

ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES

**IMPACT OF SOIL AND WATER
CONSERVATION ON CROP PRODUCTIVITY
IN THE HIGHLANDS OF ETHIOPIA**

By

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Table of Content

Chapter One

Introduction

1.1 Back Ground	1
1.2 Statement of the Problem.....	3
1.3 Objective of the Study.....	5
1.4 Significance of the Study.....	5
1.5 Scope and Limitation of the Study	6
1.6 Organization of the Paper.....	7

Chapter Two

Literature Review

2.1 Economics of Soil Degradation.....	8
2.2 Soil Conservation and agricultural productivity.....	15
2.3 SWC in Ethiopia.....	19
2. 4. Empirical Literature Review.....	20
2.5 Impact Evaluation Methodologies.....	23

Chapter Three

Methodology

3.1 Propensity Score Matching (PSM) Methods.....	28
3.2 Endogenous Switching Regression Models.....	31
3.3 Conditional Expectations and Treatment.....	36

Chapter Four

Data Analysis and Presentation

4.1 Definition and Summary of Regression Variables	38
4.1 .2 SWC and Plot Characteristics.....	44
4.2 Econometric Results.....	45
4.2.1 Propensity Score Matching (PSM) Methods.....	45
4.2.2 Endogenous Switching Regression.....	47

Chapter Five

Conclusion and Policy Implication

5.1 Conclusion.....	52
5.2 Policy Implications.....	53
6. Bibliography.....	54
7. Annex.....	66

Acronyms and Abbreviations

ATT: Average Treatment On Treated

CSA: Central Statically Agency

EEPFE: Environmental Economics Policy Forum for Ethiopia

EfD : Environment for Development

EPA: Environment Protection Authority

FIML: Full Information Maximum Likelihood

GDP: Gross Domestic Product

ISWC: Indigenous Soil and Water Conservation

MoFED: Ministry of Finance and Economic Development

NNM: Nearest Neighbor matching

PASDEP: Plan for Accelerated and Sustained Development to End

Poverty

PSM: Propensity Score Matching

RM: Radius Matching

SWC: Soil and Water Conservation

List of Tables

Table 4.1 Descriptive Statics.....	38
Table 4.2 cross tabulation of SWC and plot characteristics.....	44
Table 4.3 PSM ATT Effect of NNM and RM.....	46
Table 4.4 Estimates of Endogenous switching Regression Model.....	48
Table 4.5 Expected Value of Crop Productivity under Actual and Counterfactual Conditions.....	50

List of Annex

Annex 1: Propensity Score Matching (PSM) Result.....	66
Annex2: ATT for NNM.....	67
Annex3: ATT for RM.....	67
Annex4: Endogenous Switching Regression Estimates.....	68
Annex5: Endogenous Regression Test for TT.....	70
Annex6: Endogenous Regression Test for TU.....	70

Abstract

Soil degradation continues to be major threat of Ethiopian economy, since it is extremely dependent on agricultural sector, even though a number of soil and water conservation (SWC) methods were introduced and practiced. The major goal of this research was finding out the real impact of SWC on crop productivity in the highlands of Ethiopia. The study was undertaken by using a survey data collected by Environmental Economics Policy Forum for Ethiopia (EEPFE) in 2007 from two zones, East Gojam and South Wollo in Amhara Region. A total of 1760 households who has 5871plots were interviewed.

In this research a non parametric estimation method, propensity score matching (PSM), and a parametric estimation method, endogenous switching regression methods were used. Based on the empirical works done it was not impossible to the study to conclude the average value of crop production from plots which adopt SWC is less than that of the plots which did not use the technology

Key words: Ethiopia, soil and water conservation, propensity score matching, endogenous switching regression.

Chapter One

Introduction

1.1 Back Ground

Agriculture is the mainstay of Ethiopia's economy, since more than 80% of the country's 80 million labor forces are farmers, 90% of the exports are agricultural commodities and about half of the GDP is generated from this sector (Teshome, 2010). Owing to this fact economic development of the country is extremely dependent the performance of the agricultural sector.

However, the sector is among the most vulnerable in sub-Saharan Africa, which has suffered from recurrent droughts and extreme fluctuations of output. For instance the sector's production has been growing by about 2.3% during 1980-2000 while population was growing on average at a rate of 2.9% per year, which lead to a decline in per capita agricultural production by about 0.6% per year (Mulat, et al 2004).

According to Teshome (2010), the low productivity of the sector is a function of backward implements and methods of production, low use of modern inputs, environmental degradation and poor resource management.

Environmental degradation has significant socioeconomic and environmental consequence for society (Nyanena, undated). Such consequences might have higher impact on economies like Ethiopia because agriculture, the mainstay of the economy, by its very nature is highly dependent on natural resources. And *“Soil erosion is greatest on arable land where the average annual loss is estimated to be 42 t/ha, but may even reach 300 t/ha/year in some fields. This is six times the rate of soil formation and it probably causes an average annual reduction in soil depth of 4mm.”* Alemu (undated)

Therefore, for economies like Ethiopia by continuing experiencing the worst land degradation in the world (1900 million tons of soil per year) (Alemu, undated) and high population growth it could be impossible to achieve food sufficiency and sustainable economic growth. Therefore, it is mandatory to adopt farm technologies to mitigate negative effects of soil erosion and nutrient depletion. Since adoption of farm technology can increase agricultural production (Nyanena, undated) and overcome problem of soil erosion. Among these technologies soil and water conservation (SWC) is one which is implemented since the mid 1970s in Ethiopia (Alemu, undated). Typical SWC technologies used in Ethiopia include soil bunds, stone bunds, grass strips, waterways, trees planted at the edge of farm fields, (Kato, et al 2009)

Even though SWC technology is implemented in Ethiopia from 1970s till now (Alemu, undated), evidences show poor performance of the agricultural sector. The sector is growing by only 6% whereas the overall growth is reported to be 10.9% (MoFED, 2010). If it is so any policy measure which is intended for better growth of the agricultural sector productivity should be measured. Among these plans SWC is one therefore, the relationship between SWC and productivity of the sector should be carefully studied and measures should be taken accordingly.

1.2 Statement of the Problem

From a total of 1130 million kilo meter square area of Ethiopia 45% is highland, above 1500 meter sea level which supports 85% of the total population, 98% of regularly cultivated land and 75% of the livestock of the nation (EPA, 2003). But the highlands of the nation are highly degraded out of 54 million hectares of land constituting the highlands 19 million hectares are seriously degraded, 13 million hectares are moderately degraded while 2 million hectares of the land's soil depth is so reduced that cannot able to support cultivation Belay (1996). However, to curb this land degradation problem every year over 30 million farmers' working days are mobilized for SWC activities (Alemu undated). Therefore it is meaning full to try to assess the impact of SWC

adoption on the productivity of agriculture. This is why the research concentrates in the highlands.

On top of that a number of empirical studies had been conducted on the impact of SWC on crop productivity. For instance, Menal and Holden in 2005 tried to see the impact of SWC in the northern Ethiopia highlands while Kato et al in 2009 studied the issue in the Nile basin within Ethiopia. Dawit in 2007 also tried to see the same thing in Southern Nations and Nationalities Peoples Region, Wolyiat Zone of Damote Gale Woreda. Rebeka, in 2006 studied the determinants of households' adoption of rainwater harvesting ponds, and its impact on agricultural intensification and yield in Alaba Woreda, southern Ethiopia.

But all of the aforementioned studies used a village for their case study. Using a village as a sample of study there might not be helpful to reach on conclusion on the impact of SWC on crop productivity. Since representativeness of a village to the whole economy is very doubtful. Consequently in this study the researcher investigated the impact of SWC investment on farm productivity in the highlands of Ethiopia using plot level data from East Gojam and North Wollo zones in the Amhara region.

The sample size is also another problem of the abovementioned researches. Almost all the studies used a very small sample size. The researcher in this study therefore used data which has significant level of sample size, 5871 plots.

To this end the researcher tried to answer the question what would be the impact of adopting SWC technology on crop productivity in the highlands of Ethiopia using propensity score matching and endogenous switching regression methods.

1.3 Objective of the Study

The general objective of the study is trying to assess the impact of SWC investment on agricultural productivity households' using quantitative approach. The specific objectives of the study are:

- To identify the impact of SWC decision on crop yield
- To derive policy implications to improve the performance of soil and water conservation practices

1.4 Significance of the Study

Being an empirical study this study will contribute to the empirical literature of SWC in Ethiopia. It will also assist decision makers to identify problems encountered and to take possible corrective measures.

In addition to this, understanding the impact of the SWC is a crucial issue for designing and implementing appropriate agricultural development policies and strategies, as well as technology interventions. Therefore, the outcome of this study may serve as a source of additional information which may be of significant use to policy makers and planners during the designing and implementation of SWC technology strategies.

1.5 Scope and Limitation of the Study

The research used Environmental Economics Policy Forum for Ethiopia's (EEPFE) household survey data which is collected from East Gojam and South Wollo zones of the Amhara region of Ethiopia in 2007. The survey focused on these two zones was because these were the zones selected by the government of the Amhara region as pilot zones for the Swedish Amhara Region Rural Development Program. In the survey 1760 households sample size was interviewed.

The survey data was collected for different aspects and characteristics of rural households. It is not particularly designed to collect data to evaluate SWC on different economic outcomes. As a result the data set does not have deep information related to SWC and there might be missed variables. Owing to lack of panel data set on the study matter

cross section data is used even though panel data set is more power full on impact assessment.

1.6 Organization of the Paper

The research paper is organized in five chapters. The first chapter is introduction. Related theoretical and empirical literatures discussed in chapter two and chapter three concentrated on model specification and methodological aspects. The fourth chapter of the study presents data analysis and presentation of the main findings of the study. The last chapter discusses conclusion and policy implication of the study based on the major findings of the study.

Chapter Two

Literature Review

2.1 Economics of Soil Degradation

Clark defined “*soil erosion as a process that occurs on land under agricultural production or natural vegetation. It involves the movement of soil particles on the soil surface as a result of the actions of rain, wind or disturbance of the soil surface. The soil particles, or sediment, may be deposited elsewhere on the land or enter the water system*”.

Since less developed countries economy is highly dependent on agriculture, for instance, agriculture accounts for more than 30% of Africa’s gross domestic product (GDP) and 75% of total employment (Menal, et al, 2010) there is great concern about land degradation¹ resulting from soil erosion and its impacts on agricultural production.

Land degradation in poor countries like Ethiopia is usually emerged form over grazing and over cultivation of the land. This over grazing and over cultivation in turn generated from low productivity of the land itself. Because degraded lands cannot offer better production owing to the movement of fertile top soil part of the land then it is followed by higher

¹ Land degradation and soil erosion are different concepts but a number of literatures used the terms interchangeably. Therefore, in this study the researcher applied the same fashion.

efforts to overcome the already insufficient productivity and it leads to land degradation. In short low productivity leads to land degradation and land degradation in turn is one cause of less productivity of the land, it simply become is a vicious circle.

But soil erosion becomes a challenging economic problem due to the mismatch between public and private interests. It is because land degradation occurs as a result of land use decisions (Barrett 1989) each farming household always erode soil for his/her own production purpose at an optimal rate, and if these optimal private rates of soil erosion were consistent with what all of society would wish erosion rates to be there would not be problem (Barbier, 1995). And the problem of setting optimal rate of erosion would be solved by equating marginal benefits and costs of individual farmer's land use decision. In other word it means that each farmer would determine automatically its own private rate of soil erosion and this rate would in turn automatically reflect the socially optimal rate of erosion.

However, it is unlikely that private rates of soil erosion suits to social rates. There are several reasons for this. First, farmers are concerned only with the onsite costs² and benefits of soil erosion, whereas society

² The on-site effects of erosion can be valued in terms of the impacts on soil properties, using the replacement cost, or the impacts on crop production (Rebecca Clark).

must also be concerned with any offsite or external costs³. Externalities are defined as costs or benefits arising in a process of production⁴ which are not reflected in market prices. It is not reflected in market prices just because the existence of externalities is intimately related to the definition of property rights. Firms' outputs, in this case agricultural outputs, therefore, do not reflect these offsite costs and benefits in their prices. However, offsite costs are very crucial part of farmers' decision making in their overall activities (Barbier, 1995, 1997).

Given that all of the other institutional conditions for pure market system to realize an efficient allocation to hold, if there is a positive externality (off-site benefit) the market will produce too little in relation to the requirements of allocative efficiency, while in the case of a harmful externality (off-site cost) the market will produce more of it than efficiency requires (Mas-Colell, et al, 1995). For that matter to remain at efficient allocation one way of an efficient response to externalities may be to 'internalize' the off-site costs of land degradation through fiscal measures, for example putting taxes on agricultural inputs or outputs, or through the development of legal mechanisms for the compensation of environmental externalities.

³ The off-site effects of soil erosion are numerous but its Valuation is generally limited to the effects of reservoir sedimentation on hydro-electricity generation and water supplies for irrigation (ibid).

⁴ Theory of externalities is also consistent with consumers but here the researcher referred it for the sake of succinctly

To internalize externalities well-defined and enforced property rights, competitive markets and strong institutions are necessary condition, but the typical of many less developed countries much property remains under poorly defined ownership, limited market and weak institution (Bojö, 1991, Barbier, 1997, Ade'gbidi, in 2004 Tekie undated, and many others). As a result, in regions where off-site costs are significant they would suggest that private rates of soil erosion diverge from social rates. Therefore, externalities would have significant influence on individuals' decisions of erosion or conservation of their respective farm land.

A number of economic literatures for example Barbier, 1995, 1997, Kazianga, 2001, Kabubo-Mariara, Jane et al 2006, Samuel, 2006 Genanew and Alemu, 2010 Berhanu et al undated, and others argue that imperfect land and capital market may also play a significant role in affecting the farmers' decision to control soil erosion. According to Barbier, 1997 the most reliable indicator that a farming household will have of the effects of soil erosion on future land productivity is through land prices. However, for instance Teshome, 2010 and Berhanu et al undated, in many developing countries, show that rural land markets are imperfect or distorted. Consequently, the costs of soil erosion, in terms of foregone future crop productivity and income, may not be reflected adequately or even bear any relation to the price of land in local markets.

Similarly, Boyd, et al 2000, Boetekees, 2002, Genanew and Alemu, 2010 Berhanu et al undated, also argue that lack of effective rural credit markets may distort the farming household's decision. Owing to whether it is worthwhile investing in protecting the soil because of its future productivity and income potential as opposed to exploiting it for immediate gain today. In other words, the opportunity cost of conserving the soil may be extremely high (Fridrich, et al, undated).

It is also commonly assumed that private individuals have a quite high rate of discount⁵ that is the value attached to future as opposed to present income will be higher than the social rate of discount when considering investment options. This may render long-term investments, such as tree planting and mechanical conservation, financially unattractive to a farmer (Bojö, 1991). A farmer's discount rate may be affected by both pure time preference, reflecting the farmer's attitude to risk and uncertainty as well as the level of household poverty, and the marginal opportunity cost of capital which represents the scarcity value of savings and returns to alternative investments (Barbier, 2000).

It is obvious from economic theories that private individuals are assumed to have a high degree of time preference, and thus employ higher

⁵ For Detail Analysis One can see Ben J. Heijdra And Frederick Van Der Ploeg, Foundations of Modern Macro Economics, 2002

discount rates, on average, than society as a whole the rationale is that society can more effectively minimize risk by diversifying its investments; and of course society lives forever while individuals do not. This divergence between public and private rates of time preference leads individuals to discount future benefits excessively and thus to consume assets that society as a whole would have them conserve (Heijdra and Van der Ploeg, 2002).⁶

There is also a strong perception that poverty is both a consequence as well as a cause of resource degradation, for instance Duraiappah (1998) argue that “*the poor have traditionally taken the brunt of the blame for causing society’s many problems*” even though the lack of rigorous evidence and calling for a greater understanding of the interaction of the two processes is there (Nelson et al, (1997) cited in Malik, Sohail Jehangir 1998). The poor generally have access only to areas that have higher risk for health and income generation (Barbier, 1995, 1997, Malik, Sohail Jehangir 1998, and others). And they generally lack the resources to reduce the exposure to the risk or to invest in alleviating the causes of such risk. The relationships are not mutually exclusive and can be present simultaneously.

⁶ Derek Eaton 1996 Stefano Pagiola 1998 Edward 1995, 1997, 2000 Perman, 2003 also argued in the same fashion

Environmental degradation therefore can affect the health and nutrition status of the poor and lower their productivity. This can happen both directly through, for example, lower yields per unit of labor or land because of reduced soil quality, and indirectly through the reduced physical capacity of labor to produce because of malnutrition and poor health (Duraiappah (1998).

Boyd, et al (2000) also argued a positive influence of farm size and number of plots owned by farmers on the decision of adoption of SWC practices even though the exact pattern of causality between is not clear for both factors.

And farmer's decision to control soil erosion is also clearly influenced by the future returns to a farming system, which in turn is affected by technological improvements (Boyd, et al 2000, Sims, et al, 2001). Since technical innovation is largely devoted to devising substitutes for, or increasing the productivity of scarce factors (Barbier, 1995, 1997).

Finally, other market policy and institutional failures such as insecure tenure (Tekie, (undated) or ownership of the land (Teshome, 2010), distorted market prices for inputs and outputs (Pagiola, 1998), imperfect competition, incomplete markets, can all affect the farmer's perception of the costs and benefits of controlling soil erosion.

By altering soil properties, erosion has direct effects on crop production. *“Erosion can decrease rooting depth, soil fertility, organic matter in the soil and plant-available water reserves. Thus, the exposed soil remaining will be less productive in a physical sense. These effects may be cumulative and not observed for a long period of time”* (Eaton 1996). In connection with this FAO reports that unless conservation is introduced, 544 million hectares of rain fed cropland, that is more than one fifth of the total, could be lost by the end of the century (Bojö, 1991). Therefore, concerns about the effects of soil erosion have to be made and due attention should be paid for it.

2.2 Soil Conservation and Agricultural Productivity

Production is the process of transforming inputs to outputs. Typically, inputs consist of labor, capital equipment, raw materials, and intermediate goods purchased from other firms. Outputs consist of finished products or service, or intermediate goods to be sold to other firms. Hence, by defining the inputs and outputs with regard to when and where they are available, one can capture some aspects of the temporal or spatial nature of production.

Agricultural firms by their very nature are dependent on natural resources. Environmental problems therefore, have significant impact on

the productivity of farmers. Among different environmental problems land degradation (soil erosion) is a major threat for agriculture. For that matter from the farmer's perspective, there are essentially two components to the costs of land degradation (soil erosion):

Direct costs: - the costs to the farmer of the effort, i.e. labor, materials, equipment, physical structures, etc. that are required to undertake soil conservation measures

Foregone output: - any loss of current output that results from using less soil today or less land.

According to Nyangena 2008 yields decline partly because essential organic matter and plant nutrients are lost and Bhattacharyya et al, 2007 argue that the soil properties in terms of their influence on crop performance vary, loss of topsoil will affect different degrees of loss of crop yield.

Even though increased utilization of chemical fertilizers can compensate agricultural yield lost due to erosion, to a certain degree, this option is not available for many poor farmers. Since most farmers do not have the economic capacity to use fertilizers. And also, fertilizers, *“if not properly used, may aggravate negative environmental externalities such as pollution of surface and ground water”*, (Nyangena, 2008).

Therefore, the impacts of land degradation and the depletion of soil resources have profound economic implications for low income countries because degradation of land resources endangers prospects for economic growth and future human welfare. Environmental damage also results in loss of current income and increased risk, and particularly affects the poor (Barbier, 1995).

Hence, it is a need to conserve land resources. *“From an economic perspective, soil conservation implies saving soil for future use. Alternatively, a farmer may choose to work the soil harder today, at the expense of more erosion and less soil available for the future since soil in agriculture is usually treated as a potentially depletable resource, since the rate at which topsoil is degraded or eroded through cultivation is generally faster than the rate at which it regenerates”* (Barbier, 1995).

Thus, it is generally assumed that most farming practices will result in rates of erosion that will exceed the natural rate of soil erosion that would occur if no cultivation took place.

And in other way round, even though soil is essentially a semi-renewable resource, its erosion is also the major reason for soil loss and consequent decline in soil productivity. As a result, soil erosion has conventionally been perceived as the chief biophysical cause of declining productivity

(Ellis-Jones and Tengberg, 1999, Nyssen, et al, 2007 Bhattacharyya et al, 2007).

Therefore it is mandatory to conserve land resources. In comparison, the benefit that a farmer receives from soil conservation derives from soil being a potential income-yielding asset. The 'stock' of soil available to a farmer is essentially an economic asset that can be exploited through cultivation to yield a stream of present and future income (Barbier 2000).

Thus to the farmer, benefits of soil conservation are essentially the perceived gains in having more rather than less soil available currently and in the future. There are likely to be two types of such conservation: The gains in current and future production and thus income accruing to the farmer from having more soil available today and in the future and any additional future bequest or resale value that accrues to the farmer from having more soil and thus more potential land productivity at the time of the future bequest or sale (Ibid).

2.3 SWC in Ethiopia

Since soil degradation is a major threat for agricultural yield it is also threat economic growth of developing countries like Ethiopia (it is because the economy of LDCs is highly dependent on agriculture According to Ministry of Finance and Economic Development (MoFED) of

Ethiopia 2006, some 65–85 percent of incomes in rural Ethiopia, and particularly the highlands (which are home to over 85 percent of the 75 million Ethiopians), come from crop agriculture. Furthermore, incomes and consumption levels of these primarily subsistence farmers are extremely low. For example, MoFED (2002) cited Menale, 2008 found that in 1999–2000 the average rural adult income was only about US\$ 95.00 per year and consumption was \$136.28 per year, with about 42 percent of adults unable to obtain 2200 calories per day on average).

Therefore, there must be a way to curb the negative influence of land degradation. One way of controlling the adverse effect of soil degradation is adopting the appropriate technology which prevents soil erosion. That is SWC technology.

SWC, therefore, technology is one which is implemented since the mid 1970s in Ethiopia (Alemu, undated). Typical SWC technologies used in Ethiopia include soil bunds, stone bunds, grass strips, waterways, trees planted at the edge of farm fields, contours, and irrigation (chiefly water harvesting) (Kato, et al 2009).

2. 4. Empirical Literature Review

The economics literature investigating the impact of soil and water conservation on agricultural productivity shows mixed results. For

instance, Ade'gbidi, in 2004 examined the productivity of indigenous soil and water conservation (ISWC) investments in the Boukombe' region in Northwest Benin, using a survey among 101 farmers on farm inputs, outputs, and SWC investments.

They used a production function approach to relate SWC to farm output, and. They found that there are large productivity effects from indigenous SWC investments, a positive interaction between plot size and SWC on productivity, and SWC tends to be most productive on plots with flat or light slopes but less effective on steep plots.

Kaliba, and Rabele (2000), also assessed the impact of adopting soil conservation practices on wheat yield in Lesotho. They used input output data collected from 50 smallholder farmers in Mafeteng and Maseru districts, the major wheat growing areas in the country. Tobit model and a modified Cobb-Douglas production function were used to model adoption, and impact of, soil conservation measures respectively.

They found that soil conservation efforts were superior to inorganic fertilizer application in terms of increasing wheat yield. Increase in soil conservation efforts, coupled with low inorganic fertilizer use had a potential of increasing wheat production among smallholder farmers in the area.

In addition to this, Nyangena et al, 2008 using a plot level data came from a sample of Kenyan households in the Kiambu, Meru, and Machakos districts tried to see the impact of SWC on yield and factor returns. In their study, they attempted to estimate a yield function called translog production function. And the results showed plots without SWC generally have higher yield values per hectare.

Kato, et al 2009 using a household- and plot-level data set, they applied the Just and Pope framework using a Cobb-Douglas production function to investigate the impact different SWC technologies on average crop yields and found that SWC investments perform differently in different rainfall areas and regions of Ethiopia, which underscores the importance of careful geographical targeting when promoting and scaling up soil and water conservation technologies. They found that although soil bunds, stone bunds, grass strips, waterways, and contours all have very significant positive impacts on average crop yields in low-rainfall areas, only soil bunds have significant risk-reducing effects in these areas with low agricultural potential.

They also found that irrigation and use of improved seeds have insignificant risk-reducing effects in low-rainfall areas, suggesting that—as currently implemented—these interventions may not be appropriate adaptation strategies for these environments. Regionally, in the low

rainfall areas they found significant spatial heterogeneity, with soil bunds being risk reducing in Oromiya and Amhara, and stone bunds, grass strips, and waterways being risk reducing in the Southern Nations, Nationalities, and Peoples Region. Irrigation was only risk reducing in the high-rainfall areas of Benishangul-Gumuz.

Haileselassie and Köhlin in 2009 adopted the stochastic metafrontier approach to investigate the role of soil conservation in small-scale highland agriculture in Ethiopia. And plots with soil conservation were found to be more technically efficient than plots without. The metafrontier estimates showed that soil conservation enhances the technological position of naturally disadvantaged plots.

However, Menale et al, 2010 measured the impact of fanya juu ⁷ bunds on the value of crop production in a high-rainfall area in the Ethiopian highlands using cross sectional multiple plot observations.

They applied switching regression, stochastic dominance analysis (SDA), and decomposition and propensity score matching methods. They found that the value of crop production for plots with bunds was lower than for plots without bunds.

⁷ An Important Soil And Water Conservation Technology And The Most Popular Type Of Contour Bund In East Africa

Therefore, by watching the above researches one cannot simply generalize the impact of SWC on agricultural productivity. There are mixed results, it is due to different researchers used different methodologies. In addition to this different economic geographical location has also significant impact on the results. For instance Menale et al tried to see the North Western highlands of Ethiopia while Nyangena studied the Kenyan case it is obvious that the norms of Ethiopia and Kenya are different. The sample size is also another problem of the researches. Almost all the aforementioned studies used a very small sample size. The researcher in this study therefore used data which has significant level of sample size, 5871 plots.

2.5 Impact Evaluation Methodologies

Impact evaluation “*studies whether the changes in outcome of targets are indeed due to the program intervention and not to other factors*” Khandker et al, 2009. In general, impact evaluations can be classified into two approaches: quantitative approach and qualitative approach.

“*Qualitative analysis does not use a counterfactual analysis but relies on understanding processes observing behaviors, and condition changes*” (Asian Development Bank, 2006). And it seeks to gauge potential impacts that the program (adoption of SWC technology) may

generate the mechanisms of such impacts, and the extent of benefits (productivity) to recipients by interviewing beneficiaries to get personal opinions, conducting focus group discussions, analyzing supportive secondary data depth and group-based interviews, etc. (Asian Development Bank, 2006 Khandker et al, 2009,)

While *“quantitative impact evaluation is the use of an explicit counterfactual analysis. More specifically, quantitative impact evaluation isolates the welfare effect of a specific program by comparing the actual observed outcomes of project participants with counterfactual outcomes.”* (Asian Development Bank, 2006)

Quantitative methods can also be classified into two different approaches ex ante and ex post approaches. The ex ante design determines the possible benefits of an intervention through simulation or economic models. While Ex post evaluations measure actual impacts accrued by the beneficiaries because of the program based on actual data gathered either after program intervention or before and after program implementation. (Khandker et al, 2009).

In applying quantitative approaches there are a number of econometric challenges to be addressed. The first challenge is finding

the counterfactual, i.e. the hypothetical outcomes that would have prevailed in the absence of the program (Asian Development Bank, 2006, Khandker et al, 2009 Menale, 2010, many others). That is, one has to determine the plots productivity of adopter's in the absence of the SWC technology.

And the other problem is selection bias and comes from endogenous program placement. Program assignment is not often random because of the purposive placement and individual's self-selection into the program (Asian Development Bank, 2006, Khandker et al, 2009). That is, SWC technologies are placed according to the need of the communities and individuals, who in turn self-select given technologies design and placement (Menale, 2010). Self-selection could be based on observed characteristics for instance if a specific plot is relatively steeply it would be highly exposed to erosion and there might be a need of SWC conservation or unobserved factors, for example knowhow of advantages of adopting SWC, or both.

In connection with this Ade'gbidi, 2004 suggested two techniques which are commonly used to study the impact of soil conservation practices on crop productivity. The first approach is the crop modeling system, which uses several ecosystem factors to evaluate the

dynamics of crops and soils processes that include soil conservation measures. The technique requires a lot of data and experience in system modeling (Cox, Hammer and Robertson, 2001 cited in Ade'gbidi, 2004).

The second approach uses abstract models such as a production function based on relatively few variables to relate production to soil conservation activities (Kazianga and Masters, 2001 cited in Ade'gbidi 2004). The second technique concentrates on modeling the response of crop growth relative to several exogenous variables that ensure the survival and growth of the crop.

But some researchers argue that using direct estimation of production functions is likely to give biased estimates because input use may be endogenous to production decisions (Berndt 1991 cited in Nyngene, 2008). As an alternative, they advice estimation of the dual form of the production, i.e., a cost or profit function, however, using the dual is difficult in the absence of good estimates of factor prices for labor and land. Therefore, even though there are arguments against in using the yield function in empirical studies of agricultural productivity in this research primal production functions are used to investigate the impact of soil conservation on agricultural productivity.

Chapter Three

Methodology

In impact evaluation process the main challenging process is assuring the certainty of the change on the outcome is only from the intervention of program not from other factor. In principle, to be certain on the change of outcomes, one would like to compare the situation of the same targets with and without an intervention or treatment of the program using experimental data.

But it is unlikely to access such data sets in economics studies because at a given point in time a household or an individual cannot be in both groups at the same time (i.e. on the treated and the control groups) (Asian Development Bank, 2006 Khandker et al. 2010). Therefore, utilization of counterfactuals, what those outcomes would have been in the absence of the intervention, analysis is used for assertion of the above problem. In this research since the data available is not experimental type to make certain the change on the value of crop productivity is only from adoption of SWC statistical

methods⁸ of impact analysis is used. Both non parametric (propensity score matching (PSM) method) and parametric methods (endogenous switching regression method) of analysis are implemented to study the impact of SWC on crop productivity.

3.1 Propensity Score Matching (PSM) Methods

The basic idea of the propensity score matching method (PSM) is to match program participants (SWC adopters) with nonparticipants (SWC non adopters). But matching in terms of covariates, the exogenous variables, is very difficult since it is very difficult to find plots which are exactly the same but different only on receiving of SWC adoption (Menal et al, 2008, Khandker, et al. 2010). To solve this problem the matching process is done in the probability of participating in the program on the basis of observable characteristics (Asian Development Bank, 2006, Menal et al, 2008, Asefaw, et al 2010 Khandker, et al. 2010). It means PSM constructs a statistical comparison group of adopters and non adopters of SWC based on the propensity score of adoption of SWC.

⁸ Sometimes it is called non experimental method

Let I_{hp} denotes a dummy variable such that $I_{hp} = 1$ if the h^{th} household adopt SWC technology on plot p and $I_{hp} = 0$, otherwise. And let Y_{hp1} and Y_{hp0} denote potential observed value of crop productivity for adopter and non-adopter units respectively. Then $\Delta = Y_{hp1} - Y_{hp0}$ is the impact of the technology on the h^{th} individual on plot p , usually called treatment effect.

As the researcher observes $Y_{hp} = I_{hp}Y_{hp1} + (1 - I_{hp})Y_{hp0}$ rather than Y_{hp1} and Y_{hp0} for the same individual, the primary treatment effect of interest that can be estimated is therefore the average impact of treatment on the treated (ATT) given by

$$\tau = E(Y_{hp1} - (Y_{hp0}/I_{hp} = 1)) \quad 3.1$$

Following Rosenbaum & Rubin (1983) cited in Asfaw et al 2010, Khandker, et al. 2010, the propensity score can be estimated as

$$P(X_{hp}) = P(I_{hp} = 1/X_{hp}) \quad 3.2$$

Given the assumptions that $Y_{hp1}Y_{hp0} I_{hp}/X_{hp}$ i.e., the potential outcomes are independent of technology adoption given this imply $E(Y_{hp0}/I_{hp} = 1, P(X)) = E(Y_{hp1}/I_{hp} = 0, P(X))$ and $0 < P(X) < 1$ i.e., the potential outcomes are independent of technology adoption given X , i.e., for all X there is a positive probability of either adopting ($I_{hp} = 1$) or not

adopting ($I_{hp} = 0$), this guarantees every adopter a counterpart in the non-adopter population, The ATT can then be estimated as

$$\begin{aligned}
 \tau &= E(Y_{hp1} - (Y_{hp0}/ I_{hp} = 1)) \\
 &= E(E(Y_{hp1} - (Y_{hp0}/ I_{hp} = 0, P(X))) \\
 &= E(E(Y_{hp1}/ I_{hp} = 1, P(X)) - E(Y_{hp0}/ I_{hp} = 0, P(X))) \qquad 3.3
 \end{aligned}$$

The propensity score is a continuous variable and there is no way to get adopter 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 (3.3) (Asefaw, et al 2010). There is a need to search for counterfactual(s) that matches with each adopter depending on its propensity score. Different matching methods⁹ are used in the literature. The research used the nearest-neighbor matching (NNM) method which is one of the most frequently used matching techniques, where each treatment unit is matched to the comparison unit with the closest propensity score. And to check the robustness of the result of NNM, the impact estimate calculated using the NNM method is compared to the estimates of radius matching (RM) method as suggested by Khandker, et al. 2010.

⁹ For detail explanations refer Khandker et al, 2010

3.2 Endogenous Switching Regression Models

PSM estimation might suffer from selection bias and which comes from endogenous program placement. Since literatures show that adoption of SWC technology depends not only on the costs and benefits of each technology (observed factors) but also depends on unobserved factors. Therefore, the researcher estimated endogenous switching regression estimation to control for unobservable selection bias and to assure the results of PSM are robust.

The model used here is adapted from Nyangena, 2008 Asfaw et al 2010, and Lokshin and Sajaia, 2004. Economic theory dictates that an individual maximizes the utility when he/she chooses an alternative from a given choice set. In adopting SWC technology case, even the household's utility is not observable to anyone but only its choice of technology, one can assume a random utility model (Macfadden, 1996 cited in Nyangena, 2008), which states conditional probability of the choice, given its attributes and the characteristics of the individual, is represented by the probability of the utility greater than the rest of the alternatives (Ali, 2008).

The researcher could assume adoption to occur if the utility of the soil conservation alternative is higher than the utility of the other alternative; i.e., if $SWC_{hp}^* = SWC_{hp}^{sc} - SWC_{hp}^{nsc}$ or if $Z_{hp}\gamma + u_{hp} > 0$ (The indices h and p refer to household and plot respectively). If the variable SWC_{hp} reflects the soil conservation adoption decision and equals one (1) if there is a SWC structure by household h on plot p otherwise equals zero (0), then it can be written as:

$$\begin{aligned}
 SWC_{hp} &= 1 \text{ if } (Z_{hp}\gamma + u_{hp} > 0) & 3.4 \\
 &= 0 \text{ if } (Z_{hp}\gamma + u_{hp} \leq 0)
 \end{aligned}$$

Hence, the adoption decision Z_{hp} is a vector of the exogenous variables which has influence on decision of adoption of SWC technology, including, house hold characteristics, social capital and wealth proxies plot characteristics and input used. And γ is a vector of parameters to be estimated; and u_{hp} is an error term. The error term includes measurement error and factors unobserved to the researcher but known to the household.

The variable SWC_{hp} is a dichotomous choice variable and can be consistently estimated using a limited dependent variable model, such as binary probit (Madalla, 1983; Verbeek, 2004).

To examine the pure impact of SWC technology adoption on farm productivity one has to estimate two yield functions for plots with and without SWC as switching regression model. Since the decision of using SWC on plots is mutually exclusive finding a plot with and without SWC is unlikely.

$$Y_{hp1} = X_{hp} \beta_1 + \varepsilon_{hp1}, \quad (SWC_{hp} = 1 \text{ if } (Z_{hp}\gamma + u_{hp} > 0)) \quad 3.5$$

$$Y_{hp0} = X_{hp} \beta_0 + \varepsilon_{hp0}, \quad (SWC_{hp} = 0 \text{ if } (Z_{hp}\gamma + u_{hp} \leq 0)) \quad 3.6$$

In which the variables Y_{hp1} and Y_{hp0} are continuous variables, representing household h 's value of crop productivity per hectare from a specific plot p . If SWC_{hp} equals 1 or 0, respectively. X_{hp} is vector of a household specific characteristics explanatory variables, vector of inputs used in a production process by a household and a vector of a plot specific characteristics. Where, β_1 and β_0 are vectors of unknown parameters to be estimated and finally, $(\varepsilon_{hp1}, \varepsilon_{hp0})$ are error terms which are mutually independent and identically and independently distributed with mean zero and variance σ_ε^2 (iid $(0, \sigma_\varepsilon^2)$).

In this research it is assumed that ε_{hp1} , ε_{hp0} and u_{hp} have a trivariate normal distribution, with mean vector zero and covariance matrix:

$$\mathbf{\Omega} = \begin{bmatrix} \sigma_u^2 & \cdot & \cdot \\ \sigma_{21} & \sigma_1^2 & \cdot \\ \sigma_{31} & \cdot & \sigma_0^2 \end{bmatrix} \quad 3.7$$

Where σ_u^2 is a variance of the error term in the selection equation, σ_{21} is covariance of u_{hp} and ε_{hp1} which can be assumed to be equal to 1 where σ_1^2 and σ_0^2 are variances of the error terms in the continuous equations and σ_{31} is a covariance of u_{hp} and ε_{hp0} . The covariance between ε_{hp1} and ε_{hp0} is not defined as Y_{hp1} and Y_{hp0} are never observed simultaneously (Lokshin and Sajaia, 2004 and Maddala 1983).

An important implication of the error structure is that because the error term of the selection equation u_{hp} is correlated with the error terms of the value of crop productivity functions ε_{hp1} and ε_{hp0} the expected values of ε_{hp1} and ε_{hp0} conditional on the sample selection are nonzero:

$$E(\varepsilon_{hp1}/SWC_{hp} = 1) = \sigma_{\varepsilon u1} \frac{\phi(\beta_1 X_{hp})}{\Phi(\beta_1 X_{hp})} = \sigma_{\varepsilon u1} \lambda_{hp1} \quad 3.8$$

$$E(\varepsilon_{hp0}/SWC_{hp} = 0) = \sigma_{\varepsilon u0} \frac{-\phi(\beta_1 X_{hp})}{1-\Phi(\beta_1 X_{hp})} = \sigma_{\varepsilon u0} \lambda_{hp0} \quad 3.9$$

Where $\phi(\cdot)$ and $\Phi(\cdot)$ are the density function and the distribution function, and $\lambda_{hp1} = \frac{\phi(\beta_1 X_{hp})}{\Phi(\beta_1 X_{hp})}$, and $\lambda_{hp0} = \frac{-\phi(\beta_1 X_{hp})}{1-\Phi(\beta_1 X_{hp})}$. If the estimated covariance $\sigma_{\varepsilon u1}$ and $\sigma_{\varepsilon u0}$ are statistically significant, then the decision to adopt and the yield functions are correlated, that is there is evidence of endogenous switching and reject the null hypothesis of

absence of sample selectivity bias. This model is defined as a “switching regression model with endogenous switching” (Maddala and Nelson, 1975 cited in Mare and Winship 1987).

An efficient method to estimate endogenous switching regression models is by full information maximum likelihood (FIML) estimation (Lokshin and Sajaia, 2004). The FIML method simultaneously estimates the probit criterion or selection equation and the regression equations to yield consistent standard errors. Given the assumption of trivariate normal distribution for the error terms, the logarithmic likelihood function for the system of equations (3.4) and (3.5 & 3.6) can be given as

$$\begin{aligned} \ln L_{hp} = \sum_{i=1}^N SWC_{hp} \langle \ln \phi \left[\frac{\varepsilon_{hp1}}{\sigma_{\varepsilon 1}} \right] - \ln \sigma_{\varepsilon 1} + \ln \Phi[\varepsilon_{hp1}] \rangle \\ + (1 - SWC_{hp}) \langle \ln \phi \left[\frac{\varepsilon_{hp0}}{\sigma_{\varepsilon 0}} \right] - \ln \sigma_{\varepsilon 0} - \ln (1 - \Phi[\varepsilon_{hp0}]) \rangle \dots 3.10 \end{aligned}$$

Where, $\varepsilon_{hpj} = \frac{[\beta_1 X_{hp} + \gamma_j \varepsilon_{hpj} / \sigma_j]}{\sqrt{1 - \gamma_j^2}}$, $j = 1, 0$, with σ_j denoting the correlation coefficient between the error term, u_{hp} of the selection (equation 3.4) and error term of ε_{hpj} of yield functions (equation 3.5 and 3.6) respectively. The FIML estimates of the parameters of the endogenous

switching regression model can be obtained using the movestay command in STATA (Lokshin and Sajaia 2004).

In addition, for identification purpose, the researcher followed the usual order condition that Z_{hpj} contains at least one element not in X_{hpj} imposing an exclusion restriction on Equation (3.10). These variables do not have any direct effect on the crop income and consumption expenditure, although they are hypothesized to affect the probability that the household adopts SWC technology.

3.3 Conditional Expectations and Treatment

The aforementioned endogenous switching regression model can be used to estimate the actual and counterfactual expected value crop productivity of the farm households. And the estimated values can be used for the comparison of adoption impact between the actual and the counterfactuals. The conditional expectations for the outcome variables in the four cases, the actual expected value of adopters, the counterfactual value of adopters, the counterfactual value of non adopters, and the actual non adopters are defined as follows,

$$E(Y_{hp1} / SWC_{hp} = 1) = X_{hp} \beta_1 + \sigma_{\varepsilon u1} \lambda_{hp1} \quad 3.11$$

$$E(Y_{hp1} / SWC_{hp} = 0) = X_{hp} \beta_0 + \sigma_{\epsilon u0} \lambda_{hp0} \quad 3.12$$

$$E(Y_{hp0} / SWC_{hp} = 1) = X_{hp} \beta_1 + \sigma_{\epsilon u0} \lambda_{hp1} \quad 3.13$$

$$E(Y_{hp0} / SWC_{hp} = 0) = X_{hp} \beta_0 + \sigma_{\epsilon u1} \lambda_{hp0} \quad 3.14$$

According to Heckman et al. (2001) cited in Menale 2008 the effect of the treatment ‘to adopt’ on the treated (TT) as the difference between expected value of crop productivity and counterfactual of expected value of crop productivity that did not adopt.

$$E(Y_{hp1} / SWC_{hp} = 1) - E(Y_{hp0} / SWC_{hp} = 1) = X_{hp} (\beta_1 - \beta_0) + \lambda_{hp1} (\sigma_{\epsilon u1} - \sigma_{\epsilon u0}) = TT \quad \mathbf{3.15}$$

TT represents the effect of SWC technology on the crop productivity of the farm households that actually adopted the technology. Similarly, the effect of the treatment of the untreated (TU) can be calculated for the farm households that actually did not adopt SWC technologies as the difference between, the counterfactual of the adopters had they not been adopted and the real non adopters.

$$E(Y_{hp1} / SWC_{hp} = 0) - E(Y_{hp0} / SWC_{hp} = 0) = X_{hp0} (\beta_1 - \beta_0) + \lambda_{hp0} (\sigma_{\epsilon u1} - \sigma_{\epsilon u0}) = TU \quad \mathbf{3.16}$$

Chapter Four

Data Presentation and Analysis

4.1 Descriptive Statistics

4.1.1 Definition and Summary of Regression Variables

Empirical studies identify numerous variables as being important to a household's decision to use a new technology and affect the crop productivity. The underlying characteristic of these variables is expected at least in theory to affect the demand for the adoption of SWC and its impact on crop productivity. Overall, the factors that affect a household's decision to adopt ranges from household socio economic level variables to physical and geographical level variables. Hence, the specific variable description is done below.

<i>Description</i>	<i>Mean</i>	<i>Std. Dev.</i>
Household Characteristics,		
Sex of household head (1=male female= 0) (Sex)	0.89	0.31
Age of household head (age)	50.42	14.16
Household head years of formal school attendance (education)	1.06	2.61
Number of economically inactive household members (dependent)	3.16	1.65
Number of economically active household members (independent)	3.82	1.72
Social capital and wealth proxies		
Household's access to extension service (1=yes , 0 otherwise) (Exte)	0.41	0.49

<i>Description</i>	<i>Mean</i>	<i>Std. Dev</i>
Household's access to formal credit (1=yes , 0 otherwise)(credit)	0.62	0.48
Amount of Birr a household receive from off farm activities(off farm)	281.07	1298.78
Household livestock holding in tropical livestock unit (TLU)	3.8	3.18
Total amount of land available for cultivation in hectare (Size)	9.72	110.63
<i>Plot characteristics</i>		
Distance from residence to the plot, in minutes (parcel dist)	16.3	18.04
Farmer's perception: plot with of less fertile (1 =yes, 0=otherwise) (tef)	0.11	0.32
Farmer's perception: plot with moderately fertile soil (1=yes, 0 other wise) (lemtef)	0.32	0.46
Farmer's perception: plot with moderately slope (1=yes, 0 = otherwise) (daget)	0.73	0.44
Farmer's perception: plot with steeply slope (1=yes, 0 = otherwise) (gedel)	0.05	0.21
Farmers perception : plot with shallow soil depth (1=yes, 0 otherwise) (shallow)	0.14	0.35
Farmers perception: plots with moderately deep soil (1=yes, 0 otherwise) (medium)	0.49	0.5
Whether household owns the plot (1= owned, 0 otherwise) (owned)	0.78	0.41
Adoption of SWC technology, (1= yes , 0 = no) (SWC)	0.54	0.49
<i>Output produced and input used</i>		
Total value of cereals and pulses produced per hectare (crop)	8350.77	45012.35
Total amount of fertilizer used in kilo gram per hectare (fertilizer)	48.33	94.52
Total oxen days of traction per hectare (traction)	22.59	64.25
Total labor used per hectare (labor)	143.80	305.97
Whether the plot received manure (1=yes, 0 =no) (manure)	0.32	0.46
5871 plots observed for the analysis		

Even though agricultural is a laborious activity, it does not only need strong physical fitness it also demands different modern and traditional skills. In order to capture these variations among households in this research household characteristic, **sex** of the household head is taken into account in the model, since male and female heads may have different levels of interest for house management and physical fitness to

manage the farm. **Age** of household head has also found to be a significant factor influencing the adoption of SWC and crop productivity. Since the physical fitness of a farmer is directly affected by his/her age the farmer's decision of adopting SWC might consider his/her age. Therefore, inclusion of this variable in the model would be meaningful. In addition to the above variables number of **economically active and inactive members** of the household are hypothesized to have impact on household's decision to adopt SWC and has an effect on crop productivity. Because of the laborious characteristics of SWC structure construction and overall agricultural activity a household with larger economically active members would at least have a theoretical advantage by having more labor available for work than a household which have larger economically inactive members. Education (**Highest grade completed in formal schools**) by the household head is assumed to have an important role in determining the adoption decision and expected crop productivity. It helps to enjoy the opportunity of knowledge and awareness concerning new technology merits and demerits vis-à-vis crop productivity.

Since cereals and pulses account for more than 70% (MoFED, 2006) of the agricultural GDP of the nation in this research 5871 plots which produce twenty three (23) types of cereals and pulses are used. **Output**

can be measured in physical units (kilograms) or monetary units (Birr) to avoid aggregation bias in the analysis outputs are aggregated using local market prices from Central Statistics Agency (CSA) of the year 2007. Therefore, the value of the agricultural output produced by each household is derived by multiplying each household's physical product per hectare by the local market price.

With respect to the inputs, labor in the analysis is standardized into adult's equivalent, where 1 is for adult men, 0.75 for adult women, and 0.25 for children, and measured as the total amount of full labor days used for pre planting activities, cultivation (plowing), planting, weeding, harvesting preparation threshing and others. Family labor, hired labor, and exchange labor are also included. On average approximately 144 man's day labor per hectare were used in the entire production process of the outputs. Besides labor **average animal traction rate** and amount **fertilizer** per hectare are also incorporated in the regression analysis. Animal Traction rate is measured as oxen days it may be assumed that this affects production positively (although it may also increase erosion) and used to serve as a proxy of capital used on farm on average approximately 22.6 oxen days of animal traction per hectare was used in the production process. And the amount of fertilizer used in the process is measured in kilograms per hectare it is about 48 kilograms per

hectare. All the above variables are expected to have positive influence on the adoption decision of SWC and crop productivity.

Owing to their influence on the overall agricultural activity plot characteristics are also considered in the analysis. They would have positive or negative impact on adoption of new technology and also on agricultural productivity. The steeper the slope, the more problems there will be with soil erosion and runoff, and the less productive the plot will be. And it might indirectly encourage adoption of new technologies that are helpful to protect the plot from possible erosion. In the sample 73% of the plots are on moderately sloped, and 4% of the plots are on steep slopes. **Soil Fertility** and **Depth** of the plot are also important variables in determining the agricultural activity, adoption and/or production process. **Parcel Distance to home in** minutes and **parcel ownership** are also other important variables which may affect decision of adopting SWC and crop productivity. If the parcel is far away from the household's residence spending more time on journey to the parcel might discourage labor and choose to spend the time on the nearest parcel therefore the variable would have significant influence on the adoption decision and crop productivity of the plot. The ownership title is also another important variable because if the parcel is rented out or share cropped the producer will only interested on the short term output that he/she

can get from the plot not other valuable things like SWC adoption for the plot. It would influence the adoption decision and crop productivity.

Asset Ownership has also incorporated into the study. **Livestock Ownership** is assumed as a proxy for wealth and found it to be an impact variable on adoption of SWC and Crop productivity. Livestock ownership induces the household to apply compost for soil fertility improvement. In connection with this **income from off farm** activities is also assumed as another proxy for higher income. It can influence the household decision of adoption and crop productivity owing to the hypothetically belief that the richer household will break new ground in adopting new technology like SWC and enjoy better inputs for higher crop productivity level. Therefore, it is considered in the model. **Size** of the land which is available for cultivation is also incorporated as proxy of wealth. The variable is assumed to have direct relation with production activities, as one gets bigger plot the value of production is expected to be higher.

Household's **access to extension** service and **access to credit** are also taken as variables influence the SWC adoption and crop productivity. If the household head has access to extension service and credit it is assumed to alleviate the major information and financial constraint of the households and have indicative to participate on income generating

activity of the family. A household with access to credit will enjoy higher purchasing power and can access better inputs for its productivity and adoption of SWC than its counter parts.

4.1 .2 SWC and Plot Characteristics

Plot characteristics	SWC	
	1	0
Farmer's perception: plot with of less fertile	55.7%	44.3%
Farmer's perception: plot with moderately fertile soil	53.9%	46.1%
Farmer's perception: plot with moderately slope	46.7%	50.3%
Farmer's perception: plot with steeply slope	61.1%	38.9%

Where SWC is Adoption of Soil and water conservation technology (1= conserved, 0 otherwise)

The above table shows the cross tabulation between decision of adopting SWC and different plot characteristics. About 55.7% of the plots which are perceived to have less fertility received SWC technology where as about 44.3% of the same types of plots do not. In the same way 53.9% of plots which are assumed to have moderately fertile soils are conserved but the remaining did not conserved. This might indicate the intention of adopting SWC might be to rehabilitate the fertility rather than protecting it from erosion or degradation.

Regarding to the relationship between the slope of plots and adoption of SWC technologies the lion share taken by relatively highly sloped

plots that is (61.1%) and from those plots only 38.9% of the plots did not get the technology. And from the moderately sloped plots about 46.7% are conserved where as the remaining 53.7% did not. Perhaps this is due to fear of erosion since the probability of erosion is higher on relatively steep plots than the flatter ones.

4.2 Econometric Results

4.2.1 Propensity Score Matching (PSM) Methods

The relation between adoption of improved farm technology like SWC and farm productivity is not that much theoretically complex. The researcher estimated the crop productivity effect of SWC technology based on cross sectional data available. In this study a non-parametric method propensity score matching (PSM) and an endogenous switching regression model were used to address the research question of SWC's impact on crop productivity.

The main goal in using propensity score matching was to identify the average treatment effect on the treated plots (ATT). In the utilization of PSM in the study, the researcher first estimate a probit regression in which the dependent variable equals one if the plot adopted at least one SWC technology, zero otherwise and then check the balancing properties of the propensity scores. The balancing procedure tests whether or not

adopters and non-adopters observations have the same distribution of propensity scores. When balancing test failed, the researcher tried alternative specifications of the probit model as suggested by Khandker et al 2010. Therefore, specification used in this study is the most complete and robust specifications that satisfied the balancing tests.

Table 4.3 Propensity Score Matching of ATT Effect of NNM and RM

	Number of treated	Number of controlled	ATT	Std. Err.	T
NNM	3190	2681	-0.162	0.032	-5.109*
RM	2962	2545	-0.035	0.034	-1.801***

Where ATT = average impact of treatment on the treated NNM= nearest neighbor matching RM= radius matching , *** and * significant at 10% and 1% level of significant respectively

The PSM estimated result is based on two matching algorithms, the radius matching (RM) at row two and nearest neighborhood (NNM) at row one, are reported in table 4.3. The analysis reveals that adoption of SWC technologies has a significant negative impact on value of crop productivity. Adoption of SWC had declined the value of crop productivity by about 16% for NNM, which is significant at 1% level of significance, and 3.5% for RM, which is significant at 10% level of significance, on average compared to the non-adopters. It is the average difference between crop productivity of similar pairs of the households belonging to the non-adopters. This indicates that (assuming there is no selection bias

due to unobservable factors) crop productivity for plots which adopted SWC technology is significantly lower than the non adopters. This finding is consistent with Menale, et al 2008.

According to Khandker et al 2010 comparing different matching methods results is one approach to check robustness of average treatment effect. Since at least the findings of the already applied two matching methods estimation results are quiet similar the researcher concluded that the consistency and robustness of PSM analysis.

4.2.2 Endogenous Switching Regression

To check the overall robustness of the study's findings, the researcher estimated endogenous switching regression that can control for unobservable selection bias. The full information maximum likelihood estimates of the endogenous switching regression model are reported in table 4.3 for adoption of SWC technology. The second column of the table presents estimated significant coefficients of selection equation (3.4) on adopting SWC technology or not adopting it. The third and fourth columns of the table present significant values of value of production

functions (3.5) and (3.6) for plots that did and did not adopt SWC technology. To analyze the correlates of value of crop productivity, the researcher includes a set of explanatory variables including household demographic factors, specific individual/household head characteristics, asset holdings and plot specific characteristics.

Table 4.4 estimates of endogenous switching regression model

Description	Coefficients		
	Selection equation	Adopters	Non adopters
Sex of household head (1=male female= 0)	-0.114(0.05)**	-0.076(0.07)	0.062(0.07)
Age of household head	0.008(0.00)*	0.002(0.00)	0.001(0.00)
Household head years of formal school attendance	0.024(0.01)*	0.004(0.01)	0.017(0.01)
Number of economically inactive household members	-0.03 (0.01)*	0.016(0.01)	0.01(0.01)
Number of economically active household members	-0.052(0.01)*	-0.029(0.01)***	0.039(0.01)*
Household's access to formal credit (1=yes , 0 otherwise)	0.168(0.04)*	0.161(0.05)*	0.126(0.04)*
Amount of Birr a household receive from off farm activities	-0.00003(0.00)**	-0.00002(0.00)	.001(0.00)
Total amount of land available for cultivation in hectare	0.0004(0.00)**	0.001(0.00)*	0.001(0.00)*
Household livestock holding in tropical livestock unit	-0.044(0.01)*	-0.038(0.01)*	-0.009(0.01)
Whether the plot received manure (1=yes, 0 =no)	0.432(0.04)*	0.261(0.05)*	-0.084(0.06)
Distance from residence to the plot, in minutes	0.006(0.00)*	0.007(0.00)*	0.007(0.00)*
Farmer's perception: plot with of less fertile (1 =yes, 0=otherwise)	-0.268(0.06)*	-0.222(0.09)**	-0.131(0.07)***
Farmer's perception: plot with moderately fertile soil (1 =yes, 0 other wise)	-0.001(0.04)	-0.019(0.06)	-0.053(0.05)

Description	Coefficients		
	Selection equation	Adopters	Non adopters
Farmer's perception: plot with moderately slope (1=yes, 0 = otherwise)	-0.477(0.04)*	-0.341(0.06)*	0.003(0.06)
Farmer's perception: plot with steeply slope (1=yes, 0 = otherwise)	-0.105(0.08)	0.068(0.11)	-0.205(0.11)***
Farmers perception : plot with shallow soil depth (1=yes, 0 otherwise)	0.173(0.06)*	-0.027(0.08)	-0.201(0.07)*
Farmers perception: plots with moderately deep soil (1=yes, 0 otherwise)	0.231(0.04)*	0.095(0.06)	-0.008(0.04)
Total oxen days of traction per hectare	-0.002(0.00)	0.026(0.00)*	0.028(0.00)*
Total amount of fertilizer used in kilo gram per hectare	-0.006(0.00)*	0.008(0.00)*	0.012(0.00)*
Whether household owns the plot (1 = owned, 0 otherwise)	-0.022(0.04)	5.804(0.15)*	6.213(0.17)*
Household's access to extension service (1=yes , 0 otherwise)	0.2(0.03)*	-0.076(0.07)	0.062(0.07)
Constant	0.207(0.11)***	0.002(0.00)	0.001(0.00)
δ_{hpj} correlation coefficient between selection equation and the value of crop productivity function		1.022(0.06)*	0.099(0.11)
σ_j correlation coefficients between E and u		0.771(0.02)	0.098(0.11)

Where ***, **, and * are significant at 10%, 5% and 1% level of significance respectively
absolute value of robust standard error in parenthesis

Results from the endogenous switching regression model estimated by full information maximum likelihood (FIML) shows that the estimated coefficient of correlation between the SWC adoption equation and the value of crop productivity function (ρ_{hpj}) is positive and significantly different from zero. The results suggest that both observed and unobserved factors influence the decision to adopt modern agricultural technology and crop productivity given the adoption decision. The significance of the coefficient of correlation between the adoption equation and productivity of adopters indicates that self-selection occurred in the adoption of SWC technologies. The production function of plots that adopted SWC is significantly different (at the 1 percent level) from the production function of the plots that did not adopt.

And σ_j the correlation coefficients are both positive, but significant only for the correlation between the adoption choice equation and the SWC adopted equation. Since correlation coefficient of SWC adopters is positive and significantly different from zero the model suggests that plots which choose to adopt SWC technology produce lower crop in that regime than a random plot from the sample would have earned, and those produce without SWC technology do no better or worse than a random individual.

Table 4.5 Expected Value of Crop Productivity under Actual and Counterfactual Conditions				
Sub samples	Decision		Differences	Treatment effect
	SWC = 1	SWC =0		
Plots adopted	6.74448 (a)	6.89622 (c)	-0.151741	TT
Plots not adopted	5.662724 (d)	6.033812 (b)	-0.371088	TU

Where SWC soil and water conservation adoption decision, 1 for adopters and 0 otherwise, TT is the effect of the treatment on the treated and TU is the effect of the treatment of the untreated

Table 4.5 presents the expected value of crop productivity under actual and counterfactual conditions. The predicted value of product from endogenous switching regression model is used to examine the mean value of crop productivity gap between adopters and had they not been adopt. Cell (a) and (b) represent the expected value of product observed in the sample. The expected value of crop productivity that adopted is higher than non adopters. This simple comparison, however, can be misleading and drive the researcher to conclude that on average the crop productivity of conserved plots are more than the plots that did not adopt.

It would be better to utilize the counterfactual. It is done by subtracting cell (c) from cell (a). In connection with this the fourth column first cell of the above table presents the treatment effect of adoption of SWC. The result from the regression indicates that the mean

value of crop productivity of SWC adoption is statistically lower than had they not been adopt.

This is consistent with the result from propensity score matching. SWC adoption decreases crop productivity by about 15%. For non-adopters the mean crop productivity would have been decreased by 37% had they adopted SWC. The results are statistically significant at 1%. Because the two models are similar in result it is possible to conclude the negative impact of adopting SWC.

However, this negative impact might be due to the fact that the total analysis used a survey data. It is to say that if panel data were used the result might not coincide with the negative result. In addition to this the value of crop productivity is only a one time the value of crop productivity if difference of consecutive periods of value of crop productivity were used the result might be changed.

Chapter Five

Conclusion and Policy Implication

5.1 Conclusion

Ethiopia's economy is highly dominated by the agricultural sector, the sector that its performance is highly affected by environmental factors, which contributes more than half to the GDP; employ more than 80% of the labor force and shares 90% of the foreign trade sector. Therefore, for the well being of the economy the merits and demerits of policies concerning the sector should be carefully examined.

That is why this study investigated the impact of SWC on crop productivity. The study was undertaken by using a survey data collected by Efd in 2007 from two zones, East Gojam and South Wollo in Amhara Region. To achieve the main objectives of the study at plot level propensity score matching (PSM) and endogenous switching regression methods were used.

Based on empirical works in this research plots which adopt SWC were not better in crop production. That means the average value of crop production from plots which adopt SWC is less than that of the plots which did not use the technology. This might be due to the fact that usually the practice of adopting SWC is just not to protect the plot from

erosion rather it is to rehabilitate the already degraded plot it is clearly seen in the descriptive statistics. And the other possible reason might be that the practice of SWC took some part of the cultivable area which shows the SWC practice would take significant area of the plot only for SWC practice which is not directly productive. The other possible reason may be adoption of SWC needs more labor since in these areas, not only in the specific zones but also almost in the whole nation, cultivation practice is a manual process, therefore adoption of SWC will waste time on non direct productive activities. Based on the aforementioned reasons it is not difficult to conclude that SWC has negative effect on the production process. However if the research used a panel data the result might be changed since effects of SWC on productivity might take some more long period than a one period.

5.2 Policy Implications

From the findings of the study some policy recommendations draws, as clearly seen in the analysis part of the study SWC adopted plots in the study area are not enjoying higher productivity. This may be due to the complex array of factors affecting land management and diverse agro ecological and socio economic conditions of the area therefore, a one-size-fits-all set of policies is unlikely to work across regions.

It is known for all that there is very limited size of land available for farming in the nation in contrary to higher population growth rate. Therefore land management policies should consider the influence of a policy which directly or indirectly affects the already small available land for cultivation. That means policy makers should pre consider the land usage pattern of the SWC technology that are going to be adopted. In other words it is to say most of the farmers have fragmented and small plots of cultivation for that reason appropriate ex-ante studies should be done before measures taken.

Since the adopted SWC in the study area do not have a positive return that does not necessarily mean SWC are not good enough in enhancing total productivity. At least it shows that different SWC should be implemented to different biophysical areas by considering complex matrix the geographical economy of the nation. In addition to this it is better to support the farmer how to optimally utilize in a plot along with the size and other inputs usage in SWC technology. It can be done by planning and executing awareness programs, strengthening extension service and updating the development agents towards the area of discussion.

Even though soil is one of a semi renewable natural resource its regenerating process is very slow. Therefore, polices should not only

focus on rehabilitation. By doing the rehabilitation side by side policies protection policies should be designed and implemented, since it is relatively easy and less costly for farmers to protect the land degradation than rehabilitate it.

Owing to unavailability of panel data set on the study matter (at least for this researcher) cross section data is used. However, panel data set is more power full on impact assessment than survey data. Therefore, it would be much better for future researchers to use panel data set to assess the real impact of SWC on crop productivity. Plus to that it would be better at least to use the difference of value of crop productivity in consecutive years, which could not be done in this research due to lack of data. Therefore, impact of SWC on productivity using survey and a single year output data could not have strong inference since there might be a result change in using the aforementioned gaps.

6. Bibliography

Adegbidi, A., and Gandonou, E., and Oostendorp, R., (2004) *Measuring The Productivity from Indigenous Soil and Water Conservation Technologies with Household Fixed Effects: A Case Study of Hilly Mountainous Areas of Benin*, Economic Development and Cultural Change, Vol. 52, No. 2 , pp. 313-346

Adekambi, S., Adéyèmi, D., Franklin, A., Simtowe, P., and Biaouthe, G., (2009) *Impact of Agricultural Technology Adoption on Poverty: The case of NERICA rice varieties in Benin*, Contributed Paper prepared for presentation at the International Association of Agricultural Economists' 2009 Conference, Beijing, China,

Adeoti, A.I. (2009) *Factors Influencing Irrigation Technology adoption and its Impact on Household Poverty in Ghana*, Journal of Agriculture and Rural Development in the Tropics and Subtropics Volume 109, No. 1, pages 51–63

Akhtar, M. R., (2006) *Impact of Resource Conservation Technologies for Sustainability of Irrigated Agriculture in Punjab-Pakistan*, J. Agric. Res., 44(3) 239

Alemu Mekonnen (undated) *Erosion Control in Agricultural Areas: An Ethiopian Perspective*, GTZ-Integrated Food Security Program Ethiopia, www.vetiver.com/ETH_Mikonnen%20ICV2.PDF accessed December 2010

Ali, G. (2008) *Expected Utility in Econometric Random Utility Models*,
Sankhyā: The Indian Journal of Statistics, Volume 70-B, Part 1,
pp. 63-68

Anderson, J.R. (1999) *Poverty, Land Degradation, and Rural Research
Policy, Rural Development*, World Bank, Washington DC

Asfaw, S. and Shiferaw, B., (2010) *Agricultural Technology adoption and
Rural Poverty: Application of an Endogenous Switching Regression
for Selected East African Countries*, Poster presented at the Joint
3rd African Association of Agricultural Economists (AAAE) and 48th
Agricultural Economists Association of South Africa (AEASA)
Conference, Cape Town, South Africa,

Asian Development bank (2006) *Impact evaluation methodological and
operational issues*, www.adb.org/economics, Publication Stock No.
080906. Philippines

Barbier, E. B. (1995) *The Economics of Soil Erosion: Theory, Methodology
and Examples*, Paper based on a presentation to the Fifth Biannual
Workshop on Economy and Environment in Southeast Asia,
Singapore, November 28-30,

_____. (1997) *The Economic Determinants of Land Degradation
In Developing Countries*, Phil. Trans. R. Soc. Lond. B 352, page 891-
899

_____. (2000) *The economic linkages between rural poverty and land degradation: some evidence from Africa*, Agriculture, Ecosystems and Environment 82, page 355–370

Barrett, S., (1989) *Optimal Soil Conservation Reform of Agricultural Pricing Policies*, International Institution for Environment and Development, London

Belay T. (1996), *Characteristics and Landscape Relationships of Vertisols And Vertic Wvisols Of Melbe, Tigray*, Ethiopian journal of Science Vol 19 No. 1, Addis Ababa university

Berhanu G. and Pender, J., Ehui, S., (undated), *Land Tenure and Land Management in the Highlands of Northern Ethiopia*, homepages.wmich.edu/~asefa/Conference%20and%20Seminar, accessed January 2011

Bhattacharyya, T., Babu, S., Ram D., Mandal1, C., Dhyani, B. L. and Nagar1, A. P. (2007), *Soil Loss and Crop Productivity Model In Humid Subtropical India*, Current Science, Vol. 93, No. 10, 25

Boetekees, S. (undated) *Rural Credit and Soil and Water Conservation: A case study in Tigray, Northern Ethiopia, Policies for Sustainable Land Management in the Ethiopian Highlands*, working paper 2002-03, www.edepot.wur.nl/119999, accessed January 2011

Boyd, C., Turton, C., Hatibu, N., Mahoo, H.F., Lazaro E., Rwehumbiza, F.B., Okubal P., and Makumb, M., (2000) *The Contribution Of Soil And Water Conservation To Sustainable Livelihoods In Semi-Arid Areas Of Sub-Saharan Africa*, Agricultural Research & Extension Network, Network Paper No 102, www.odi.org.uk/work/projects/agren/papers/agrenpaper_102.pdf, accessed January 2011

Clark, R., (undated) *Methodologies for the Economic Analysis of Soil Erosion and Conservation*, CSERGE Working Paper GEC 96-13, www.cserge.ac.uk/sites/default/files/gec_1996_13.pdf, accessed December 2010

Duraiappah, A.K., (1998) *Poverty and Environmental degradation: A Review and Analysis of the Nexus*, World Development Vol. 26, No. 12, pp. 2169-2179,

Eaton, D. (1996), *the Economics of Soil Erosion: A Model of Farm Decision-Making*, Environmental Economics Program Discussion Paper Dp 96-01

Eleni T. A., (2008) *Continued Use of Soil and Water conservation Practices: a Case study in Tulla District Ethiopia*, MSc Thesis, Wageningen University, The Netherlands

Ellis-Jones J and Tengberg, A. (2000) *The impact of indigenous soil and water conservation practices on soil productivity: examples from Kenya, Tanzania and Uganda*, Land Degrad. Develop. 11: 19 -36

EPA (Environmental protection Authority), *State of Environmental Report for Ethiopia*, Addis Ababa

Ethiopia, Government of the Federal Democratic Republic of. (2008) *Dynamics of Growth and Poverty in Ethiopia (1995/96-2004/05*, Development Planning and Research Department (DPRD) and Ministry of Finance and Economic Development (MOFED).

Friedrich, T. and Kienzle, J. (undated) *Conservation Agriculture: Impact on farmers' livelihoods, labor, mechanization and equipment*, www.fao.org/ag/ca/CA-Publications/ACSAD%202007.pdf, accessed January 2011

Genanew B. and Alemu M., (2010) *Investments in Land Conservation in the Ethiopian Highlands: A Household Plot-Level Analysis of the Roles of Poverty, Tenure Security, and Market Incentives*, Environment for Development Discussion Paper Series, EfD DP 10-09

Haileselassie A. M. And Köhlin, G., (2009) *Soil Conservation and Small-Scale Food Production in Highland Ethiopia a Stochastic Metafrontier Approach*, University Of Gutenberg School Of Business, Economics and Law, Working Papers in Economics No 405

Heijdra, B. J., and Van der Ploeg, F., (2002) *Foundations of Modern macro Economics*, Published in the United States by Oxford University Press Inc., New York

Kaliba, A.R.M. and Rabele, T. (undated) *Impact of Adopting Soil Conservation Practices on Wheat Yield in Lesotho*, webapp.ciat.cgiar.org/tsbf_institute/managing_nutrient, accessed December 2010

Kabubo-Mariara, J., Linderhof, V., Kruseman, G., Atieno, R., and Mwabu G., (2006) *Household Welfare, Investment in Soil and Water Conservation and Tenure Security: Evidence From Kenya*, PREM Working Paper: PREM 06/06

Kazianga, H., and Masters, W. A., (2001) *Investing in Soils: Fields Bunds and Microcatchments in Burkina Faso*, *Environmental and Development Economics*, 7(3):571-592.

Kato, E., Ringler, C., Mahmud Y., and Bryan E., (2009) *Soil and Water Conservation Technologies: A Buffer against Production Risk in the Face of Climate Change? Insights from the Nile Basin in Ethiopia*, IFPRI Discussion Paper 00871

Karki, L. B., and Bauer, S. (undated) *Technology Adoption and Household Analyzing factors determining technology adoption and impact of project intervention: A case of smallholder peasants in Nepal*, www.tropentag.de/2004/abstracts/full/107.pdf, accessed January 2011

Khandker, S. R., Koolwal, G.B., and Samad, H. (2010), *Handbook on Impact Evaluation Quantitative Methods and Practices*, the World Bank, Washington DC

Lokshin, M., and Sajaia, Z., (2004) *Maximum Likelihood Estimation of Endogenous Switching Regression Models*, *Stata Journal* 4(3): 282-289

Maddala, G.S. (1983) *Limited dependent and qualitative variables in Econometrics*, Cambridge, U.K.: Cambridge University Press

Malik, S. J., and Nazli, H., (1998), *Rural Poverty and Land Degradation: A Review of the Current State of Knowledge*, the Pakistan Development Review 37: 4 Part II (Pp. 37:4, 1053–1070)

Mare, R. D., and Winship, C., (1987), *Endogenous Switching Regression Models for the Causes and Effects of Discreet Model*, CDE working paper 87 – 32

Mas-Colell, A., Whinstone, M. D., Green, J. R., (1995), *Micro economics theory*, oxford university press Inc. New York.

Menale Kassie, Holden, S., Köhlin G., and Bluffstone, R., (2008)
Economics of Soil Conservation Adoption in High-Rainfall Areas of the Ethiopian Highlands, Environment for Development Discussion Paper Series, EfD DP 08-09

Menale Kassie and Holden, S.T, (2005) *Parametric and Non-parametric Estimation of Soil conservation adoption impact on yield risk*, Paper presented in the 6th International Conference of the European for Ecological Economics held June 14 – 18, 2005.

Ministry of Finance and Economic Development (MoFED) (2006)
Ethiopia: Building on Progress A Plan for Accelerated and Sustained Development to End Poverty (PASDEP) (2005/06-2009/10) Volume I: Main Text, Addis Ababa

Nyanena, W., (Undated) *Essays on Soil Conservation, Soil Capital and Technology Adoption*, Department of Economics School of Economics and Commercial Law, Goteborg University, www.slu.se/Documents/externwebben/overgripande-slu, accessed December 2010

Nyangena, W. and Köhlin G. (2008), *Estimating Returns to Soil and Water Conservation Investments: An Application to Crop Yield in Kenya*, Environment for Development Discussion Paper Series, EfD DP 08-

Nyssen, J., Mitiku H., Moeyersons J., Poesen J., and Deckers, J.,
(2004) *Environmental policy in Ethiopia: a rejoinder to Keeley and Scoones*, The Journal of Modern African Studies, Vol. 42, No. 1 (pp. 137-147)

Nyssen, J., Descheemaeker, K., Nigussie H., Mitiku, H., Deckers J.,
Poesen J., (2007) *Lessons learnt from 10 years research on soil erosion and soil and water conservation in Tigray*, Tigray Livelihood Papers No. 7

Pagiola, S., (1998) *Economic Analysis of Incentives for Soil Conservation*,
To be published by Science Publishers, Inc., on behalf of the World Association of Soil and Water Conservation, the International Board for Soil Research and Management, and the Soil and Water Conservation Society of Thailand.

Porras I., Maryanne G., Meijerink, G., (2007) *Farmers' adoption of soil and water conservation: potential role of payments for watershed services*, Green Water Credits Report 5

Rebeka A. (2006) *Impact Assessment of Rainwater Harvesting Ponds: The Case of Alaba Woreda, Ethiopia*, Msc Thesis, School of Economics, Addis Ababa University

Samuel G., (2006) *Land, Land Policy and Smallholder Agriculture in Ethiopia: Options and Scenarios*, Paper prepared for the Future Agricultures Consortium meeting at the Institute of Development Studies 20-22 March 2006

Sims, B. G., Ellis-Jones J., and Twonlow S. J., (undated) *The development of low cost of soil and water conservation for smallholder farmers in the mid- Andean Valleys of Bolivia*, 16th symposium of the international Farming systems association

Tekie Alemu, (undated), *Insecure land tenure regimes and soil conservation*, Department of Economics, Göteborg University, eldorado.ucof.mx/icons/bdl/arc/02.pdf, accessed January 2011

Teshome T. D., (2010) *Nature of Property Units in Ethiopia: Case Study Two Pilot Projects, Facing the Challenges – Building the Capacity* Sydney, Australia, 11-16 April 2010

Yihenew G., Tadele A., Mitiku H., and Yamoah C., (undated) *Lessons from Upstream Soil Conservation Measures to Mitigate Soil Erosion and its Impact on Upstream and Downstream Users of the Nile River*, CP 19 Project workshop Proceedings, [rosenberg.ucanr.org/documents/BahriZaragossaJune2008\[1\].doc](http://rosenberg.ucanr.org/documents/BahriZaragossaJune2008[1].doc), accessed December 2010

Zhao, J.,(2005) *The Role of Information in Technology Adoption under Poverty*, world institute of development and economics research, research paper no. 2005/41

7. Annex

Algorithm to estimate the propensity score

The treatment is swc

swc	Freq.	Percent	Cum.
0	2,681	45.67	45.67
1	3,190	54.33	100.00
Total	5,871	100.00	

Estimation of the propensity score

Iteration 0: log likelihood = -3801.3584
 Iteration 1: log likelihood = -3418.9305
 Iteration 2: log likelihood = -3414.5317
 Iteration 3: log likelihood = -3414.5287

Probit regression

Number of obs = 5507
 LR chi2(21) = 773.66
 Prob > chi2 = 0.0000
 Pseudo R2 = 0.1018

Log likelihood = -3414.5287

swc	Coef.	Std. Err.	z	P> z	[95% Conf. Interva]
sex	-.0895259	.0615263	-1.46	0.146	-.2101153 .0310634
age	.0086346	.0014039	6.15	0.000	.0058829 .0113862
yrschool	.0363275	.0071082	5.11	0.000	.0223957 .0502594
depfamsize	-.0465891	.011105	-4.22	0.000	-.0682468 -.0249315
indepfamsize	-.0607031	.0110682	-5.48	0.000	-.0823964 -.0390099
dummyformcr	.2308961	.0376999	6.12	0.000	.1570058 .3047865
amttoffarm	-.000023	.0000148	-1.56	0.118	-.000052 5.88e-06
size	.0004111	.0002073	1.98	0.047	4.82e-06 .0008174
tlu	-.0445506	.0059812	-7.45	0.000	-.0562736 -.0328276
owned	-.0367588	.0430586	-0.85	0.393	-.1211522 .0476345
manure	.4566507	.0414533	11.02	0.000	.3754038 .5378975
parceldist	.0059157	.0010281	5.75	0.000	.0039006 .0079307
tef	-.295397	.0656131	-4.50	0.000	-.4239964 -.1667976
lemtef	-.0443185	.0424215	-1.04	0.296	-.1274631 .0388261
daget	-.524051	.0457087	-11.47	0.000	-.6136384 -.4344635
gedel	-.0971085	.0897414	-1.08	0.279	-.2729984 .0787814
shallow	.1872534	.0634752	2.95	0.003	.0628442 .3116626
medium	.2855921	.0407353	7.01	0.000	.2057524 .3654318
traction	-.0082998	.0030143	-2.75	0.006	-.0142077 -.0023919
fertilizer	-.0047139	.0007239	-6.51	0.000	-.0061327 -.0032951
lncrop	.0074804	.01587	0.47	0.637	-.0236241 .038585
_cons	.236462	.1552393	1.52	0.128	-.0678014 .5407255

Note: the common support option has been selected
 The region of common support is [.00826749, .9806109]

Description of the estimated propensity score
 in region of common support

Estimated propensity score					
	Percentiles	Smallest			
1%	.1311708	.0082675			
5%	.2303129	.0127158			
10%	.2967766	.0135168	Obs	5507	
25%	.4139533	.0232436	Sum of Wgt.	5507	
50%	.5405804		Mean	.5383659	
			Std. Dev.	.1800776	
75%	.6741039	.9434607			
90%	.7750399	.9446447	Variance	.0324279	
95%	.8292018	.9584289	Skewness	-.1511999	
99%	.893667	.9806109	Kurtosis	2.497815	

 Step 1: Identification of the optimal number of blocks
 Use option detail if you want more detailed output

The final number of blocks is 8

This number of blocks ensures that the mean propensity score is not different for treated and controls in each blocks

 Step 2: Test of balancing property of the propensity score
 Use option detail if you want more detailed output

The balancing property is satisfied

This table shows the inferior bound, the number of treated and the number of controls for each block

Inferior of block of pscore	swc		Total
	0	1	
.0082675	156	34	190
.2	278	98	376
.3	465	240	705
.4	560	454	1,014
.5	522	604	1,126
.6	337	627	964
.7	163	559	722
.8	64	346	410
Total	2,545	2,962	5,507

Note: the common support option has been selected

 End of the algorithm to estimate the pscore

Annex II Average impact of treatment on the treated for nearest neighbor matching

ATT estimation with Nearest Neighbor Matching method

(random draw version)

Analytical standard errors

n. treat.	n. contr.	ATT	Std. Err.	t
3190	2681	-0.162	0.032	-5.109

Note: the numbers of treated and controls refer to actual
nearest neighbour matches

Annex III Average impact of treatment on the treated for radius matching

ATT estimation with the Radius Matching method

Analytical standard errors

n. treat.	n. contr.	ATT	Std. Err.	t
2962	2545	-0.035	0.034	-1.801

Note: the numbers of treated and controls refer to actual
matches within radius

Annex IV ENDOGENOUS SWITCHING REGRESSION ESTIMATES						
	Coef.	Std. Err.	Z	P>z	[95% Conf.	Interval]
SWC section one						
Sex	-0.1142307	0.0552267	-2.07	0.039	-0.2224731	-0.0059883
Age	0.0079359	0.0013752	5.77	0.000	0.0052406	0.0106311
Yrschool	0.0244661	0.0068921	3.55	0.000	0.0109579	0.0379744
depfamsize	-0.0309344	0.0105025	-2.95	0.003	-0.051519	-0.0103498
indepfamsize	-0.0520059	0.0105217	-4.94	0.000	-0.0726281	-0.0313837
dummyformcr	0.1682082	0.035801	4.7	0.000	0.0980396	0.2383768
amtofffarm	-0.0000313	0.0000135	-2.31	0.021	-0.0000578	-4.77E-06
Size	0.0004976	0.0001963	2.53	0.011	0.0001128	0.0008824
Tlu	-0.0444408	0.0057007	-7.8	0.000	-0.0556139	-0.0332677
Manure	0.4315688	0.0394168	10.95	0.000	0.3543133	0.5088242
Parceldist	0.0055279	0.0009839	5.62	0.000	0.0035995	0.0074564
Tef	-0.2680485	0.0636116	-4.21	0.000	-0.3927249	-0.143372
Lemtfe	-0.0007609	0.0405801	-0.02	0.985	-0.0802965	0.0787747
Daget	-0.4770337	0.0440313	-10.8	0.000	-0.5633336	-0.3907339
Gedel	-0.1055705	0.0852111	-1.24	0.215	-0.2725813	0.0614403
Shallow	0.1733365	0.0607197	2.85	0.004	0.0543281	0.292345
Medium	0.2310938	0.0388213	5.95	0.000	0.1550054	0.3071822
Traction	-0.0019237	0.0027919	-0.69	0.491	-0.0073957	0.0035484
Fertilizer	-0.0057785	0.0006712	-8.61	0.000	-0.007094	-0.0044629
Owned	-0.0222068	0.0364125	-0.61	0.542	-0.0935741	0.0491604
Exte	0.2007765	0.031812	6.31	0.000	0.1384261	0.2631269
_cons	0.2066741	0.1124579	1.84	0.066	-0.0137393	0.4270875
Value of crop production for adopters						
Sex	-0.0765572	0.0746984	-1.02	0.305	-0.2229633	0.0698489
Age	0.0020401	0.0019316	1.06	0.291	-0.0017458	0.0058259
Yrschool	0.0043627	0.0094282	0.46	0.644	-0.0141162	0.0228416
depfamsize	0.0164941	0.0144998	1.14	0.255	-0.0119249	0.0449132
indepfamsize	-0.0289904	0.0154225	-1.88	0.06	-0.059218	0.0012372
dummyformcr	0.1606369	0.0521084	3.08	0.002	0.0585062	0.2627675
amtofffarm	-0.0000243	0.000022	-1.11	0.268	-0.0000673	0.0000187
Size	0.0011954	0.0001896	6.3	0.000	0.0008237	0.0015671
Tlu	-0.0383376	0.0089983	-4.26	0.000	-0.0559739	-0.0207013
Manure	0.2611575	0.0537469	4.86	0.000	0.1558155	0.3664996
Parceldist	0.0071823	0.0013595	5.28	0.000	0.0045177	0.0098469
Tef	-0.2222613	0.0941112	-2.36	0.018	-0.4067159	-0.0378068
Lemtfe	-0.0191589	0.0559081	-0.34	0.732	-0.1287368	0.090419
Daget	-0.341496	0.0598368	-5.71	0.000	-0.458774	-0.224218

Gedel	0.0681602	0.1137595	0.6	0.549	-0.1548043	0.2911247
Shallow	-0.0271395	0.0834524	-0.33	0.745	-0.1907033	0.1364243
medium	0.0953996	0.0560022	1.7	0.088	-0.0143627	0.2051619
traction	0.0262522	0.0039752	6.6	0.000	0.0184611	0.0340434
fertilizer	0.008254	0.0010417	7.92	0.000	0.0062122	0.0102957
_cons	5.804324	0.1533813	37.84	0.000	5.503702	6.104946
Value of crop production for non adopters						
sex	0.0609351	0.0684043	0.89	0.373	-0.0731349	0.195005
age	0.0005936	0.0016544	0.36	0.72	-0.0026489	0.0038361
yrschool	0.0169796	0.008612	1.97	0.049	0.0001004	0.0338589
depfamsize	0.0102189	0.0123663	0.83	0.409	-0.0140186	0.0344565
indepfamsize	0.0397671	0.0120015	3.31	0.001	0.0162446	0.0632896
dummyformcr	0.1269625	0.04077	3.11	0.002	0.0470547	0.2068702
amtofffarm	-8.10E-06	0.0000125	-0.65	0.517	-0.0000326	0.0000164
size	0.0008076	0.0002681	3.01	0.003	0.0002821	0.0013331
tlu	-0.008753	0.0058919	-1.49	0.137	-0.0203009	0.0027949
manure	-0.084895	0.0583473	-1.45	0.146	-0.1992537	0.0294636
parceldist	0.0066977	0.0011877	5.64	0.000	0.0043697	0.0090256
tef	-0.1310823	0.0696238	-1.88	0.06	-0.2675424	0.0053777
lemtef	-0.0531021	0.0467717	-1.14	0.256	-0.1447729	0.0385688
daget	-3.74E-02	0.0640082	-0.58	0.559	-0.1628397	0.0880677
gedel	-0.204283	0.1056111	-1.93	0.053	-0.411277	0.0027109
shallow	-0.2005129	0.0711644	-2.82	0.005	-0.3399926	-0.0610333
medium	-0.0079745	0.0467526	-0.17	0.865	-0.099608	0.0836589
traction	0.0284023	0.003548	8.01	0.000	0.0214484	0.0353562
fertilizer	0.0123817	0.0007263	17.05	0.000	0.0109581	0.0138053
_cons	6.213192	0.1664131	37.34	0.000	5.887028	6.539356
/lns1	0.3832224	0.0213455	17.95	0.000	0.3413859	0.4250588
/lns2	-0.026206	0.0152511	-1.72	0.086	-0.0560976	0.0036856
/r1	1.022302	0.0579213	17.65	0.000	0.9087782	1.135826
/r2	0.0992041	0.1117185	0.89	0.375	-0.1197602	0.3181684
sigma_1	1.467004	0.0313139			1.406896	1.52968
sigma_2	0.9741344	0.0148566			0.9454469	1.003692
rho_1	0.7708025	0.0235082			0.7205453	0.8130037
rho_2	0.0988799	0.1106262			-0.1191909	0.3078498
Wald test of indep. eqns : chi2(1) = 15.27 Prob > chi2 = 0.0001						

Annex V Endogenous Regression Test For TT						
Two-sample t test with equal variances						
Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
SWC = 0	2681	6.89622	0.011265	0.5833	6.874131	6.91831
SWC = 1	3190	6.74448	0.008212	0.463784	6.72838	6.76058
combined	5871	6.813772	0.00688	0.52717	6.800285	6.82726
Difference		0.151741	0.013671		0.124941	0.17854
diff = mean(0) - mean(1)						t = 11.0997
Ho: diff = 0				Degrees of freedom = 5869		
Ha: diff < 0		Ha: diff! = 0				Ha: diff > 0
Pr(T < t) = 1.0000		Pr(T > t) 0.000			Pr(T > t) = 0.0000	

Annex VI Endogenous Regression Test For TU						
Two-sample t test with equal variances						
Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
SWC = 0	2681	6.033812	0.008504	0.44032	6.017137	6.050487
SWC = 1	3190	5.662724	0.011886	0.671321	5.639419	5.686029
combined	5871	5.832182	0.007912	0.606242	5.816671	5.847692
Difference		0.371088	0.015129		0.34143	0.400746
diff = mean(0) - mean(1)						t = 24.5287
Ho: diff = 0				Degrees of freedom = 5869		
Ha: diff < 0		Ha: diff! = 0				Ha: diff > 0
Pr(T < t) = 1.0000		Pr(T > t) 0.000			Pr(T > t) = 0.0000	

Declaration

I, the undersigned, declare that this thesis is my original work, has not been presented for a degree in any other university. All the resources and materials used for the thesis have been duly acknowledged.

Declared By:

Name: _____

Signature: _____

Date: _____

Confirmed by:

Name: _____

Signature: _____

Date: _____

Place: Addis Ababa University