe Y_{hp1} or Y_{hp0}, but never both.

$E(Y_{hp1} \mid C_{hp} = 1)$ could be constructed from the data. Missing is the information required to identify $E(Y_{hp0} \mid C_{hp} = 1)$, referred to as the counterfactual outcome (what would have been the yield of conserved plots had they not had conservation). If soil conservation adoption was non-random, we substituted the unobservable $E(Y_{hp0} \mid C_{hp} = 1)$ for the observable $E(Y_{hp1} \mid C_{hp} = 1)$ when estimating ATT. Hence, we ended up with selection bias equal to

$E(Y_{hp0} \mid C_{hp} = 1) - E(Y_{hp0} \mid C_{hp} = 0)$ (Heinrich et al., 2010).

According to Menale et al. (2008), the method of matching solved the evaluation problem by assuming that, conditional on W_{hp}, Y_{hp1} and Y_{hp0} are independent of C_{hp}**:**

$$Yhp1, Yhp0 \perp Chpi \mid Whp \quad (2)$$

This is referred to as the conditional independence assumption (CIA). The CIA required that all sets of W_{hp} affecting both the net value of crop income and soil conservation be included in the matching. When CIA held, we could therefore use the net crop income from non-conserved plots as an approximation of the counterfactual outcome.

$$E(Y_{hp0} \mid C_{hp} = 1) = E(Y_{hp0} \mid C_{hp} = 0) \quad (3)$$

The basic idea of matching is to pair conserved and non-conserved plots on the basis of their observable characteristics. Matching on covariates is difficult to implement when the set of covariates is large. To overcome the curse of dimensionality, if matching on W_{hp} is valid so is matching on the propensity score $P(W_{hp})$.

Propensity score (response probability) is defined as the conditional probability that plot P received soil conservation given covariates:

$$P(W_{hp}) = Pr(C_{hp} = 1 \mid W_{hp}) \quad (4)$$

Then, ATT (**τ)** can be estimated as follows:

$$\tau = E(Y_{hp1} - Y_{hp0} \mid C_{hp} = 1, P(W))$$

$$= E(Y_{hp1} \quad C_{hp} = 1, P(W)) - E(Y_{hp0} \quad \mid C_{hp} = 1, P(W))$$

$$= E(Y_{hp1} \quad C_{hp} = 1, P(W)) - E(Y_{hp0} \quad \mid C_{hp} = 0, P(W)) \quad (5)$$

When applying the propensity score, the question is which estimating model and variables to use

(Menale et al., 2008). About a model, in the study we will use probit model in calculating propensity score of plots receiving soil conservation. But, selecting covariates requires choosing a set of variables that will plausibly satisfy the CIA. However, since the CIA is an untestable assumption, we will never know whether it has been met. Thus, depending on theoretical, empirical studies and location specific context, the study will incorporate different variables which simultaneously affect both soil conservation and net value of crop income.

4. Result and Discussion

4.1 Descriptive analysis

4.1.1 Household and plot Characteristics

In this section, household and plot characteristics are summarized. Independent sample t-test was used to see whether the differences in mean values of continuous variables of household and plot characteristics differed significantly. Chi-square statistics was employed to see the associations between categorical variables. The summary of statistics for discrete variables is given in table 1 and the summary of statistics for continuous variables is given in table 2.

4.1.1.1 Household characteristics

Share of men respondents was 90.34 % of the household who owns plots with conservation and 86.36 % of the households with conserved plots. However, there was statistically significant association between gender and adoption of soil conservation measures on once own plots.

The mean age of households with conserved plots was higher than the mean age of households with non-conserved plots. The mean age for the household respondents with and without conserved plots was 49.06 years and 47 years, respectively. Furthermore, the mean age for households with conserved plots is significantly higher than the mean age for households with non-conserved plots.

The mean educational achievement of households with conserved plots was lower than the mean variable of interest of households with non-conserved plots. The mean education achievement for the household respondents with conserved plots was 1.52 years and without conserved plots was 1.73 years respectively. But the difference was not statistically significant.

Furthermore, labor use which is standardized in the study in to adult's equivalent with inclusion of family labor, hired labor and debeyat labor (exchange labor) averages approximately 43 man's day per hectare, 40 man's days per hectare and 42 man's days per hectare for households with conserved, households with non-conserved plots and for the total sampled households in the entire production process of the outputs respectively with insignificant mean difference.

Household respondents with conserved plots own 1.55 hectare mean land size which is higher than 1.54 hectare mean land size owned by the respondents with non-conserved plots. However, the mean difference land size ownership is not statistically significant between the two groups. For all respondents access to extension services is 100%. The proportion of households with conserved plots and with non conserved plots in relation with extension service by government workers is no available.

4.1.1.2 Plot characteristics

Of the total 352 plots, almost 19% of conserved plots are very fertile but this number is higher for non-conserved plots with approximately 30%. On the other hand, approximately 81% and 70% conserved and non-conserved plots are fertile. Furthermore, the proportion of variation between the plot groups in association with soil fertility is significant at 5%.

Farmers with conserved plots took on average approximately 15 minutes during journey to reach to plots but for farmers with non-conserved plots the mean journey time to plots was 14 minutes with insignificant mean difference.

Table 1: frequency, percentages and chi-square results for dummy variables

Variables		With conservation N=176		Without conservation N= 176		$\chi 2$
		N	%	N	%	
sex	Female	17	9.66	24	13.64	1.353
	Male	159	90.34	152	86.36	
extension	Access	176	100	176	100	Not avail.
	No access	0	0	0	0	
soil fertility	Very fertile	33	18.75	52	29.55	5.599**
	Fertile	143	81.25	124	70.45	

** Significant at 5% level of significance

Table 2: Mean, St. Dev., and t-values for continuous variables

Variable	Conservation	N	Mean	St. Dev.	Mean difference	t-value
Age	Without	176	47	10.853		
	With	176	49.062	12.085	-2.063	-1.685***
	Total	352	48.031	11.515		
Education	Without	176	1.716	2.960		
	With	176	1.523	2.687	0.193	0.64
	Total	352	1.619	2.825		
Size of land	Without	176	1.542	0.767		
	With	176	1.559	0.776	-0.017	-0.207
	Total	352	1.550	0.771		
Labor	Without	176	40.286	28.948		
	With	176	43.152	39.316	-2.866	-0.779
	Total	352	41.719	34.504		
Distance	Without	176	13.619	14.178		
	With	176	14.733	15.524	-1.114	-0.703
	Total	352	14.176	14.856		

*** = significant at 10%

4.1.2 Value and net value of crop income

The mean crop income for the total respondent's data was 3394.82 Birr. Specifically, mean crop income for households with conserved plots and non-conserved plots was 3572.46 Birr and 3217.18 Birr. But, the mean difference was not statistically.

Correspondingly, the net crop income (after deducting cost of fertilizer from crop income) earned by households with and without conserved plots has no significant mean difference. Generally,

households with conserved plots on average received net crop income of Birr 2883.33 and households with non-conserved plots received on average 2639.97 Birr per hectare respectively.

Table 3: net and value of crop income

Variable	Plots	N	Mean	St. Dev.	Mean difference	t-value
Value of crop income	Without con.	176	3217.18	2474.99		
	With con.	176	3572.46	3167.06	-355.28	-1.173
	Total	352	3394.82	2843.47		
Net value of crop income	Without con.	176	2639.97	2314.36		
	With con.	176	2883.33	2869.98	-243.37	-0.8757
	Total	352	2761.65	2606.14		

4.2 Propensity Score Matching (PSM) Method Results

4.2.1 Estimation of propensity score

The main goal of using propensity score method in the study was to identify average treatment effect of terracing adoption on treated plots (ATT). To identify ATT, study applied probit regression.

Therefore, in the probit model from which the study brought propensity score and in the entire matching process, the study included only those variables which influence both treatment and outcome variables. In general, the model is well specified as LR statistics is 16.7 whose *p* value is 0.0329 which is very small and Pseudo R-squared coefficient is 0.0343.

4.2.2 Estimation of ATT

Table 4 reports the estimates of the average treatment effects estimated by stratification and kernel matching methods. All analyses were based on the implementation of common support condition. Furthermore, the standard errors for the ATT are calculated using bootstrapping with 100 replications.

The outcome variable in the study is the net value of crop production per hectare. The analysis shows the existence of a significant positive impact of soil conservation on net value of crop production. Adoption of soil conservation measures increased net value of crop production by

about ETB 164 for stratification and ETB 299 for kernel matching methods on average to conserved compared to the non-conserved; which are both significant at 10%. Hence, net crop productivity of plots with soil conservation is significantly higher than the non-conserved once. This finding of the study is consistent with Menale, et al. 2011.

Table 4: Estimates of the average treatment effect

Matching Method	Number of Treated	Number of Non treated	ATT (in ETB)	Std. Err	T
Stratification	176	176	164.454	126.538	1.30***
Kernel matching	176	176	299.402	232.095	1.290***

Where

ATT = average treatment effect

***Significant at 10%

4.2.3 Region of common support

It is important to check the overlap or common support region for the conserved and non-conserved plots. Figure 4.1 shows the distribution of propensity scores and the region of common support. The bottom half of the figure shows the propensity scores distribution for the non-conserved, while the upper-half refers to the conserved plots. The figure indicates that the common support condition is satisfied as there is overlap in the distribution of the propensity scores of both treated and non-treated plots.

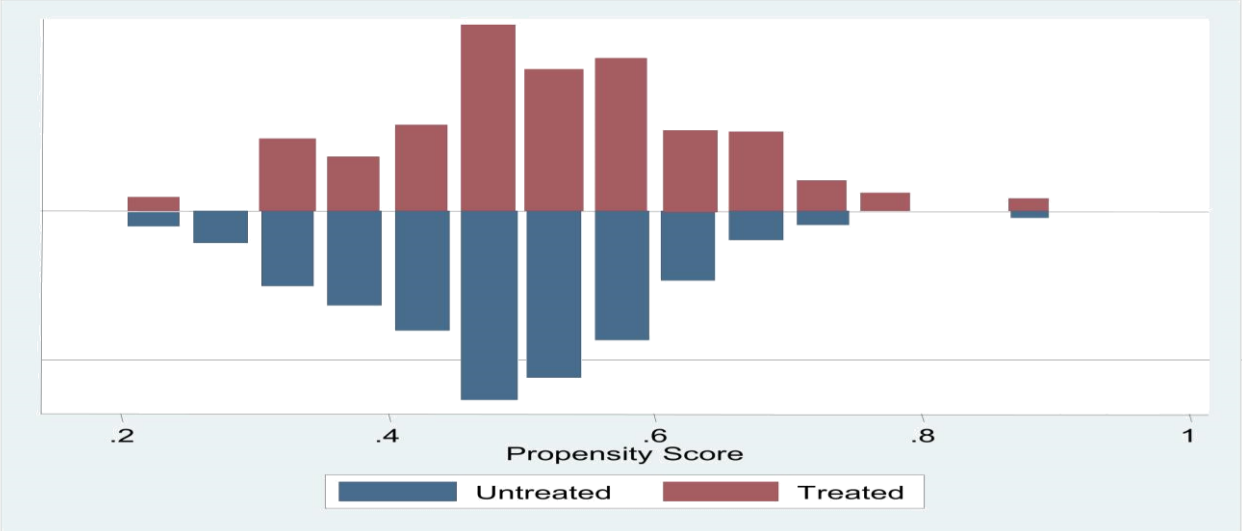

Figure 1: Common support region

5. Conclusion

In Ethiopia the livelihoods of the vast majority of its population depend heavily on agriculture; efforts to sustain and improve the sector's productivity are therefore crucial to the country's economic development and to the welfare of its people. Securing food and a livelihood is inextricably linked to the exploitation of the natural resource base. In Ethiopia, over 85 percent of the population lives in rural areas and depends on smallholder agriculture (Alemneh, 2003). Owing this fact agriculture is the back bone of the Ethiopian economy and one on which the livelihoods of the poor are highly dependent. Thus, as an effort to sustain and improve agricultural productivity in terms of introducing soil and moisture (water) conservation technologies, the relationship between soil conservation and crop production should be studied.

To achieve the main objectives, the study used modern impact assessment method Propensity Score Matching (PSM) to control for self-selection and program selection bias. As indicated in the main body, the study estimated ATT (Average Treatment on Effect on Treated), incorporated t-test and standardized bias as matching quality measures.

When analyzing the impact of soil conservation on net crop income in the study area, ATT estimates suggest that net crop income of plots with soil conservation is significantly higher than plots without conservation. For instance, ATT estimates from stratification and kernel matching methods shows that existence of a significant positive impact of soil conservation on net crop income of about ETB 164 and ETB 299 per hectare for conserved plots.

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