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College of Business and Economics

Department of Economics

**IMPACT OF SOIL AND WATER CONSERVATION ON CROP
PRODUCTIVITY IN THE HIGHLANDS AREA OF GUMER
DISTRICT, GURAGE ZONE**

By

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Wolkite, Ethiopia

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**Impact of Soil and Water Conservation on Crop Productivity in the
Highlands Area of Gumer District, Gurage Zone**

**A thesis submitted to the school of graduate studies in partial
fulfillment of the requirements for the degree of master science in
Development Economics**

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Advisor Approval Sheet

I, the undersigned, declare that this research entitled “Impact of soil and water conservation on crop productivity in the highlands area of Gumer District, Gurage Zone, Ethiopia” is my own thesis work. I have undertaken the research thesis work independently with the guidance and support of the research adviser. This thesis has not been submitted for any degree or diploma program in this or any other institutions and that all sources of materials used for the thesis have been duly acknowledged.

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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

FTC: Farmer's training center

GDP: Gross Domestic Product

GOE; Government of Ethiopia

ISWC: Indigenous Soil and Water Conservation

MoFED: Ministry of Finance and Economic Development

NNM: Nearest Neighbor matching

KM: Kernel matching

PASDEP: Plan for Accelerated and Sustained Development to End Poverty

PSM: Propensity Score Matching

RM: Radius Matching

SWC: Soil and Water Conservation

SCRIP; Soil conservation research project

SM: stratification matching

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Abstract

Land degradation due to soil erosion and nutrient depletion is one of the main problems constraining the development of agricultural sector in Ethiopia. As part of innervation activities a numbers of soil and water conservation (SWC) practice have been promoted to smallholder farmers living in highly degraded area of the country. This study was conducted to investigate the impact of soil and water conservation on crop productivity. To meet this objective primary data was gathered in 2015 EC from 183 SWC participant and 160 non participant that were randomly selected in the district kebele. For this study, primary data collected through structured questioners, focus group discussion and interviews with key informants. Descriptive, inferential statistics and propensity score matching (PSM) models were used to address the stated objectives. Age, sex, family size, farm experience, land sloppiness, extension contact, education, household crop income and training all influence participation in soil and water conservation practice. ATTE revealed that crop income differed positively between the treatment and the control groups. The total household income increased by 422 ETB as the result of participation in the program. This demonstrate the importance of soil and water conservation for boosting of crop income. As a results government, research institute and other stakeholders should invest in farmers' capacity building through extension service and training to achieve soil and water conservation goals while simultaneously addressing the livelihoods of the farmers.

Key words: ATTE, propensity score matching, logit, household crop income

CHAPTER ONE

1. INTRODUCTION

1.1. Background of the study

Land degradation in the form of soil erosion and fertility depletion is a major challenge in the Ethiopian highlands due to its adverse impacts on crop productivity, food security and natural resource conservation (Laekemariam *et al* 2016, Teklu *et al.* 2018, and Adimassu *et al.* 2017).

(Laekemariam *et al.* 2016) stated that the principal causes of soil erosion are rapid population growth and improper land resources management and utilization which finally declining agricultural productivity. Erratic and erosive rain fall, steep terrain, deforestation, inappropriate land use, land fragmentation, overgrazing and weak management practices are among the factors that cause land degradation in the country (Osman and Sauerborn 2001). According to (Bewket, 2007, Adimassu, 2012) the root causes of soil erosion in Ethiopia are due to deforestation, intense rainfall cultivation of steep slope to fulfill the demand of a growing population. Soil erosion and degradation limit food production, pose a threat to climate change and human health pollute the air and water quality by releasing particles, sediments, and nutrients (FAO,2019).Every year, soil erosion destroys approximately 10 million acres of agricultural land, decreasing the quality of cropland available for food production (Pimentel,2006). Soil deterioration is estimated to cost 0.4% of the global GDP each year (Nkonya et al, 2016).

The impact of erosion is particularly severe in the highlands of the country (areas that lie above 1500 masl), which constitute less than half of the country (\approx 43 percent of the country) (FAO, 1986). In the mid of 1980s, 50% of the highlands are significantly eroded, 25% seriously eroded, while 4% had reached a point of no economic return (FAO, 1986). . Many studies reported the extent of soil erosion based on erosion modeling. Soil Conservation Research Project (SCRIP) estimated that about 1.5 billion tons of soil eroded (Hurni, 1984; Kruger, 1995), whereas FAO (1984) and Hurni (1993) reported annual soil loss from Ethiopian highlands to be 200-300 tons ha/year. The report of (Bagegnehu *et al.* 2019) in the Southern Region reported that the soil loss as 42,413.7 ton per year soil with an average annual soil loss rate of 4.27ton/ha/year. The impact of soil erosion both on-site nutrient loss and off-site sedimentation of water resources ((Emrah *et al.* 2007). According to Adimassu *et al.* 2017, indicated that soil loss due to erosion in the

Ethiopian highlands is between 42 and 175.5 tons/ ha/ year. Other studies on crop fields have also confirmed that declining soil fertility and limited water availability resulted to low crop yields on Ethiopian highlands (Laekemariam *et al.* 2016, Teklu *et al.* 2018). In an effort to curb soil erosion and nutrient depletion, government of Ethiopia (GoE) in collaboration with local community and several donors have been implemented large national soil and water conservation (SWC) program since the 1970s (MOARD 2005). The GoE, since 1980s, has supported rural land rehabilitation through watershed development approach and management has moved from a focus on physical SWC to the integration of social, economic, and environmental development (MOARD 2005). Welu and Solomon (2015) explained that soil bund, fanyajuu bund and deep trench structures are widely implemented physical SWC structures to conserve cultivated land from soil erosion.

In Ethiopia, soil and water conservation practices has been started after famine in 1973 and 1985 as food-for-work program to mitigate soil erosion problems (Hoben, 1996). After this program, various physical and biological soil and water conservation measures has been implemented by extensions, research institutions, and other development practioners through collective action, community collective action, and farmer's personal trial (Wagayehu and Lars, 2003). Typical SWC technologies used in Ethiopia include soil bund, stone bund, grass strip, water ways, tree planted at the edge of farm field (kato, *et al.* 2009). According to IFAD (1992), conservation measures are broad classified as agronomic measures, physical /structural/ measures, and biological/vegetative/ measures. Similarly Genene and Abiy (2014), most of the farmers in south western Ethiopia practices introduced and indigenous soil and water conservation activities like; contour farming, furrow making, residue leaving, agronomic practices, putting trash lines on contour, etc.

Therefore, the study should be initiated to investigate the impact of soil and water conservation on crop productivity in Gumer district of Gurage zone SNNPR.

1.2. Statement of the Problem

From a total of 1130 million kilo meter square area of Ethiopia 45% is highland, 1500 meter above 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). On top of that a number of empirical studies had been conducted on the impact of SWC on crop productivity. The complexity and fragility of Ethiopian land scape makes its soil highly susceptible to land degradation and consequently the serious negative impact on farmer's livelihoods and food security status (Lakew, 2005). Natural resource degradation is closely linked to community livelihoods. Community based soil and water conservation participation and planning was adopted with the aim to improve livelihoods of farmers and enhance ecosystem function (Lakew, 2005). The research in the previous study address only on village as sample of SWC on crop productivity.

Using a village as a sample of study there might not helpful to reach on conclusion on the impact of SWC on crop productivity. Since representativeness of a village to the whole economy is too small. Consequently in this study there should be investigated the impact of SWC investment on farm productivity in the highlands area of Gumer district, using house hold level data from Gurage Zone Gumer district in the Southern region of Ethiopia. Soil degradation is the existing problem in the study area that face soil fertility problem and impact on crop productivity. However, there is no study which investigate the impact of soil and water conservation practices in crop productivity in Gumer district Gurage Zone, SNNPR.

In this study the researcher was focus on to try to answer the question what should be the impact of adopting SWC practices on crop productivity in the high land area of the study area (gumer district).

1.3. Objectives of the study

1.3.1. General Objective

- ✓ To investigate the impact of soil and water conservation on crop productivity in the highlands area of Gumer District, Gurage Zone

1.3.2. Specific objectives

- ❖ To examine SWC practice in the highland area of Gumer district
- ❖ To examine the impact of SWC on crop productivity in the highland area of Gumer district
- ❖ To identify the determinant of SWC in the highland area of Gumer district

1.4. Research Question

What is the impact of soil & water conservation in crop productivity in the study area?

What is the determinant of SWC practices in the highland area of Gumer district?

1.5. Significance of the study

The output of this study is expected to be helpful to the development agents in the study area to enhance awareness of the community particularly non participant household in the importance of soil and water conservation measures. In addition to this, understanding the impact of soil and water conservation governing agencies (government and non-governments), such as district and regional natural resource development planner and their partners. And also used as reference source for future research and fill the gap of data constraint particularly in the study area.

1.6. Scope of the study

This study was conducted in Gumer district which is found in Gurage zone, SNNP of Ethiopia. The study mainly deals with the impact of soil and water conservation practice on crop productivities.

1.6.1. Limitation of the study

It was difficult to collect each respondent information due to bad weather limited budget

It was difficult to get exact secondary data from the concerned office (Agricultural office).

1.7. Organization of the study

This thesis contained five chapters. The first chapter deals with the introduction part. The second chapter deals with related literature review where the basic SWC concepts and relevant empirical studies were discussed. The third chapter of the thesis deals with a brief description of the study area and methodology of the research (data collection and analysis method) and the fourth chapter deals with data analysis and interpretation of the results the last chapter concerned discussion and recommendation of the results .

CHAPTER TWO

Literature Review

2.1. Theoretical Literature Review

2.1.1. Economy 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 degradation resulting from soil erosion and its impacts on agricultural production.

Land degradation in poor countries like Ethiopia is usually emerged from 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 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 (Menal, *et al*, 2010).

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 costs and benefits of soil erosion, whereas society must also be concerned with any offsite or external costs. Externalities are defined as costs or benefits arising in a process of production 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).

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 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 discount 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 (Boj , 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 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).

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, SohailJehangir 1998). The poor generally have access only to areas that have higher risk for health and income generation (Barbier, 1995, 1997, Malik, SohailJehangir 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.

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).

Finally, other market policy and institutional failures such as insecure tenure 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 (Boj , 1991). Therefore, concerns about the effects of soil erosion have to be made and due attention should be needed.

2.1.2. 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 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 decrease 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.

2.1.3. Soil and water conservation 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 (afforestation, soil bund, tracing and other soil and water conservation mechanism) which prevents soil erosion that is SWC technology.

SWC, therefore, technology is one which is implemented since the mid1970s in Ethiopia. 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. 2. 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.

The researcher 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.

The researcher 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 trans log 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 fanyajuu 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.

2.3. 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.

2.4. Conceptual framework

The conceptual framework used in this study makes a reference to the process of evaluating the impact of a program or an intervention on an outcome indicator. It requires conceptualizing and answering the tough question: 'what would be happen to the participants of a program/an intervention have they not participated in it?' Referrers to as 'the fundamental problem of causal inference' or 'fundamental evaluation problem' this is a serious issue since an individual can only be in a state of either participating or not participating in the program at a given time. The ideal way to deal with the problem of counterfactuals is to employ Randomized Control Trials (RCTs) following the potential outcome approach or Roy–Rubin model. However, RCTs will not viable in the present study setting due to non-random allocation of farm households to treatment and control groups (i.e., placement/targeting bias) and selection bias. The alternative to the

experimental approach was the used for quasi-experimental approaches, which seek to create, using empirical methods a comparable control group that can serve as a reasonable counter factual.

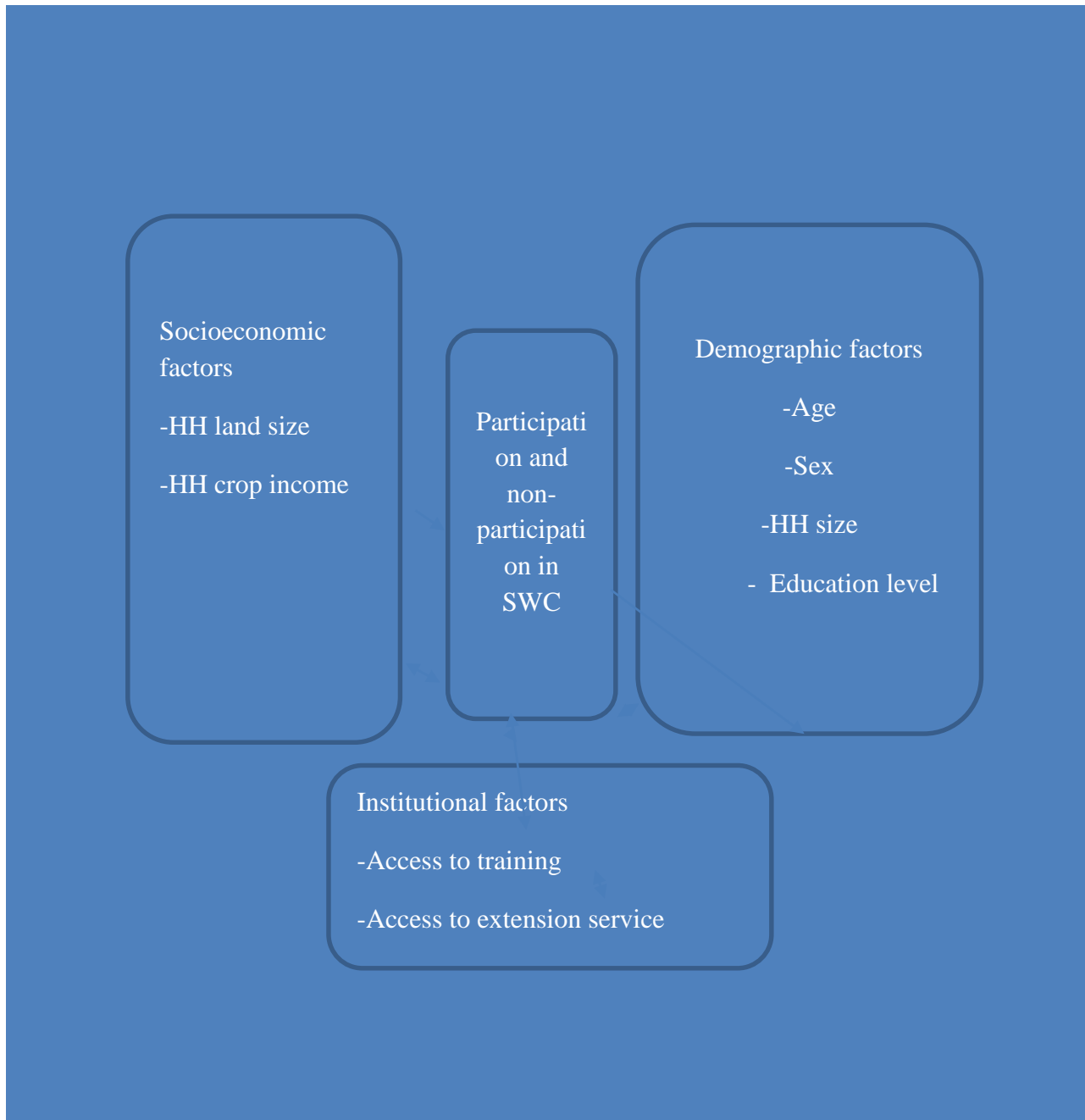


Figure- 3 Conceptual framework for participation of soil and water conservation practices

Source own computation, 2023

CHAPTER THREE

3. RESEARCH METHODOLOGY

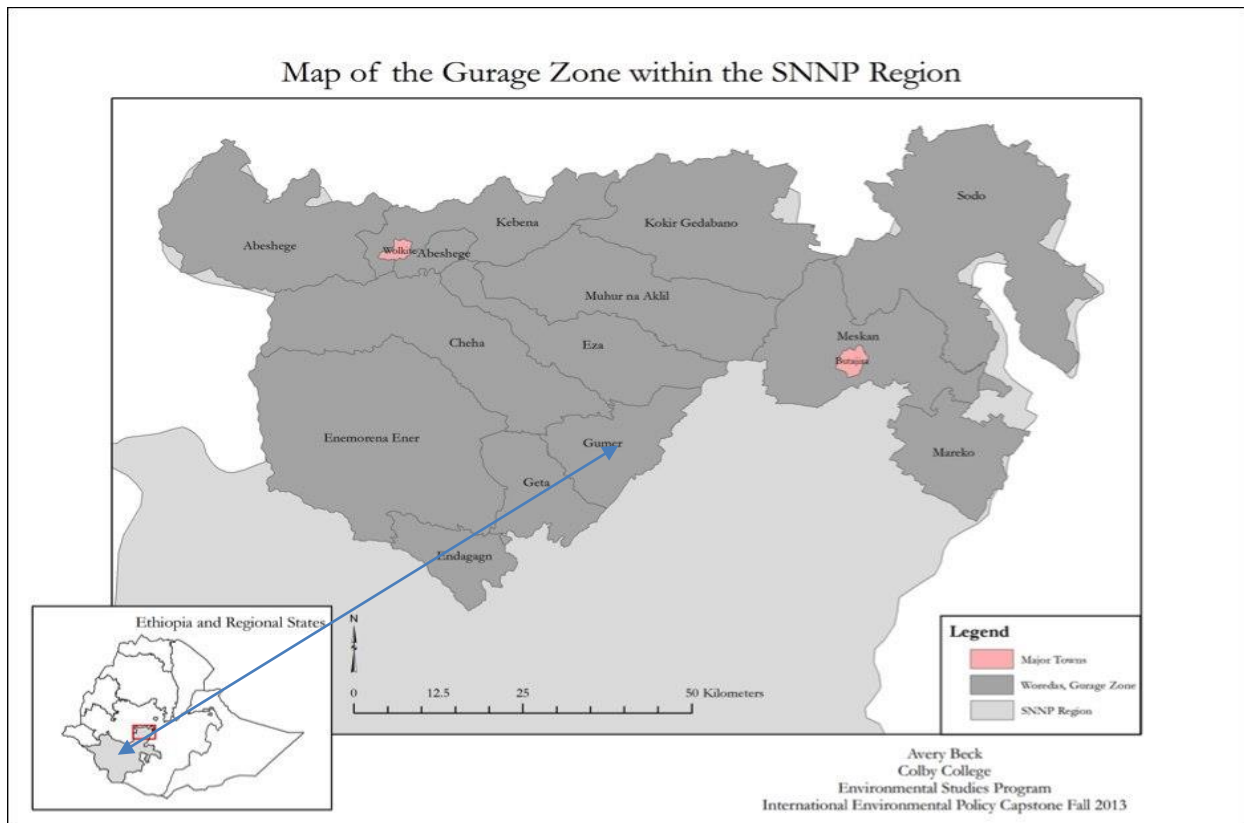
3.1. Description of the study area

Gumer district was one of the woreda in Gurage zone. The woreda forms the upper rectangular land mass of the high land, it bordered by Ezha woreda in the north, Geta woreda in the south, Silte zone in east and Cheha woreda in west. The town of the woreda (Arekit) was found 65km far from the zone town (Wolkite), 220km far from Addis Ababa and 260km far from Hawassa.

The district overall size was estimated to be 25,352 hectare, with one urban and eighteen rural kebeles. The altitude of the district ranges from 1700 to 3178 meter above sea level, the minimum and maximum temperature of the district is 16 to 21 degree centigrade and annual rainfall ranges between 900 to 1200mm.

The total population of the woreda were 116,362, from this population 56,992 were men and 59,370 are women. According to the census information from the total population 5.75% were urban and the others 94.25% were rural dweller (woreda administration).

Figure 1: map of study area



Source;- Web. colby.edu,2013

3.2. Sampling procedure and sample size determination techniques

In this research, cross-sectional survey design was used to assess the impacts of SWC on crop productivity. Before data were collected, adopter and no adopter households were identified for the survey. Based on a cross-sectional survey design, the study applied a quantitative and qualitative mixed research approach, which was important for the study at an available time and available resources. Cross-sectional survey relies on existing differences rather than change following intervention; and, groups were selected based on existing differences and the collection of data was undertaken at one point in time. Households in the chosen kebeles split in to two groups. Using a simple random sampling techniques, 343 representative sample household (183 program participant and 160 non-program participant) were selected for the final phase (table 1).

The total number of households in these kebeles were 3239. This number was the sum of the household number for Bade, 989; Jenboro, 906 and Bercher 1334

To determine the sample size, sample size determination formula of Kothari (2004) was used.

According to him the sample size for finite population was computed as:

$$n = \frac{z^2 * p * q * N}{e^2(N-1) + z^2 p * q} \text{ Where; -}$$

n= sample size z= the value of standard variant at a given confidence level

p= sample proportion, q= 1-p, p and q indicates the proportion of program participant and non-participant, respectively, with a 50% of probability.

e = given precision rate or acceptable error N = the population size and

For this study: The precision level 0.05 is being used

The sample proportion of 0.5 and z value 1.96 is used

Then: N=3239, e= 0.05 z= 1.96 p= 0.5 and q= 1-0.5= 0.5

Therefore the sample size computed as: $\frac{1.96^2 * 0.5 * 0.5 * 3239}{0.05^2(3239-1) + (1.96^2 * 0.5 * 0.5)} = 343$

Table 1: proportional distribution of sample households

Names of kebeles	Total number of household	Number of sample	Participation in and non-participation	
			SWC	SWC
Jenboro	906	96	55	41
Bercher	1334	142	76	66
Bade	989	105	52	53
Total	3229	343	183	160

Source: own computation Dec, 2015 EC

3.3. Data source and Type

Both qualitative and quantitative data were collected from primary and secondary sources. Primary data for the study was collected from selected sample households and using focus group discussion.

To collect primary data, a close-ended structured questionnaire was used as a tool to collect data from sample households. From the household survey, the data about socio-economic, institutional and demographic characteristics of the respondents and the study area were collected.

The enumerator, kebele development agents (DA) as they are more familiar and have acceptance by local peoples which helps to obtain reliable data and helps to well manage the data collection process. The enumerators were an intensive training on data collection procedures, interviewing techniques and the detailed contents of the questionnaire. Strict supervision was done by the researcher during the course of the survey.

Secondary data gathered from documents and publications of different organizations, woreda Agricultural and administration office and from journals which were relevant to impact of soil and water conservation on crop productivity were collected. In order to get relevant and detailed information about households' impact of soil and water conservation on crop productivity practice in the district, focus group discussion and key-informants interview was used in the study area. For both, focus group discussion and key informant interviews were also used in the study area. For both, focus group discussion and key informant interview, unstructured interview,(guiding question) were used as a tool for data collection.

Three focus groups, one from each selected kebeles consisting of 4 to 6 purposively selected farmers household heads, by including male and female household heads, were used for collecting the detailed data using guiding questions. In focus group discussion the socio-economic and institutional issues that the impact of SWC on crop productivity were stressed and data that could support household survey data collection were used.

3.4. Method of data analysis

Data Analysis- Basic statistics and econometric methods used to analyze the empirical data by STATA version 14.2. Descriptive and inferential statistics were used to describe sampled

households and draw relevant conclusions about them in terms of the different demographic, economic and institutional characteristics and the SWC practices that have been made available to farmers.

3.4.1. Descriptive data analysis

Descriptive statistics, such as mean and standard deviation, were used to present summary statistics of quantitative data related to demographic, socio-economic, and institutional characteristics of sample households.

3.4.2. Inferential statistics

T-test and Chi-Square (χ^2) test, were used to assess the existence of statistically significant differences in observations between SWC technology user and non-user groups of respondent's. In the present study a number of econometric methods were used elsewhere to study impact of programs (Pender and Gebremedhin, 2006). The propensity score matching (PSM) has become a popular approach to estimate causal treatment effects and was being increasingly applied in policy program evaluations (Heinrich *et al*, 2010) mainly because it was based on comparable observations which reduces the selection problem when there was two categories of response. This study have been used PSM to analyze the impact of SWC practices on crop productivity in the highland of the study area.

3.4.2. Propensity score matching methods (PSM) for impact analysis

Impacts are discreet (usually binary) variables. Treatments are heterogeneous in the population (Heckman *et al*.1997. Robin 1997), developed a frame work that each household has two potential outcome; an outcome when adopting technology (y_1) and not adopting technology (y_0). If we let the adoption status d , $d=1$ for adoption of SWC practices and $d=0$, for no adoption of SWC practices, then it was possible to write the observed outcome Y of the household performance as a function of the two potential outcome as

$$Y = dy_1 + (1-d)y_0 \text{-----} (1)$$

The causal effect of the adoption of on its observed outcome Y is the difference between the two outcome ($y_1 - y_0$). But because of the realization, the potential outcome is mutually exclusive that is only one of the two outcome has been observed at a time (Nguezet *et al*, 2011). It is also impossible to measure the individual effect of adoption in any households. However, it can be possible to estimate the mean effect of adoption on a population households. Such mean parameter is called average treatment effect (ATTE) (Imben and Wooldridge, 2009)

The following relationships characterize the logit model, following Gujarati and Porter (2009) constructed over probabilities. Accordingly, given the probability of being in the SWC program (π_i)

$$P_i = \frac{e^{z_i}}{1 + e^{z_i}}, \quad \text{And the probability that a household belongs to non-program, } (1 - \pi_i) \quad (1)$$

$$1 - P_i = \frac{1}{1 + e^{z_i}}. \quad (2)$$

The odd ratio ($\pi_i / (1 - \pi_i)$) is defined as $\pi_i / (1 - \pi_i) = e^{z_i} / (1 + e^{-z_i}) = e^{z_i}$ (3)

And L , the logit model should be modelled by the following relationship

$$L_i = \ln(\pi_i / (1 - \pi_i)) = Z_i = \beta_1 + \beta_2 X_2 + \beta_3 X_3 + \dots + \beta X_i + u_i, \quad (4)$$

Where Z_i is the probability of adoption, β_1 is intercept, β_2 is estimated regression coefficients, X_i is pre- conservation program intervention characteristics, and $U_i = a$ disturbance term. The propensity score ranged from 0 to 1. All statistical analyze were performed using STATA14.2.

Propensity score matching model: -

For this study, the intervention was participation in SWC practice. However, estimating the effect of treatment on outcome is a major challenge because of the following three expected biases: the selection of observables resulting from sampling bias, the selection of comparison groups in the presence of externality, and the selection of unobservable characteristics (Wooldridge, 2010). According to Mendola (2007) both OLS and IV procedure impose linear functional form, and finding instrument are very difficult in impact analysis procedure. In addition to this, unlike an observed control variable, an instrumental variable is assumed not to have any direct effect on the outcome. Instead, the instrumental variable is thought to influence only the selection in to the treatment condition which results in over estimation or under estimation of the impact under consideration. In simple regression or logistic model, the coefficient on the control variables would be the same for participant and non-participant. Due to this limitation, the PSM method developed

by Rosenbaum and Rubin in (1983) is generally adopted in various literature to examine the effect of treatment on outcomes. Because of non-parametric approach to the balance of covariate between the treated and the control groups, the PSM methods improve the ability of regression to produce reliable causal estimate (Conniffe *et al.* 2000). Thus, by considering these advantage PSM was used for this study to estimate the impact of participation in soil and water conservation technology on crop productivity. Despite many advantages, PSM can't handle the problem of unobserved characteristics, and therefore depends on the quality of the observational data (Li, 2013). This study attempted to minimize this limitation by collecting quality data, the inclusion of the most relevant variables, and the use of recommended matching techniques. According to Caliendo and Kopeinig (2008), the implementation of PSM involve six steps. These are: estimation of propensity score, choosing the matching algorithm, checking for common support region, matching quality test, impact estimation and sensitivity analysis.

Estimating the propensity score:

According to Kousar *et al.* (2019), the propensity score is defined $p(x_i)$ as the conditional probability of receiving a treatment given pre-treatment characteristics:

$P(x_i) = \text{prob}(D_i=1/x_i) = E(D_i/x_i)$ where $D_i=(0,1)$ is the dummy for participation and x represent the vectors of household characteristics. The conditional distribution of x , given the propensity score $p(x)$, is similar in both group of participant and non-participants. PSM constructs a statistical comparison group that is based on a model of the probability of participating in the treatment (T) conditional on observed characteristics (x), or the propensity score: $p(x) = \text{pr}(T=1/x)$. Since the propensity is unknown, the first task is matching is to estimate this propensity score. Estimating the propensity score involves the identification of the probability of participation in WSC.

When estimating the propensity score, two choice have to be made. The first one concerns the model to be used for estimating the probability of participation in soil and water conservation, and the second one is about the variables to be included in that model (Caliendo and Kopeinig, 2005). For binary dependent variables, the model that are used to estimate the probability of participation against non-participation households are logit or probit models. However, the choice between the

two is not as problematic as they provide the same results (Fadare *et al.*, 2014). Therefore, due to its simplicity, the logit model was used to determine the propensity score of the sample households.

Matching theory in the propensity score generated through the logit model should include predictor variables that influence the selection procedure or participation and the outcome of interest (Bergstra *et al.*, 2019). Based on this suggestion, 16 independent variables that simultaneously affect household' decision to participate SWC and the outcome variables were included in this study.

The common support region determination:

According to Rosenbaum and Rubin (1983), the validity of the output of the PSM method depends on two basic assumption: the conditional independence (CIA) and the common support condition. The CIA argues that the treatment needs to meet the criterion of being exogenous, meaning that any systematic difference in outcome between treatment and control groups with the same values for characteristics X can be attributed to treatment. The common support condition means that there is sufficient overlap in the treated and untreated unit characteristics to find appropriate matches. The common support region is the area that contains the minimum and maximum propensity scores of treatment and control group of households. It is a region where the propensity score of the participant and non- participant overlap. Then, outcome of treatment and control households with similar propensity score are compared to obtain the program effect. Households for which no match is found are dropped because no bias exists for comparison. This is done by cutting off those observation whose propensity scores are smaller than the minimum and greater than the maximum of participation and non-participant groups (Caliendo and Kopeinig, 2005).

Choosing matching algorithm:

Matching aims to find the closest comparison group from a sample of participant to non-participant. Thus, after the estimation of the propensity scores, seeking an appropriate matching estimator is the major tasks. There are four common matching algorithm that are widely used, including nearest neighbor matching(NNM), kernel matching(KM), radius matching and caliper matching(CM) algorithm (Caliendo and Kopeinig, 2008). Among them, a matching estimator that

bears low pseudo R², results in large matched samples and insignificant explanatory variables after matching should be chosen among them (Dehejia and Wahba, 2002).

Testing the matching quality (effect analysis):

The matching quality of the best matching algorithm should be tested for its quality using different parameters. The basic idea is to compare the situation before and after matching and check if there are any difference after condition on the propensity score. Whether the matching procedure can balance the distribution of different variables or not since our conditioning is on propensity score rather than on all variables in both treated and comparison groups (Caliendo & Kopeinig, 2021). While there are different procedures available to check, the basic aim of all of them is to compare before and after matching and if there still exists any difference after conditioning on the propensity score. If the differences exist, there is an indication of incomplete (unsuccessful) matching and suggests remedial for actions (Caliendo & Kopeinig, 2021). Based on this, matching considered a good match when there is no statistically significant difference in the mean of covariate of both group, significant mean bias reduction and low pseudo-R² (Caliendo & Kopeinig, 2021). There are several indicators to check for matching quality. These are standardized bias, t-Test, joint significance and Pseudo-R², and stratification test.

Impact estimation

Following matching quality test, impact estimation needs to be conducted using the average treatment effect on the treated (ATT). It is the mean outcome difference between intervention participant and non-participant matched by PSM. ATT are defined as the average effect for sample households with a given value of the explanatory variables. Hence, the ATT of the individual can be defined as the difference between the expected outcome variable (household income). For this study it is estimated by taking the mean difference between participant and non-participant that are matched through the propensity scores (Caliendo & Kopeinig, 2005).

ATT will be estimated as

$$ATT = E(Y_{1i} - Y_{2i} / D_i = 1)$$

$$ATT = E [E(Y_{1i} - Y_{2i} / D_i = 1, p(x))]$$

$$ATT = E [E(Y_{1i} / D_i = 1, p(x)) - E(Y_{2i} / D_i = 0, p(x))] \text{ where}$$

Y_{1i} is the expected outcome variable (household income) if the household i participate in SWC
 Y_{2i} is the expected outcome variable (household income) of households i that did not participate in SWC and x represent the vector of household characteristics.

Sensitivity analysis

An assumption of the matching methods are based on CIA, which states that the researchers should observe all variable that are at the same time influencing the participation decision and outcome variable (annual income). The estimation of participation effect with matching estimators is based on the confoundedness or selection of observation assumption. However, if there are unobserved variables that affects the assignment in to treatment and the outcome variable simultaneously, a hidden bias might arise which invalidate the CIA and its result in biased estimate of ATT. Since estimate are not robust against. It is important to test the robustness of results depart from the identified assumption. However, it is impossible to estimate the magnitude of selection bias with non- experimental data. To address such a problem. In this study. Sensitivity analysis was applied accordingly (Rosenbaum, 2002).

Estimation of the propensity score

After the estimation of the propensity score and the logistic model appropriate diagnostic measure were used on the data that the hypothesized variables. Accordingly the tests for outlying observation, multicollinearity and heteroscedasity and model specification, goodness of fit and omitted variables were used. Outlying observation with extreme influence (residual value >2.5) were removed from the analysis. To this effect out of the observation were discarded. Results of multicollinearity test using variance inflation factors showed that there was no serious problem of multicollinearity detected. Similarly the test for the presence of heteroscedasity using Breush-Pagan test showed that there was no heteroscedasity problem at $<5\%$ propability level and further comparison of standard error difference between the two cases. Result of post estimation test showed that the model perform well. The model in general was significant at $<1\%$ level of

significance showing the appropriateness of the model for estimation. The goodness of fit is test using Hosmer-Lemeshow test result insignificant value suggesting that the model was fit to explain the relationship well. The model was also checked for model specification using link test and the results indicated that there was no such a problem.

3.4.3 Description of variables and Hypothesis

3.4.3.1 The Dependent variable

The dependent variable in this model is the participation of household in soil and water conservation practices and its impact on crop productivity. It is a dummy variable indicating that a given household has participated in soil and water conservation program taking a value 1 or 0 otherwise.

3.4.3.2. Outcome variable:

The outcome variable in this study is the total annual income of household. It is a continuous variable by which it measured in birr. It is expected that formal market participation increase net potato and barley income of the households. Therefore, it is expected that participation in formal market would improve net potato and barley income of the households.

3.4.3.3. Independent (Explanatory) Variables

Binary logit model was used to estimate propensity scores using a composite of pre intervention characteristics of the sample house hold and matching was performed using propensity score of each observation. The dependent variable of the model was dummy indicating whether a given house hold has adopt SWC measures taking a value of 1 or 0 otherwise.

According to matching theory the PSM generate through the logit model was include predictor variable and the outcome of interest. Therefore, before matching the result of logit estimation shows that the probability of household taking part in SWC work should be significantly determined by:-

1. **Age (Age HH).** The age of the household head is continues variable and linked to soil and water conservation practice negatively and substantially. Despite years of agricultural knowledge,

farmers become more risk-averse as they aged, making it difficult for them to implement SWC methods.

2. Level of education (EDU). This is a dummy variable taking a value of 1 if the household head has a formal education and 0 if a farmer has no formal education at all. Education increase farmer ability uses of SWC and has significantly positive relationship between education and SWC practices.

3. Family size (FAMS). A continues variable and household who have more family size have more opportunity to participate in SWC program than household that have less family member, so family size have significantly positive impact on SWC participation.

4. Farm experience (Far Exp). It is a continuous variable measured by years stayed in SWC practices and have got more experience in impact of SWC in agricultural productivity. So it has positive relationship between them.

5. Extension service (EXTN). The variable is measured as a dummy variable taking a value 1 if the household head has contact the development agent and 0 otherwise.

Extension services will be expected to have positive effect for SWC participation and farmers that have frequent contact with development agent (DA) will have better knowledge to do SWC practices.

6. Farm size (FARSIZ). Is continues variable, the number of hectare of land that the household owned affect the participation in SWC practice. Means if the larger the hectare of land owned their participation in soil and water conservation practices is high and have positive relationship.

7. Sex (SHH). Is a dummy variable that taking a value 1 if the house hold head is male and 0 other wise and have significantly negative effect on SWC practice because of male and female may have different level of interest and physical fitness on participation in SWC practice.

8. Farm distance (FARMDIS). Is continues variable farm distance that household will be negative and insignificantly influenced. Predictors starting that female and household who are traveling long distance from their home to farm will be less likely to involve in SWC activities.

9. Economically active household. It is hypothesized that economically active household have impact on household decision to adopt SWC and has positive effect on crop productivity.

10. Sloppiness of the land. It is continues variable that influence the adoption of SWC on crop productivity. The steeper the slope, the more problem will be with soil erosion and runoff and the less productivity the land will be. And it might indirectly encourage adoption of new technology that are helpful to protect the land from possible erosion.

11. Land ownership. It is a dummy variable that take 1 the land ownership 0 other wise and it is another important variable because if the land is rented out or share cropped the producer will only interested on the short term output that he/she can get from the land no other valuable things like SWC adoption for the land.

12. Livestock ownership (TLU).Is assumed another proxy for wealth and found it to be an impact variable on adoption of SWC and crop productivity. This is induces the household to apply compost for soil fertility and has positive effect to practice on SWC technology.

13. Crop yield. As the farmer participate in soil and water conservation increase crop yield and positive relationship with SWC

14. Distance to FTC. It is a continues variable,the distance between the farmer's residence and the farmer's training center negatively influence the involvement of soil and water conservation practices. Thus, living further from FTC is decrease the livelihood of engaging in SWC practices.

15. Training. Farmers with access to trainings are eager to adopt to soil and water conservation practices. This shows a strong and positive relationships with program participation, implying that households that receive training will more likely to undertake soil and water conservation.

CHAPTER FOUR

RESULT AND DISCUSSION

This chapter describe the major finding of the study obtained from the survey and secondary data. Both descriptive statistics and econometric model were used to analyses the primary data. Under descriptive statistics mean, standard deviation and percentage were used to describe household and farm characteristics that affect household decision to participate in soil and water conservation practices.

In the second section, econometric model results for soil and water conservation program participant and non-participant of explanatory variables are explained.

4.1 Demographic and socioeconomic characteristics of households

Table 2 explained that the socioeconomic characteristics of the SWC participant and non-participating households are presented. The results demonstrated that male households headed accounts 70.26% of the sample households, whereas female household heads account only 29.74%.

71.72 % of the SWC participant and non- participant read and write, 28.28% are didn't read and write. In terms of training access 67.35% were access to training and 32.65% didn't have training access.

Table 2. The socio-economic characteristics of participants and non-participant in SWC

Variables	Category	frequency%	participation on swc	non-participation on swc
Sex	female (0)	102(29.74%)	74(21.57%)	28(8.16%)
	Male (1)	241(70.26%)	155(45.19%)	86(25.07%)
Education	No read & write (0)	97(28.28%)	32(9.33%)	65(18.95%)
	Read & write (1)	144(41.98%)	107(31.2%)	37(10.79%)
	Primary school (2)	96(27.99%)	86(25.07%)	10(2.92%)
	Secondary school (3)	6(1.75%)	4(1.17%)	2(0.58%)
Training	No access to training (0)	112(32.65%)	9(2.62%)	103(30.03%)
	Access to training (1)	231(67.35%)	220(64.14%)	11(3.21%)

*** Statistically significant at 1% **

The result shown in table 3, explained that on average family size of both groups have 7 members on the other hands on average farm size of the household heads of program participant have 0.94 ha of land whereas, the HH's head of non-program participant have 0.95 ha of land. On the other hands, the frequency of extension service visits, on average the program participant got 19 times and non-participant got 18 time as per season work. Both program participant and non-participant the households head age were 54 years old. The average annual household income program participant was 6047.46 ETB but the average annual income of non-participant was 5688.28 ETB. The average distance between household home to farmer training center was 1.34 km for program participant and 1.38 km for non-program participant

Table 2- characteristics of households and program participation (continuous variables)

Variables	Total sample		participant in swc		non-participant in swc	
	Mean	SD	Mean	SD	Mean	SD
Age	53.9621	4.753118	53.43716	4.537404	54.5625	4.934397
Family size	7.011662	1.464945	7.038251	1.538395	6.98125	1.380328
Farm size	0.943513	0.3716023	0.939618	0.379607	0.947969	0.363675
TLU	2.049563	1.014741	2.076503	1.066289	2.01875	0.9547753
HH crop income	5879.913	1525.856	6047.459	1440.56	5688.281	1601.012
Farm experience	26.02915	6.398033	25.51913	6.340036	26.625	6.433978
Distance to FTC	1.365466	1.574203	1.34623	1.549446	1.387469	1.606644
Extension contact	18.95044	4.0725	19.06557	4.003579	18.81875	4.158604

***And statistically significant at 1% and 5% respectively**

Source own survey, 2023

4.1.1 Crop Yield

Table 4: Major crop production in the study area

s/n	Variable Name	Potato			Barley		
		Area(ha)	production(qt)	Yield(qt/ha)	Area(ha)	production(qt)	Yield(qt/ha)
1	Participant in SWC	0.321	31.3	97.5	0.132	2.23	17
2	non-participant in SWC	0.322	30.36	94	0.138	2.28	16

Source own survey, 2023

The main crop in the study area during 2014/2015 agricultural season are listed in table 4. potato yielded 97.5 qt/ha and barley produced 17 qt/ha whereas non participant produced potato 94 qt/ha and barley produced 16 qt/ha. On average those who participate in soil and water conservation program produce greater agricultural product than those who did not. This is because the soil and water conservation program in the treatment group preserve more soil nutrient than those who did not. Birtukan *et al* (2020) found that water shade management intervention hosted crop yield and revenue. Which is consistent with our finding.

4.2. Econometric analysis

In this section econometric estimation results is presented and discussed. In this study one of the objective was to analyses the economic importance of Soil and water conservation in household income. As noted earlier to analyses the economic importance of household crop income participation in SWC activities logistic regression model was employed and propensity score matching estimation technique was used for the impact of SWC on crop productivity in household income.

4.2.1. Determinant of household participation in soil and water conservation practices

In this study logistic regression model was used to determine the degree of influence and the direction of the relationship between household socioeconomic characteristics and the household decision to participate in soil and water conservation technology. Before taking the variable in to the propensity score matching model some assumption were tested among the explanatory and dependent variable and there is no serious problem of propensity score matching assumption to be violated. The test resulted some of the propensity score matching assumption have been described as follows.

Heteroscedasity test: Brusch pagen /cook Weisberg/ the existence of the problem of Heteroscedasity were tested by Brusch pagen/cook Weisberg hettetst/. This test results shows there

was no Heteroscedasity problem with chi2 value 0.48 and the corresponding p-value 0.4862 which reject the null hypothesis that accept the alternative hypothesis.

Ho: constant variance

Variables: fitted value of userandnonuser SWC

chi2 (1) =0.48

Pro>chi2=0.4862

In (appendix IV)

The variance inflation factor (VIF) and contingency coefficient were used to test the multicollinearity problem among continuous and dummy variables. For the continuous variables the VIF greater than ten(10) reveals that have strong correlation and measure inflation in variance due to multicollinearity and the value of contingency coefficient is a chi-square measure of association where a value greater than 0.8 shows the existence of multicollinearity problem(Green, 2003). Based on the result in (appendix v), the mean VIF value was 1.00 for each explanatory variables. This implies that the data had no serious problem of multicollinearity. This is because for all explanatory variables, the value of VIF are by far less than 10. The contingency coefficient was 0.4862, this result shows that there was no strong association different hypothesis discreet explanatory variables, since the respective coefficient were very low (<0.8).see appendix

The goodness of fit of the model for the logistic regression model, an intuitively appealing way to summarize the result of the fitted logit model was via a classification and model specification was tested by link test

Table 5: Logit model result of household’s soil and water conservation participant and non-participant

Explanatory variable	Coef	Std.Err	Z value	P>z	odd ratio
Age	-0.0996257	0.499086	-2.00	0.046	0.9051762
Sex					
Male	-0.8506663	0.3275616	-2.60	0.009	0.4271302
Family size	0.4340858	0.1508475	2.88	0.004	1.543551
Farm land ha	-0.414842	0.4703546	-0.88	0.378	0.6604446
CultiPotato land ha	0.380111	1.373846	0.28	0.782	1.462447

Potato production qt	0.0126537	0.0154815	0.82	0.414	1.012734
Barley land ha	-3.042374	12.77643	-0.24	0.812	0.0477215
Barley production qt	-0.3287671	0.7666539	-0.43	0.652	0.7198106
Education					
Literate	0.3020629	0.3468341	0.87	0.384	1.352646
Primary	0.8707032	0.4033926	2.16	0.031	2.38859
Secondary	0.3113041	0.7970206	0.39	0.696	1.365204
Farm experience	-0.549716	0.269089	-2.04	0.041	0.9465121
Distance to FTC (km)	-0.256785	0.0968257	-0.27	0.791	0.9746484
Land sloppiness	-1.027846	0.152214	-6.75	0.000	0.35777769
No of animals (TLU)	-0.004324	0.1525678	-0.00	0.998	0.9995677
HH crop income	0.0002668	0.0001169	2.28	0.023	1.000267
Extension service	0.0872555	0.0351603	2.48	0.013	1.091175
Training					
Access to training	2.079477	0.3340726	6.22	0.000	8.000286
-cons	2.090023	2.404037	0.87	0.385	8.085115

Log likelihood = -157.63083

Number of observation =343

LRchi2 (16) =158.69

Pro> chi2 =0.000

Pseudo R2 =0.3348

Source: own computation, 2023

4.2. The economic impact of soil and water conservation on crop productivity

4.2.1 Determinant of soil and water conservation

The result of logistic regression model investigated that the factors of influencing farmers participation in soil and water conservation initiatives presented in Table.5. The expected values fit the observed data well, according to the result of binary logistic regression model, including all predictors were highly significant (pro >2, DF =16 and p=000).

Age of HH head; - The age of HH head was linked to soil and water conservation practice negatively and substantially. Despite agricultural knowledge, farmers become more risk averse as they age, making as difficult for them to implements soil and water conservation methods. When all others variables held constants, a one year increase in age reduce the involvement of soil and water conservation practice by 9.9%. This finding is in line with those of Asfaw and Neka (2017), similarly, Daniel and Mulugeta (2017) reported that older farmers became exhausted and were unable to take care their farmlands. In contacts to our findings Mengistu and Assefa (2020) discovered that there was a favorable condition between age and SWC.

Sex of household head (Sex); - Sex of the household heads is negatively correlated with the adoption of introduced SWC practices at statistically significant level (coef =-0.8506663; p-value=0.009). This showed that male headed households are more likely to be engaged in implementation and maintenance of SWC practices than female headed households. The odds ratio of logistic regression showed that male household heads adopted the introduced SWC practices by the factor of 42.71 % than female headed households. In addition, females are involved in taking care of their children, preparing food and other related tasks at home.

Corresponding to this, Aberha(2008);Eleni(2008);Krishhan *et al.*(2008) obtained that male headed households have a higher chance to involve in soil and water conservation practices since constructing and maintaining SWC practices demand much labor. Hence, female headed households are not motivated to invest in soil and water conservation. Contrary to this, a research conducted by Fikru(2009) in Koga Watershed in Northern Ethiopia reported that gender did not have any relationship with the adoption of introduced SWC structures since women have the culture of working in their farmlands. Similarly, a research conducted by Tenge *et al.*

(2004) explained that female headed households have adopted more than males. Most fields affected by erosion have been planted with annual food crops which are mainly cultivated by women.

Household family size (family size);-refers the number of family size in a given HH's have positive impact on the participation of SWC practices positively. Adoption of new technology often implies a need for additional labors, family size contribute to participate in SWC practices. Tesfay and Alemu (2001), shows family size influence the engagement of soil and water conservation practices positively by 154.4 %

Family size correlated insignificantly but positively with the adoption of introduced SWC practices (coef=0.4340858; p-value= 0.004).Eleni (2008); Habtamu (2006); Million and Kassa (2004) stated similar results. They described that small sized household family is less likely to involve in retaining of soil and water conservation practices than larger sized household family. The larger the family size could provide the required labor for implementing and maintaining conservation practices. But Fikru (2009); Aklilu (2006); Foltz and Jeremy (2003) stated that farmers with larger family sizes are less likely to continue using introduced soil and water conservation practices. Because there is competition for labor between food generating off-farm activities and investment in maintenance of soil and water conservation practices. Similarly, Budry et al. (2006); Bekele and Holden (1998) indicated that physical conservation practices occupy a large area and compete for the scarce productive land resource. Thus, households with large family sizes tend to remove the constructed physical conservation structure from their farmlands.

Education (Educ);- Farmers who attained primary school were found to be more likely to participate in soil and water conservation practices positively as compared to illiterate farmers Keeping all variables equal, this is consistent with Bekele (2014). Educational status of household heads correlated positively with the adoption of introduced SWC practices at .05 level of significance level (coef= 0.8707032; p- value = 0.031). This showed that relatively better educated farmers are engaged in the adoption of the newly introduced SWC practices. The odds ratio also revealed that educated household farmers adopted the introduced SWC practices by the factor of 238.9% than non-educated (illiterate) household farmers. Similarly, Fikru(2009);Tiwari *etal.*(2008);Aberha(2008);Kirshna,BicolIngrid,andGirdhari(2008);Millionand Kassa(2004);Abera(2003); Okoye (1998);Gould, William, and Klemme*989) described that better education level of household heads having strong and positive relationship with farmers' adoption

of SWC conservation practices. Better exposure to education increases farmers' better understanding of the benefits and constraints of soil conservation (King& Alderman,2001).Contrary to this, Eleni(2008);Francis(1999) elaborated that illiterate farmers are better to be involved in the use of SWC practices than educated farmers who are usually engaged in the off-farm activity.

Household farm experience (farmexp); - Farm experience has negative relation with adoption of soil and water conservation at ($P < 0.05$). The negative sign showed that as age of farming experience increased the adoption of SWC practice decreased. Because farmers who are in the old age have lack of information and labor to practices SWC. This result is in line with Tsegaye (2014). This result contradicts with the finding a longer farm experience, a better knowledge, attitude and skill was developed on the operation SWC practices. The odds ratio indicated that the adoption of SWC practices were increased by a factor of 94.65% for an increase in farm experience by one year

Household crop income (cropincom);-rural income generating activities (RIGA) project on its survey across Ethiopia obtained that 51% share of household income is derived from crop production. This study results shows that 100 % of the total household income in the study area were earned from crop sales.

Extension contact;-participation in soil and water conservation practice is directly related to the frequency of extension contact. The odd ratio shows that 1.09 difference in the frequency of extension in favor of program participant over non-participant (at a 1% significance level). This means that the farmers understanding of physical and biological soil and water conservation practice had broadened through extension contact. According to Abebe and Bekele(2014),Sileshi *et al* (2019), and Wordofa *et al*(2020),households with more extension contact and service have a better grasp of land degradation problem and consider soil and water conservation practice as a solution.

Training: Farmers with access to training initiated the adoption of soil and water conservation practices. This shows a strong and positive relationship with program participation, implying that households that received training were more likely to undertake soil and water conservation. This is possible because training improves the soil and water conservation knowledge and skills of the farmers. According to Tiwari *et al.* (2008), Asfaw and Neka (2017) Chesterman *et al.* (2019),

Mengistu and Assefa (2020), Darkwah *et al.*(2019) training has a positive and significant impact on participation in soil and water conservation efforts. This indicated that farmers could be trained to raise awareness and support the adoption of modern technologies. According to Njenga *et al.* (2021), training provides farmers with a platform for queries and justifications.

Land sloppiness (Slope): Econometric result indicates that slope of land has negative relation with adoption of soil and water conservation and significant at ($P < 0.05$) because slope was an indicator of soil and water loss from the farm land. Thus, farmers cultivating at sloping fields perceived the problem of soil loss than farmers who cultivate at gentle or level sloping fields.

Farmers which have land from sloping area were more likely to adopt SWC technologies than on none sloping lands. Keeping other things held constant, the odds ratio showed that the adoption of SWC practices increased by 35.6% for one extra unit increase of the land sloppiness. The results is agreed with the finding of Alufah *et al.* (2012) indicate that slope of land influence the adoption of SWC measures.

4.2.2. Estimation of propensity score

Testing the balance of the propensity score and covariates

After selecting the best performing matching algorithm which satisfy the prior identified performance criteria, the balance of propensity score and explanatory variables was checked by the selected matching algorithm (kernel matching 0.5 distance in this case). Table 5.1 shows that the standard bias difference between identified explanatory variables before matching was in range -0.6%-91.9% in absolute value. But after matching the remaining standardized error difference between explanatory variables lay between 3.9%-17% in absolute value which is below the critical level of 20% suggested by Rosenbaum and Rubin(1983). It is clear that the main intention of estimating propensity score is not to get a precise prediction of selection in to treatment. Rather, the balance of the distribution of relevant variables in both groups (Caliendo and Kopeinig, 2008). Therefore, the selecting matching algorithm, kernel matching with 0.5 distance has created a covariate balance between participant and non-participant households which is important to conduct impact analysis.

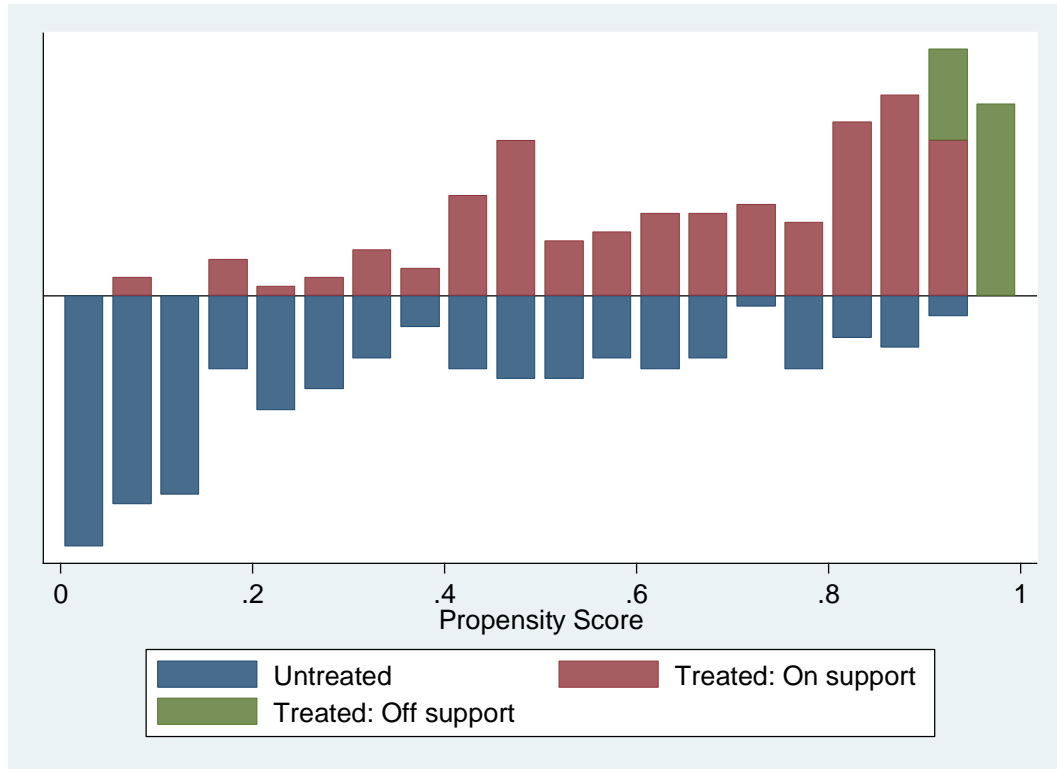
Table 5.1. propensity score and covariate balance

variable	unmatched matched	mean		% bias	% reduct	t test		v t /v c
		treated	control			t	p> t	
Age	u	53.437	54.563	-23.7		-2.2	0.028	0.85
	m	53.829	53.574	7.5	68.4	0.69	0.489	1.02
Sex	u	0.62842	0.70625	-16.5		-1.52	0.128	
	m	0.66447	0.74342	-16.8	-1.4	-1.51	0.133	
Family size	u	7.0383	6.9813	3.9		0.36	0.72	1.24
	m	7.0263	6.9342	6.3	-61.6	0.55	0.58	1.34
Farm land	u	0.93962	0.94797	-2.2		-0.21	0.836	1.09
	m	0.96842	1.0525	-22.6	-906.4	-1.87	0.063	0.97
Education	u	1.1311	0.85	32.9		3.04	0.003	1.06
	m	1.0526	1.3355	-33.1	-0.6	-2.49	0.013	0.61*
Farm experience	u	25.519	26.613	-17.1		-1.58	0.114	0.97
	m	25.862	24.809	16.6	3.1	1.31	0.192	0.61*
Distance to FTC	u	1.3462	1.3875	-2.6		-0.24	0.809	0.93
	m	1.3738	1.553	-11.4	-334.6	-0.97	0.334	0.93
Land sloppiness	u	1.0464	1.9563	-96.9		-8.97	0	0.91
	m	1.1711	1.3421	-17.6	81.8	-1.54	0.124	0.9
TLU	u	2.0765	2.0187	5.7		0.53	0.6	1.25
	m	2.0197	1.9539	6.5	-13.9	0.6	0.55	1.3
House hold crop income	u	6047.5	5688.3	23.6		2.19	0.029	0.81
	m	6076.9	5654.1	27.8	-17.7	2.64	0.009	1.25
Extension service	u	19.066	18.819	6		0.56	0.576	0.93
	m	18.803	18.974	-4.2	30.7	-0.39	0.7	1.42*
Training	u	0.85792	0.45	94.6		8.85	0	
	m	0.82895	0.86184	-7.6	91.9	-0.79	0.429	
Potato land in ha	u	0.32115	0.32269	-1.5		-0.14	0.891	0.95
	m	0.31862	0.30099	17	-1044.9	1.64	0.103	1.45*
Potato production in qn	u	31.279	30.356	9.9		0.92	0.36	1.1
	m	31.382	34.336	-31.8	-220.2	-2.79	0.006	1.18
Barley land in ha	u	0.1324	0.13831	-19.7		-1.84	0.067	0.54*
	m	0.13382	0.13217	5.5	72.2	0.6	0.552	1.71*

Barley production in qn	u	2.2276	2.2849	-11.6		-1.08	0.28	0.68*
	m	2.2349	2.1543	16.4	-40.6	1.65	0.099	1.62*

4.2.3 Common support condition

After estimating the values of propensity score for soil and water conservation user and non-user. The next step in the propensity score matching technique is the common support condition. Only observations in the common support region matched with the other group considered and the other group be out of further consideration. Once the region of common support is identified, sample HH that fall outside region have to be dropped and the treatment effect can't be estimated for these sample HH. The propensity score graph in figure (2) revealed that the distribution of the total sample HH in adopter and non-adopter in the sample HH with respect to estimated propensity score. The common support region would then lie on 0.06675137 and 0.98571863 it exclude treated units whose propensity score is higher than the highest propensity score of the control unit and control unit whose propensity score is lower than the lower propensity score of the treatment units. Therefore, HH whose estimated propensity score less than 0.06675137 and larger than 0.98571863 were not considered for the matching exercise. With this restriction, totally 31 HH in the adopter side were discarded from the analysis. The common support condition obliges to drop down observation with probability of participation greater than 0.98571863. Accordingly 152 observation from the participant and 160 from non-participant groups satisfy the common support



condition.

Figure 2: PS graph

Source, own survey 2023

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
household_crop~e	Unmatched	6047.45902	5688.28125	359.177766	164.2429	2.19
	ATT	6076.90789	5654.11184	422.796053	287.362387	1.47

Note: S.E. does not take into account that the propensity score is estimated.

psmatch2: psmatch2: Common			
Treatment support			
	off support	on support	Total
Untreated	0	160	160
Treated	31	152	183
Total	31	312	343

Source; own computation, 2023

4.2.4. Matching algorithm selection

Propensity score and covariate test were used to verify whether the matching estimator adequately balanced all explanatory factors for the three matching algorithm (caliper matching, kernel matching and nearest neighbor matching) According to Caliendo and Kopining(2008), Kernel matching with bandwidth(0.25) is the best estimators because it produce relatively large sample size minimum mean bias (0.104)low pseudo R2(14.1) and best balancing test(all explanatory variable are insignificant after matching. As a results, we estimated the ATE participation in SWC practices on crop income using a Kernel matching algorithm.

4.3. Average treatment effect (ATE) with test

To attain the main objective of this study, on this section evaluated the program impact on the outcome variable for their significant impact of soil and water conservation adopter, after the pre intervention difference were controlled. The impact indicators which consider as outcome variable are household income. Their estimated average treatment effect (ATE) is (422.79 birr) annual income from crop production.

4.4. Matching estimation of the ATT based on the propensity score outcome

4.4.1. Nearest neighbor matching (attnd.ado)

The most straightforward matching algorithm is nearest neighbor (NN) matching. The individual

from the comparison group is chosen as the matching partner for a treated individual that is closest in terms of propensity score.

Table 2: ATT estimation with nearest neighboring matching analytical standard errors

n. treat.	n. contr.	ATT	Std. Err.	t
183	65	518.770	335.702	1.545

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

Source; own survey data 2023

ATT estimation with nearest neighboring matching method (random drawn version)

Bootstrapped standard error

Table 3: ATT estimation with nearest neighbor matching bootstrapped standard error

n. treat.	n. contr.	ATT	Std. Err.	t
183	65	518.771	293.257	1.769

Note; the number of treated and controls refers to the nearest neighboring matches.

Source; own survey data 2023

The nearest neighboring only 65 controls variables have matched to 183 treated analytical standard error (335.702) and bootstrapped standard error (293.257) ATT both of them are equal. These results are very close to the one obtained by Dehejia and Wahba (1998).

4.4.2. Radius matching (attr.ado)

Dehejia and Wahba (2002) suggest a variant of caliper matching which is called radius matching. The basic idea of this variant is to use not only the nearest neighbor with in each caliper but all of the comparison members with in the caliper

Table 4: ATT estimation with in radius matching analytical standard error

n. treat.	n. contr.	ATT	Std. Err.	t
2	2	600.00	1172.204	0.512

Note; the number of treated and controls refers to the actual matches with in radius.

ATT estimation with radius matching methods.

Boots trapped standard errors

Source; own survey data 2023

Table 5: ATT estimation with radius matching bootstrapped standard error

n. treat.	n. contr.	ATT	Std. Err.	t
2	2	600.00	1701.889	0.353

Note; the numbers of treated and controls refers to the actual matches with in radius.

Source; own survey data 2023

In radius matching all the treated as well as controls (in the common support which has been imposed here)are used in this results analytical standard error(1172.204) and boots trapped (1701.889) ATT of both of them are equal. The estimate of ATT is greater than to the one obtained in kernel matching.

Kernel matching (atrk.ado)

The matching algorithm discuss so far have in common that only a few observation from the comparison groups are used to construct the counterfactual outcome of a treated individual. As Smith and Todd (2005) note, kernel matching can be seen as a weight regression of the weight

counterfactual outcome on an intercept with weight given by the kernel weight. Weight depend on the distance between each individual from the control group and the participant observation for which the counterfactual is estimated.

Boots trapped standard errors

Table 6: ATT estimation with kernel matching method

n. treat.	n. contr.	ATT	Std. Err.	t
183	124	437.716	222.738	1.965

Source; own survey data 2023

The kernel match only 124 different controls have been matched to 183 treated analytical standard errors can't computed. The bootstrapped standard error (222.738) then the estimate of ATT is less than to the one obtained with radius matching.

4.4.3. Stratification matching (atts.ado)

The idea of stratification matching is to partition the common support of the propensity score in to a set of interval (strata) and to calculate the impact with in each interval by taking the mean difference in outcome between treated and control observation. This method is also known as Interval matching, blocking and sub classification (Rosenbaum and Rubin, 1983)

ATT estimation with stratification matching

Methods Analytical standard error

Table 7: ATT estimation with stratification analytical standard error

n. treat.	n. contr.	ATT	Std. Err.	t
183	128	282.615	175.706	1.608

Source; own survey 2023

ATT estimation with the stratification matching methods

Bootstrapped standard error

Table 8: ATT estimation with stratification bootstrapped standard error

n. treat.	n. contr.	ATT	Std. Err.	t
183	128	282.615	171.775	1.645

Source; own survey 2023

In stratification matching only 183 different treated have been with stratification out of 128 control groups. The analytical standard error (175.706) & bootstrapped standard error (171.775) estimate of the ATT was quite different from to the one obtained in nearest neighbor matching. But overall the results obtained atnd, attr, atk &atts are a positive range (282.6 to 600)

Table 9: ATT for outcome variable of interest

Variable	Sample	Treated	Control	Difference	S.E.	T-stat
household_crop~e	Unmatched	6047.45902	5688.2812	359.177766	164.2429	2.19
	ATT	6076.90789	5654.11184	422.796053	287.362387	1.47

Source: own computation, 2023

The result obtained agreed with studies by Oudul *et al*, (2011) who found that adoption of SWC had no significant impact on technical efficiency of smallholder farmer in Rwanda and Democratic Republic of Congo. Some other studies have conclude that the impact may be negative. For instance, Nyangena and Kholin (2008) found that plot without SWC had higher yields than those use SWC. Nominal results of analysis of treatment effect indicate that there was a sign of positive impact on the variable considered due to SWC program (Table 9). Due to this reason SWC program are not the short term nature impact are to be realized gradually with increase adoption

and intensification of activities.

Table 10: Chi2-square test for joint significant of variable.

Sample	Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	% Var
Unmatched	0.335	158.820	.000	23.0	14.1	155.8*	0.70	14
Matched	0.104	43.83	.000	15.5	16.5	78.7*	1.35	43

Source: own computation, 2023

Testing for joint significant of variable revealed that, after matching, pseudo-R2 was fairly low and likelihood ratio test were insignificant (Table 12). This support the hypothesis that both groups have the same distribution in the covariant after matching.

4.5 Sensitivity analysis

There may be a hidden biases against the result of matching estimation and hence testing robustness the result is recommended. As it is not possible to estimate the magnitude of the selection bias with non-experimental data, the problem can be addressed through using sensitivity test. The basic issue in testing sensitivity is to check whether the treatment effect is due to unobserved factor or not Rosenbaum (2002) propose using Rosenbaum bounding approach in order to check the sensitivity of the estimated ATT. The result shows that the impact of soil and water conservation technology adoption is not changing the adopter and non-adopter households if it is allowed to differ odd of being treated up to $\gamma = 3$.

That means for the outcome variable estimated at various level of critical value of γ , the p-critical value are significant which further indicate that consideration of important covariate that affected both adoption and outcome variable. We couldn't get the critical value γ where the estimated ATT is questioned even if we have set γ largely up to 3.

Mhbounds household_crop_income, gamma (1(0.5)3)

Mantel-Haenszel (1959) bounds for variable household_crop_income

Gamma	Q_mh+	Q_mh-	p_mh+	p_mh-1
1	-0.077658	-.077658	0.53095	0.53095
1.25	-0.077658	-.077658	0.53095	0.53095
1.5	-0.077658	-.077658	0.53095	0.53095
1.75	-0.077658	-.077658	0.53095	0.53095
2	-0.077658	0.53095
2.25	-0.077658	-.077658	0.53095	0.53095
2.5	-0.077658	-.077658	0.53095	0.53095
2.75	-0.077658	-.077658	0.53095	0.53095
3	-0.077658	-.077658	0.53095	0.53095

Gamma- log odds of differential assignment due to unobserved factors

Qmh+: Mantel-Haenszel statistic (assumption: overestimation of treatment effect)

Qmh- : Mantel-Haenszel statistic (assumption: underestimation of treatment effect)

Qmh+ : significance level (assumption: overestimation of treatment effect)

Qmh- : significance level (assumption: underestimation of treatment effect)

CI+ -upper bound confidence interval (a=.95)

CI+ - lower bound confidence interval (a=.95)

Source: own computation econometric data result (2023)

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This research paper examined the underlying impacts of adoption of soil and water conservation and productivity in Gurage Zone, Ethiopia. The logit regression result showed that household family size, education, extension service, household crop income and training were found to be positive in determining the adoption of soil and water conservation participation decision. Besides, age of households, sex, farming experience and land sloppiness were statistically significant while influencing adoption of SWC participation decision negatively. Furthermore, the effect of participation on the livelihoods of smallholder's farmers basically reflected on its annual income from annual crop. Impact of participation on income of households estimate using propensity score matching. The impact analysis result revealed that adopting of SWC practices has significant role on the improvement of total income. On average the annual income of SWC adopter was 422.79 ETB as compared to non- adopter. Based on this result the government, research institute and other stakeholders in the study area should give more emphasis to the dissemination of soil and water conservation practices. According to the PSM estimation, the adoption of SWC has a dual impact on household wellbeing. Increase SWC practice increase yield and annual income. With this respect, allowing farmers to interact with this technology not only the direct impact on annual income but also a direct substitution effect on the other livelihood aspect. This leads to a conclusion that adopting SWC practices will be one of the basic instrument to enhance the living standard of farming community by increasing crop productivity.

5.2 Recommendation

- ✓ Education is a positive impact on soil and water conservation technology adoption of farmers to participate in SWC has getting formal and non-formal education by minister of education and minister agriculture more focus practical training.
- ✓ Continuous agricultural extension service agent is a positive impact on the adoption of soil and water conservation technology, so government more emphasis especially minister agriculture establishment of strengthening the institutionalize extension linkage among

different stakeholder at research level, region, zone, woreda and kebele level to disseminate SWC technology to reduce the risk.

- ✓ If the female household head were negative impact on SWC technology adoption. This problem is solved by governmental organization, especially women and children affair office, non-governmental and other stakeholder that emphasis continuous training and awareness creation of SWC technology.
- ✓ Farmers with access training initiate the adoption of SWC technology practices. This shows strong and positive impact for the implementation SWC technology because of this the government and other stakeholder facilitate training on grass root level to introduce the SWC technology and the effect.

Finally different SWC technology has applied but the farmers did not implemented actively and positively so SWC program designers and implementer at all level, should promote the positive sign of the program for achieving the desired objective of increased net crop production and household income. Further studies may also be appropriate to identify the underlying causes governing the achievement of the program in the study area (district).

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appendix 1 : Questionnaires

Household survey questionnaire SWC

Research Title:-Impact of SWC on Crop productivity in Gumer District, Southern Ethiopia.

Zone*District**kebele*.....*village*.....

Name of the enumerator..... Signature..... date.....

1. General socio-economic information

1.1. Name of household head..... Age.....

1.2. Sex 1. Male 0. Female

1.3. Marital status: 1. Married 2. Single 3.Divorce 4. Widowe.

1.4. Total family size..... Male..... Female

1.5. Category of family size Age< 15yrs..... Age15-64yrs.....Age above 64...

1.6. Education level in gradewhat is your status now?

1.7. a) can read and write b) cannot read and right c) elementary d) high school e) diploma

1.8. Farming experience.....years

1.9. Distance from home to the farm landin (km).....in (hr)?

1.10 Distance from home to FTCin (km).....in (hr)?

2. Land holding Owing in 2021/2022 G.C

2.1. Total land holdings in (timad).....Cultivated.....Grazing.....Fallowother.....

2.2. Number of plots owned.....

2.3. Slope of the land

1. Very steep 2. Steep. 3. Gentle slope. 4. Flat

3. Perception on the SWC practice in the area and its impacts.

3.1. Did you participate in SWC practice provided by government? 1) yes 2) no

3.2. If yes, which type 1. Physical SWC practice 2. Biological SWC practice 3. Both?

3.3. In which kind of soil conservation programs have you been involved? 1. Food for work
2. Money for work 3. Free 4. Others (Specify)

4. Livestock Ownership 2021/2022G.C

4.1. Do you have livestock? 1. Yes 0. No, if yes, number owned?
Cows.....Oxen..... Heifer..... Calves..... Sheep.....Goat.....
Donkey.....Horse..... Mule..... Poultry...

5. Cropping pattern (2021/2022)GC

Major Crops grown	Area covered in ha	Yield obtained in qt	Amount consumed in qt	Amount sold in qt	Income earned from selling in Birr
Potato					
Barley					
Wheat					
pea					
bean					
Others					

5.1. Have you noticed an increase in production from these major crops? 1. Yes 2. No

5.2. If yes, what do you think is /are the main reasons for the increase in crop production?

- 1. Better effort (labor productivity) 2. Improved cultivation practice 3. Improved soil and water conservation practice 4. Other specify

3.7If no, what do you think is/are the main problem if not increased?

- 1. Soil erosion problem
- 2. Labor productivity problem 3. Technology usage problem (row planting, new varieties)
- 4. Other

Amount and cost of fertilizer and chemicals used for the crop

Type of crop to which fertilizer applied	NPS (kg)	Urea (kg)	Cost of fertilizer (Birr)	Manure in (kg)	Compost in (kg)	Cost of chemicals applied (Birr)
Potato						
Wheat						
Barley						
pea						
bean						
others						

6. Animal forage related questions

6.1 Did you grow any animal forage in your farm? 1. Yes 2. No if yes,

6.2 Which type? 1. Elephant grass 2. Desho grass 3. *sesbania* and *lucinia* 4. *Acacia decurrens* and *acacia saligina* 5. All

What is the purpose of growing? 1. for feeding livestock 2. For soil water conservation 3. For sale as a source of income 4. 1 and 2 5. All

7. Income generated from farming and non/off-farm activities

7.1. Did you have any other source of income other than agriculture? 1. Yes 2. No

7.2. What are your main sources of income? 1. Farming 2. Off-farm 3. both

7.3. Income from (crop.....Livestock sell..... Dairy products.....Fruit and related..... animal forage selling..... Remittance... Non-farm (daily labor, petty trade, handcraft, etc, Total income.....Birr

1. Social Responsibility

Do you have any responsibility in the community? 1. Yes 0. No

1.1. If yes, what is your responsibility in the community? 1. Administrative 2. Social
3. Religious 4. Watershed committee member 5. All

1.2. Do your responsibilities have a negative impact in farming activities? 1. Yes 0. No

2. Credit access

2.1. Is there a credit access in your area? 1. Yes 2. no

2.2. Have you got credit in the past three years 2021/22?(2013/2014) 1. Yes 0. No

2.3. If yes, how much have you borrowed in the last two yearsbirr From
microfinance..... Cooperatives Relatives..... local money lenders.....

2.4. Did you started to repay 1) if yes 2) no if yes, how much did you repaid back.....

2.5. If it is not totally repaid, why?

8. Extension Service. Number of contacts with development agents per year

8.1. Have you been advised by any development agent about SWC practices? 1. Yes, 0.no

9. Training and related service provision

9.1. Have you got training related with soil conservation practice? 1. Yes 2. No if yes,

9.2. Who provided the training? 1. Research center 2. NGO 3. Agricultural Offices 4.
Agricultural Offices and NGO

9.3. Have you been advised by any of these organizations to undertake soil conservation
practices? 1. Yes, 0.no

10. Awareness related with soil erosion

11. Do you perceive soil erosion problem in your area? 1. Yes 0. No

If yes, what is the indication that such problem exists

1. Productivity decrease
2. Soil depth decrease
3. Soil color changes
4. Others.....

- a. Is your farmland prone to erosion? 1. Yes 0. No If yes, how much of your farmland affected by erosion in ----- (timad)
- b. How do you perceive the level of parcel's (land) exposure to soil erosion? 1. No risk
2. Medium 3. High exposure to erosion
- c. How does the household perceive the soil erosion since starting farming as Compared to the past? 1. Increasing 2. Decreasing 3. No change 4. Do not know

12. If increasing, what measures did you taken to rehabilitate the conditions? 1. Apply physical soil conservation method

2. Apply biological soil conservation method

3. Apply both soil conservation methods

- a. Did you practice any of the following physical soil conservation practice(s)?
- b. 1. Terrace 2. Counter bunds 3. Grass strip 4. Soil and stone bund
- c. If you did not practice any soil conservation measures, what is the reason?
- d. 1. Lack of money 2. Labor shortage
3. Awareness problem 4. Others

13. Questions related Labor availability

- a. Do you have labor shortage for farm activities? Yes =1 no =0
- b. If yes, for which kind of farm activities? 1. Crop production 2. Livestock production
3. Soil conservation activities
- c. If yes for the question12.1, how do you solve the problem? 1. Hiring labor
2. Use debo system 3. Other (specify)

14. If you hire labor, how much do you pay per year? ____

Unscented

appendix 2 Table 11: Chi2-square test for joint significant of variable.

Sample	Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	% Var
Unmatched	0.335	158.820	.000	23.0	14.1	155.8*	0.70	14
Matched	0.104	43.83	.000	15.5	16.5	78.7*	1.35	43

appendix 3; ATT for outcome variable of interest

Variable	Sample	Treated	Control	Difference	S.E.	T-stat
household_crop~e	Unmatched	6047.45902	5688.2812	359.177766	164.2429	2.19
	ATT	6076.90789	5654.11184	422.796053	287.362387	1.47

appendix 4: Heteroscedasity test

. estat hettest

Breush-Pagan / Cook-Weisberg test for heteroskedasticity

Ho: Constant variance Variables: fitted values of household_crop_income

chi2 (1) = 0.48 Prob > chi2 = 0.4862

appendix 5: Multicollinearity check

Variable	VIF	1/VIF
Treated	1.00	1.000
Mean VIF	1.00	

Appendix 6: variance inflation factor for variables

```
. vif
```

Variable	VIF	1/VIF
barleyland-a	7.57	0.132116
barleyprod-t	7.54	0.132619
age	2.35	0.424846
familysize	2.29	0.437186
farmlandha	1.64	0.607953
household_~e	1.59	0.629979
farmexperi-e	1.36	0.734919
education	1.27	0.786174
landslopin~s	1.16	0.862038
TLUnumbero~l	1.15	0.868136
training	1.15	0.869272
sex	1.13	0.885496
distanceto~m	1.09	0.921150
extensions~e	1.04	0.958409
potatoprod-t	1.03	0.969702
potatoland-a	1.02	0.978275
Mean VIF	2.15	

Appendix 7: estat gof

Logistic model for userandnonuser, goodness-of-fit test

Number of observations = 343

Number of covariate patterns = 343

Pearson chi2 (325) = 340.79

Prob > chi2 = 0.2626

Appendix 8: Link test for model specification

. linktest

Source	SS	df	MS	Number of obs	=	343
Model	61.1462398	2	30.5731199	F(2, 340)	=	694.63
Residual	14.9645474	340	.044013375	Prob > F	=	0.0000
				R-squared	=	0.8034
				Adj R-squared	=	0.8022
Total	76.1107872	342	.222546161	Root MSE	=	.20979

userandnon-r	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]
_hat	1.127849	.1362498	8.28	0.000	.8598507 1.395848
_hatsq	-.1215169	.1269641	-0.96	0.339	-.371251 .1282171
_cons	-.0095437	.0234266	-0.41	0.684	-.055623 .0365357

Appendix 9: Sensitivity analysis out-come variable

. mhbounds household_crop_income, gamma(1(0.25)3)

Mantel-Haenszel (1959) bounds for variable household_crop_income

Gamma	Q_mh+	Q_mh-	p_mh+	p_mh-
1
1.25	-.077658	-.077658	.53095	.53095
1.5	-.077658	-.077658	.53095	.53095
1.75	-.077658	-.077658	.53095	.53095
2	-.077658	.	.53095	.
2.25	-.077658	-.077658	.53095	.53095
2.5	-.077658	-.077658	.53095	.53095
2.75	-.077658	-.077658	.53095	.53095
3	-.077658	-.077658	.53095	.53095

Gamma : odds of differential assignment due to unobserved factors
 Q_mh+ : Mantel-Haenszel statistic (assumption: overestimation of treatment effect)
 Q_mh- : Mantel-Haenszel statistic (assumption: underestimation of treatment effect)
 p_mh+ : significance level (assumption: overestimation of treatment effect)
 p_mh- : significance level (assumption: underestimation of treatment effect)

Userandnonuser	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
Age	-.0539651	.0279065	-1.93	0.053	-.1086607	.0007306
Sex	-.5380726	.1898064	-2.83	0.005	-.9100863	-.1660589
Family size	.2989109	.0843933	3.54	0.000	.1335031	.4643187
Farmland	.0017087	.235716	0.01	0.994	-.4602863	.4637036
Education	.2043007	.1072372	1.91	0.057	-.0058803	.4144818
Farm experience	-.028305	.0149344	-1.90	0.058	-.0575759	.000966
DistancetoFTCinkm	-.0044728	.0539638	-0.08	0.934	-.1102399	.1012943
Landslopiness	-.6159064	.0845072	-7.29	0.000	-.7815374	-.4502754
TLUnumberofanimal	.0125955	.0887077	0.14	0.887	-.1612685	.1864594
Extension service	.0494638	.0202795	2.44	0.015	.0097167	.0892109
Training	1.171682	.185504	6.32	0.000	.8081007	1.535263
Potatolandinha	.2387628	.8005696	0.30	0.766	-1.330325	1.80785
Potatoproductioninqnt	.0071197	.0087923	0.81	0.418	-.0101128	.0243523
Barleylandinha	-4.474768	7.356792	-0.61	0.543	-18.89382	9.94428
Barleyproductioninqnt	-.0424504	.4469668	-0.09	0.924	-.9184893	.8335884
_cons	1.350904	1.32524	1.02	0.308	-1.246519	3.94832

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
household_crop~e	Unmatched	6047.45902	5688.28125	359.177766	164.2429	2.19
	ATT	6076.90789	5654.11184	422.796053	287.362387	1.47

Note: S.E. does not take into account that the propensity score is estimated.

psmatch2: psmatch2: Common

Treatment support

Assignment Off support on support Total

Untreated	0	160	160
Treated	31	152	183
Total	31	312	343