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Impact of Soil Conservation on Household Income in East Wollega, H/G/ Wollaga and West Shawa Zones of Oromia Region

Gemechisa Yadeta

Bako Agricultural Engineering Research Centre, Oromia Agricultural Research Institute, Addis Ababa, Ethiopia

Email address:
gemechisaya@gmail.com

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Abstract: Land degradation in many third world countries threatens the livelihood of millions of people and constrains the ability of countries to develop a healthy agricultural and natural resource base. This study was conducted to explore Impact of Soil Conservation on Household Income in East Wollega, H/G/ Wollaga and West Shawa Zones of Oromia Region. In this study, three-stage sampling procedure was used to select six districts, tuwelve kebeles and 252 specific sample farm households. Descriptive and econometric analyses were employed. This study has been designed with objective of to assess the impacts of the SWC on yields and farmers' income, to assess community perception towards the ongoing SWC interventions. and to identify constraints and opportunities on SWC practices in the study area. The analysis is based on the data collected from randomly selected 252 farm households in western Ethiopia. a propensity score matching method for impact analysis to avoid bias arising from possible self-selection. The descriptive analysis showed that, out of the 252 household heads, in the study area the average farm size of the respondents was fragmented into 3.36 parcel, each with average 2.26 hectares. In the sampled area, 13.3%, 57.8%, 14.8%, and 14.1% of the interviewed farmers has been built SWC structures on cultivated land by SLM programme, by campaign, with their family and through both (campaign and family) respectively. The results obtained through a propensity score matching method was 7931.3 Ethiopian Birr net on household income of farmers increase for adopters as compared to non-adopters.

Keywords: Soil Conservation, Propensity Score Matching, Physical Soil Conservation, Household Income

1. Introduction

Land degradation in many third world countries threatens the livelihood of millions of people and constrains the ability of countries to develop a healthy agricultural and natural resource base. The economic and social costs will be severe if nothing is done to correct the existing situation in many countries. Traditional agricultural practices have diminished soil productivity to the extent that many agricultural soils are depleted of nutrients and unable to naturally sustain crop productivity. In the coming decades, a crucial challenge for agriculture in SSA will be meeting food demands without undermining further the environment. Increasing productivity and economic returns to smallholder farming in a sustainable manner is a central challenge to achieving global poverty reduction and environmental management objectives [1].

Continuous cropping and inadequate replacement of nutrients removed in harvested materials, or on site burning of crop residues, and erosion have hastened soil degradation. Besides low soil fertility, drought, erratic rainfall, and climate change are frequently mentioned by farmers' as constraints to crop production [2]. Physical soil and water conservation structures are designed to intercept and reduce runoff velocity, pond and store runoff water, convey runoff at non erosive power, trap sediment and nutrients, promote formation of natural terraces over time, prevent flooding of neighboring lands, reduce sedimentation of waterways, streams, and rivers, and improve soil properties or land productivity [3].

Recently, studies using Propensity Score Matching to evaluate impacts of a variety of soil and water conservation investments to estimate the average treatment effect of value of production per household compared to non-adopters [4]. In Ethiopia, similarly, Holden, S. T. et al. used nearest neighbor and kernel matching to measure the impacts of stone terraces in Tigray region and found a significant and positive effect on land productivity [5].

In Ethiopia, significant SWC activities were implemented during the 1970 and 1980s by mobilizing farmers through their peasant associations, mainly in food for work programs [6]. This approach was criticized for its top down approach. In many parts of the country, the government has also been launched SWC through integrated and participatory watershed development approaches. Nearly in 2004/05 the ongoing 30 day national SWC-based watershed management campaign was started and is expected to continue [7]. Over the past years, a number of physical soil and water conservation practices were implemented with special attention as to increase production and productivity. However, the impact of the soil and water conservation technologies on household's income has not been seen and documented. Therefore, this study has been designed with objective of to assess the impacts of the SWC on yields and farmers' income, to assess community perception towards the ongoing SWC interventions. And to identify constraints and opportunities on SWC practices in the study area.

2. Methodology

2.1. Description of the Study Area

The study was conducted in West Shawa, East Wollaga and Horo Guduru Wollaga zone Oromia National Regional State, Ethiopia, at six districts situated in the area as follow.

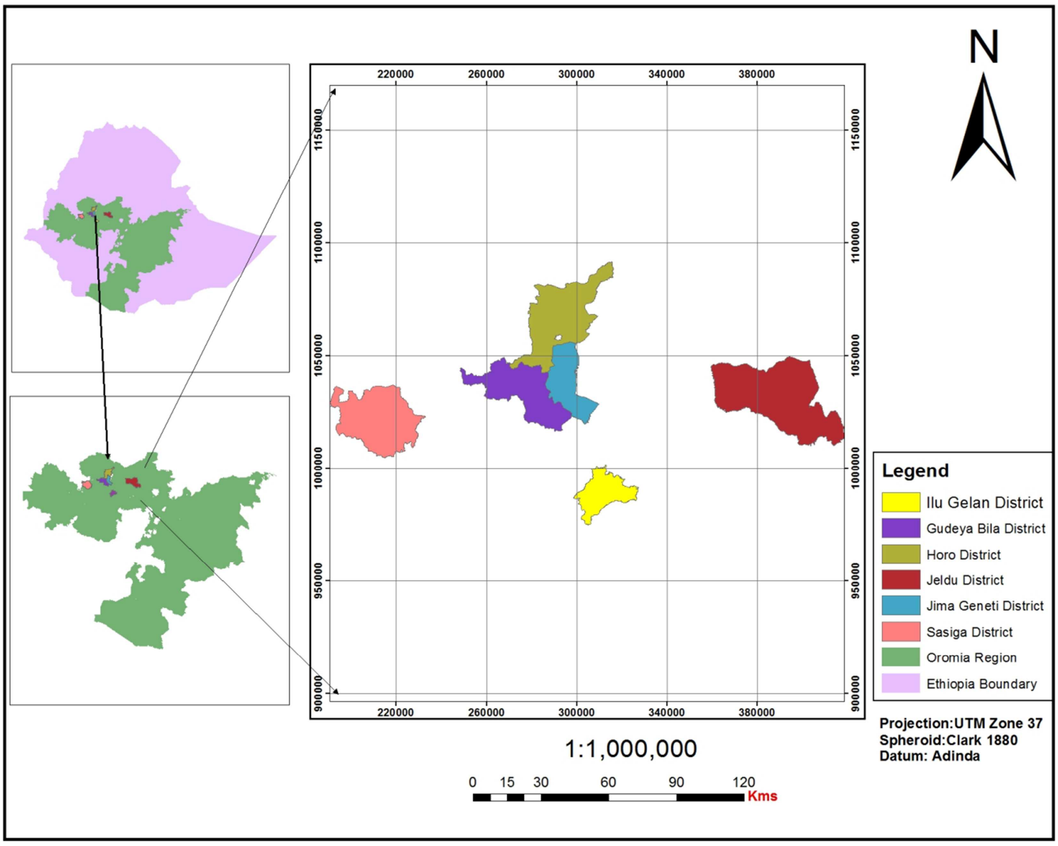

Figure 1. Map of Western Oromia zone, Sasga, Gudeya Bila, Horo, Jima Genet, Ilu Galan and Jaldu districts.

2.2. Methods of Data Collection

The data for study was collected from both primary and secondary sources. Cross-sectional data was collected from the survey of randomly selected sample farmers. For the primary data collection, specifically designed and pre- tested questionnaire based on the objective of the study. Primary data was collected from respondents by interview, focus group discussion and personal observation of structures in the study area. Sasiga and Gudeya Bila districts from East Wollaga, Horo and Jima Genet from H. G. Wollaga and Ilu Galan and Jaldu districts from West Showa zone were selected purposively due to its high potential with physical soil and water conservation structures in relation to other districts in the zone with collaboration zonal experts. Second, from the sampled districts, two PAs where soil erosion is severe and many conservation structures of land management have been undertaken were selected purposely. The farmers in each kebele were stratified into farmers with and without physical soil conservation structure on their farms giving the relative homogeneity of the sample respondents consequently. A total of 252 sample respondents were selected to provide information through simple random sampling techniques (147 respondents, these their farms have physical soil conservation structure and 105 without).

Table 1. The distribution of household's sample size from each kebele.

Zone	District	Kebele	Categories/structure		
			With out	with	Total
E. wollaga	Sasga	Gamane	10	13	23
		Sanbat Dure	18	13	31
	Gudeya Bila	Haro Gudisa	23	13	36
		Agalo Gidam	12	14	26
H. G. Woll	Jima Genet	Gamo Nagaro	2	9	11
		Caro Gobano	2	13	15
	Horo	Dilalo Baro	3	10	13
		Didibe Kistana	7	14	21
W/ Showa	Ilu Galan	Hobera Binenso	9	10	19
		Rafiso Kamno	6	12	18
	Jaldu	Tulu Gura	7	13	20
		Kolu Galan	6	14	20
	Total		105	147	252

2.3. Methods of Data Analysis

Both descriptive and econometric methods of data analysis were used. Descriptive analysis like frequency percentage, mean were used. Additionally, inferential statics t-test and ch2 test also used to compare socio-demographics of households with and without conservation structures.

2.4. Econometrics Method of Data Analysis

To answer the objective of assessing the impact of soil and water conservation practice on households' income PSM was used. If the technologies were randomly assigned to farmers, the average treatment effect (ATE) can be computed as follows:

$$ATE = E(Y1 \mid D = 1) - E(Y0 \mid D = 1)$$

However, technologies are rarely randomly assigned instead, technology adoption usually occurs through self-selection of farmers or, sometimes, through program placement. In the presence of self selection or program placement, the above procedure may result in a biased estimation of the impacts of improved technologies. Since the treated group (i.e. the adopters) are less likely to be statistically equivalent to the comparison group (i.e. the non-adopters) in a non-randomized setting. The propensity score matching (PSM) method, which was developed by Rosenbaum P. R has been extensively used in economics since 1990s to solve the above problem [8]. Rosenbaum P. R defined 'propensity score' as the conditional probability of receiving a treatment given pre-treatment characteristics [8]

$$P(X)= Pr\{D = 1|X\} = E\{D|X\}$$

where D = {0, 1} is the indicator of exposure to treatment and X is the multidimensional vector of pre-treatment characteristics. D=1 for treated observations and D=0 for control observations. The propensity scores are estimated using the logit models with dependent variable coded as 1 for his farm with physical conservation structures and 0 for otherwise. Matching was performed by pairing each participant in the program with one non-participant with similar observable characteristics captured in the propensity scores. The income differences between participants and non-participants was calculated.

Table 2. Definitions of variables in propensity score matching.

Variable name	Categories	Explanation
Dependent variable	Dummy	1 if structure done on his farm 0 otherwise
Outcome variable	continuous	Cereal crop yield per hectare per farmer
Independent variable		
Age of household head	Continuous	Age of household head
Education of household	Continuous	Education status of household head
Social position	Dummy	1 if house hold has any social position in kebele level 0 otherwise
Practiced Physical soil conservation before campaign	Dummy	1 if practice physical soil conservation by himself before campaign work launch 0 otherwise
Family numbers	Continuous	Number of household members
training	Dummy	1 if access to training of soil conservation practices 0 otherise
Family perception on erosion problem	Dummy	1 if his families members have real perception on soil erosion problem 0 otherwise
Degree of soil erosion problem on his farm	Dummy	If his farm plot seriously affected by soil erosion before structure 0 otherwise

3. Results and Discussion

Descriptive statistics of socio-economic characteristics of the sample households.

In this study descriptive statistics was used to explain the different socio-economic characteristics of the sample households. The proportion of male-headed households was 92%. The categories family members above 15 years engaged on agriculture with full time work were indicated (table 3).

Table 3. Distribution of sample household heads by sex, family members age group and labor availability.

Categories	Frequency	%
Respondents (% male)	233	92
Household participate in d/t social position (% yes)	146	58
Family members above 15 years engaged on agriculture with full time work		
Only one	12	5
Two person only	201	80
Three and above	39	15
Family face labor shortage in agricultural activity mostly (% yes)	138	54.6

According to the ILO the economically active population includes people aged 15 years and over [9]. The number of families engaged on agricultural activity with their full time above 15 years was to be reduced to only house hold head and its spouse. The proportion of household with only two person working agricultural activity with full time was 80% of sampled households. This may be a gap for labor intensive activity of construction/maintenance of physical soil conservation practices.

3.1. Farm Fragmentation of the Sample Households

Farm fragmentation has increasingly emerged as one of the key problems of subsistence farming of Ethiopia. According to a recent national survey data, the average farm size of Ethiopian farmers was fragmented into 2.3 plots, each with 0.35 hectares [10]. However, in the study area the average farm size of the respondents was fragmented into 3.36 parcel, each with average 2.26 hectares. More than one third of surveyed farms consisted of more than 3 plots (Table 4). According to Jesse B et al. Practices of soil erosion control are affected negatively by farm fragmentation [2].

Table 4. *Distribution of sample HH heads by farm land fragmentation and land holding.*

Numbers of parcel	Number of farmers	Percent
One parcel	34	14
Two parcel	54	22
Three	62	25
Four	48	20
Greater or equal to five parcel	45	19
Total	245	100
Average number of parcel (=3.36)		
Average total land (2.26 hectares)		

3.2. The Relationship of the Different Socio-economic Variables to Conservation Programme

The statistical significance of the variables was tested for both dummy and continuous variables using chi-square (x^2) and t-tests, respectively. The average age of the household head was 43 years. The average family size was 7.1 persons and the number of livestock owned in tropical livestock was 7.96 for with structures and 6.57 for without structures. There was a difference in livestock numbers between with and without structure. Livestock ownership is a proxy measure for asset ownership [11].

Table 5. *Farmers with and Without structures (summary statistics for continuous variables).*

Variable n=252	With structures	Without	Total	T-value
Age (years)	42.4 (14.07)	42.28 (12.82)	42.34 (13.55)	-0.07
Education (years)	5.21 (3.79)	4.62 (3.57)	4.97 (3.7)	-1.26
Family no.	7.27 (3.07)	6.85 (2.67)	7.09 (3.07)	-1.12
Total land (ha)	2.39 (1.65)	2.07 (1.89)	2.26 (1.76)	-1.42*
Livestock units (TLU)	7.95 (5.37)	6.57 (5.77)	7.37 (5.57)	-1.93*
Annual income from crop (birr)	23830	14521	19951	-2.73*

*indicates significant at 1%

3.3. The Relationship of the Different Dummy Variables to Conservation Programme

According to table 6 the samples were composed of both households headed with social position in the kebele. The proportion of households headed participated was 29% for with structure. The composition of households headed not participated in social position do not have structure were only 13%. Therefore, the percent of households headed with having more social position in the kebele were significantly higher than that of without social position.

Table 6. *Relationship of dummy variables with farmers with and without the structure.*

Variables	Category	Without structure		With		X^2 value
		Frequency	%	Frequency	%	
Social position	No	32	13	74	29	9.9*
	Yes	73	29	73	29	
Fertility decline of his land	No	12	5	13	5	1.11
	Yes	93	37	134	53	
Seriously affected of his land by erosion	No	64	33	23	12	11.9*
	Yes	41	21	68	34	
Off farm income	No	73	31	104	44	0.12
	Yes	24	10	38	15	
Training of soil conservation	No	37	15	53	22	0.01
	Yes	62	26	91	37	

3.4. Farmers' Perception of Soil Erosion Severity to Soil Conservation Practice

As given in Table 6, perception of soil erosion problem is an important factor for farmers to make decisions on conservation investments. There was statistically significant relationship between perception problem of severity of soil erosion (Seriously affected) and soil conservation structures. It showed that the increase in severity of the problem increases the likelihood of farm household's choice of structures.

3.5. Different Soil Conservation Structure in the Study Area

3.5.1. Biological Soil Conservation Activities

There are numerous biological soil conservation techniques used to control soil loss and run-off and increase soil fertility. Many farmers in the study area exercised different biological soil conservation activities (table 7). Crop Rotation- was the most important soil conservation mechanisms of the farmers of the study area as indigenous where maize, teff and nug grown rotationally. 89%, 0.8% and 3.8% of respondents use crop rotation, mixed cropping and inter cropping respectively.

Table 7. *Some biological conservation conducted in the study area.*

Variables	Category	Frequency	%
Crop rotation	No	51	22.1
	Yes	201	79.9
Mixed cropping	No	249	99.2
	Yes	3	0.8
Inter cropping	No	242	96.2
	Yes	10	3.8
Integrated biological with physical conservation	No	155	61.6
	Yes	97	38.4

3.5.2. Physical Soil Conservation Activities

In addition, in each district the most common soil conservation measures done were physical structure especially soil bund. In the sampled area, 13.3%, 57.8%, 14.8%, and 14.1% of the interviewed farmers has been built SWC structures on cultivated land by SLM programme, by campaign, with their family and through both (campaign and family) respectively (table 8).

Table 8. *Physical soil conservation structures done by.*

	Structure done by	Frequency of HH	Percent
1	SLM	20	13.3
2	Campaign	85	57.8
3	Family	22	14.8
4	Both (Campaign and family)	20	14.1
	Total	147	100

3.6. Damage of Physical Soil Conservation Structure

The risk of damage of structures was always happened due to an exceptional storm and un appropriate designing of the structures. Failure to pay attention to this point can lead to greater erosion than if the structures had not been installed in the first place. Where there are a series of structures on a hills slope there is a risk if a structure was broken near the top, then those downhill would also get damaged [12]. Moreover, during field observation, soil erosion and gully formation were observed on cultivated and grazing lands (Figure 2). Gully formation and expansion is one of the major problems in degraded watersheds that reduces the cultivable area and grazing lands [12]. According to Bancy M vegetative materials should have to be required for bund stabilization at least in every season [13].

Figure 2. *Gully formation from bund already constructed on cultivated lands in Diga and Horo districts (during the survey).*

In the study conducted by Tu A. et al. the long-term effectiveness of different soil and water conservation measures in reducing both overland runoff and sediment erosion and they concluded the rate of runoff loss and soil erosion decreased rapidly over time [14]. Other problem examined was most of the farmers in the study area damaging the structure which is going to stabilized itself for requiring fertile land under the embankment of soil bund which is the immediate output rather than considering intermediate and long term impact of structure. In addition, the farmer constructs local water way between the bund already going to stabilized which obtain long term stabilization of physical structures of conservation. So, immediate action must be taken soon as to each farmers will see long term advantage of structure done on his farm land.

Thirty to forty-five days per year have had already been allotted as soil conservation days by government development programs. According to FGD conducted in each districts, more commonly the program focuses on measuring and reporting the amount of bund constructed and how many people participate rather than on assessing whether programs have achieved their intended goals and there is no any monitoring and evaluation for its sustainability of the structures was the problem identified in this soil and water conservation programme in the study area. However, according to Rosalía R. et al. monitoring and evaluation (M&E) helps to evaluate the extent to which the programme/project is having or has had the desired impact [15]. Out of 147 respondents where physical soil conservation done on their farm land greater than by half

(53.7%) do not exercise any maintenance of the structures. Bund stabilizers (Integrated biological with physical) were planted on the structures only were done on 33.5% of respondent's farm land.

Table 9. *HHS practices on maintenance of SWC structures and plant biological conservation (%).*

	District	Farmers with structures n=147	Do you maintain structure (%yes)	Integrated biological with physical (%yes)
1	Horo	24	11.5	.03
2	Jima Genet	22	60.9	20.8
3	Ilu Galan	22	44.8	24
4	Jaldu	27	47	57
5	Sasga	26	58.8	59
6	Gudeya Bila	27	56.4	40.50
	Total	147	46.3	33.5

3.7. The Different Impact of the SWC Technologies on HH Productivity

Household perception on different advantage of physical SWC

The household with the conservation structure done on their farm (n=147) interviewed on different advantage of structure according to their perception. In increased crop yield, increase fodder production, increase season stream flow and decrease stream siltation problem and nearly 79%, 69%, 37% and 73% respectively replied as it has a good impact.

Table 10. *Respondent perception towards different advantage of conservation.*

Variable	Farmers with structures	Frequency of "Yes"	%	Frequency of "no "	%
Increase Crop yield	140	110	79	30	21
Increase fodder production	144	100	69	44	31
Increase season stream flow	134	50	37	84	63
Decrease stream siltation problem	111	81	73	30	27
Total			64		36

3.8. Estimating Results of Propensity Scores

Agriculture is accounting for 79 percent of income and crop production being the most frequent for 62 percent of small family farm in Ethiopia [1]. So the impact of the SWC technologies on household's crop yields were considered, especially the yield (qt/hectare) obtained from three main cereals crops (maize, teff and wheat) produced in 2011 years. The propensity scores are estimated using the logit models with dependent variable coded as 1 for his farm with physical conservation structures and 0 for otherwise. Matching was by considering yield of 2011 crop season obtained from his crop as outcome variable. According to [8] when data often do not come from randomized trials but from (nonrandomized) observational studies. propensity score matching as a method to reduce the bias in the estimation of treatment effects with control. Before estimate of propensity score whether the matching was effective in creating a good control group was checked as follow.

Table 11. *Propensity score matching of different variables.*

Variable	Mean			T test	
	Treated	Control	%bias	t	p>t
Age	42.759	41.367	10.3	0.85	0.394
Education	4.964	5.036	2.0	-0.16	0.871
Social position	.48921	.48921	0.0	0.00	1.000
Distance to DA	3.714	2.1381	40.6	3.99	0.000
Family number	7.3309	7.2446	3.0	0.26	0.797
Practiced SWC before	.50376	.37719	25.9	2.00	0.046

Ps R^2 =0.066 p>chi2= 0.001 Mean Bias =13.6.

Table 12. *ATE of income of household.*

Total output	Coef.	Std. Err.	Z	P>z	[95% Conf.	Interval]
ATE structure (with vs with out)	7931.3	3414.12	2.32	0.020	1239.8	14622.96

From the result indicated in the table above the average income of farmers with structure was estimated to be 7931.3 birr greater than farmers without structures.

3.9. PSM Estimation Results

Propensity Score Matching (PSM) analysis for the impact of soil conservation on crop yield was conducted by using logit model with using psmatch2 command. The logit regression of propensity score (Table 13) showed that the conditional probability of participation in physical conservation was affected by educational level of household head, access to any social position of household, numbers of family members, family perception on erosion problem affects the probability of participation in physical conservation structures.

Table 13. *Estimate for propensity score through logit model.*

Variable	Coef.	Std. Err	z	P>|z|
Social position	-1.457358	.3861413	3.77	0.000 ***
Education	.0936973	.0482242	1.94	0.052 ***
Family number	.0127414	.0592621	0.22	0.830
Practiced physical soil conservation before campaign	.5930617	.3539894	1.68	0.094 **
Training	-.0929447	.3839217	-0.24	0.809
Family perception on erosion problem	.4353114	.1629326	2.67	0.008***
Degree of soil erosion problem on his farm	.8443806	.6258176	1.35	0.177
_cons	-.3683867	.6737684	-0.55	0.585

4. Conclusion

The objective of this study was to evaluate the impact of soil conservation practice on household income in west Shawa, East Wollaga and H/G/Wollaga zones of Oromia region of Ethiopia. The empirical results showed that educational level of household head, access to social position of household in kebele, numbers of family members, family perception on erosion problem affects the probability of participation in physical conservation structures. Soil conservation in agricultural technologies play a key role in increasing agricultural productivity as well as increasing household income. A propensity score matching approach was used to compare adopter households with non-adopters of structures in terms of their income from crop production from one year of cross sectional data. The econometric results showed that conservation technologies had a positive impact on farmers' income levels.

In addition to increase in crop yield the house hold examine as conservation structure increase the fodder productivities. Hence, scaling up with the best practices of the adopters to other farmers can be considered as one option to enhance farmer's income.

5. Recommendation

The conservation programe have a positive impact on yield of crop. Therefore, the study recommends that agricultural extension continue the activity by considering the link of physical and biological conservation activities with maintenance every year. A good monitoring and evaluation until existing structures should be established to show sound practices.

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