

**PARTICIPATION IN WATERSHED MANAGEMENT PROGRAMS AND
ADOPTION OF SUSTAINABLE LAND MANAGEMENT PRACTICES IN
BASSONAWORANA DISTRICT, CENTRAL HIGHLANDS OF ETHIOPIA**

PhD Dissertation

By

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ADDIS ABABA UNIVERSITY
COLLEGE OF DEVELOPMENT STUDIES

**PARTICIPATION IN WATERSHED MANAGEMENT PROGRAMS AND
ADOPTION OF SUSTAINABLE LAND MANAGEMENT PRACTICES IN
BASSONAWORANA DISTRICT, CENTRAL HIGHLANDS OF ETHIOPIA**

A Dissertation Submitted to the Center For Rural Development, College of Development Studies,
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of DOCTOR OF PHILOSOPHY IN RURAL DEVELOPMENT

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DECLARATION

I declare that this dissertation, which I submit for the degree of PhD in Rural Development at the Center for Rural Development, College of Development Studies of Addis Ababa University, is my original work and no material in this document has previously been submitted to another university for any degree. References from other authors have been duly acknowledged.

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This is to certify that the thesis prepared by **Kidane Tafa Teka**, entitled **Participation in Watershed Management Programs and Adoption of Sustainable Land Management Practices in Bassanaworana District, Central Highlands of Ethiopia** and submitted in partial fulfilment of the requirements for doctoral degree in Development studies (Rural Development) complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

Signed by the Examining Committee

Examiner _____ Signature _____ Date _____

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Advisor _____ Signature _____ Date _____

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ACRONYMS AND ABBREVIATIONS

| | |
|--------------------|--|
| ANRS | Amhara National Regional State |
| BWOA | Basonaworana Office of Agriculture |
| CBA | Cost-Benefit Analysis |
| DEEP | Department of Energy and Environmental Protection |
| ESR | Endogenous Switching Regression |
| ESIF Management | Ethiopia Strategic Investment Framework for Sustainable Land |
| FGDs | Focus Group Discussions |
| FFW | Food-for-work |
| GDP | Growth Domestic Product |
| IWM | Integrated Watershed Management |
| MoARD | Ministry of Agriculture and Rural Development |
| MESR | Multinomial endogenous switching regression |
| MVP | Multivariate Probit |
| OLS | Ordinary least squares |
| pca | Principal Component analysis |
| PI | Participation Index |
| PPI | People's Participation Index |
| PIA | Program Implementing Agency |
| SFM | Soil Fertility Management |
| SLM | Sustainable Land Management |
| SLMP | Sustainable Land Management Practice |
| SLMPs | Sustainable Land Management Practices |
| SSA | Sub-Saharan Africa |
| SWC | Soil and Water Conservation |
| TLU | Tropical Livestock Unit |
| TOT | Transfer of Technology |
| UNCCD | United Nations Convention to Combat Desertification |
| UNDP | United Nations Development Program |

UNEP

United Nations Environment Program

WCED

World Commission on Environment and Development

WMPs

Watershed Management Programs

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LIST OF ARTICLES/MANUSCRIPTS

- I. Kidane Tafa, Bamlaku Alamirew and Aklilu Amsalu, 2018. People's participation in watershed management programs: micro level evidence from Basonaworana district, Ethiopia (submitted).
- II. Kidane Tafa, Bamlaku Alamirew and Aklilu Amsalu, 2018. Adoption of multiple sustainable land management practices in Basonaworana district, central highlands of Ethiopia (under review).
- III. Kidane Tafa, Bamlaku Alamirew and Aklilu Amsalu, 2018. Does adoption of sustainable land management practices payoff? Empirical evidence from Basonaworana district, Ethiopia (under review).

GENERAL SUMMARY

Many studies globally and nationally have underlined the natural resources which are the base of agriculture and other economic activities are under threat of degradation in many forms. In Ethiopia, there is a widespread concern about the threat of land degradation due to soil erosion that potentially results in decreased agricultural production. In response to this, government and other partners have taken various initiatives via implementing different watershed management programs (WMPs) and promoting sustainable land management practices (SLMPs) so as to prevent soil erosion and enhance sustainable agriculture. However, the adoption of these practices by farm households is low (Tesfaye *et al.*, 2014; Wolka, 2014). Accordingly, the productivity of agriculture in the country has remained one of the lowest in the world. Owing to these facts, researchers, policy makers and practitioners have big concern on these issues.

On the other hand, despite the number of studied on SLMPs, prior empirical studies have focused on the adoption and impact of single practice/technology in different plots ignoring the combined use of SLMPs in a plot. In addition to this adoption of SLMPs in combinations may provide greater or lower revenues than individuals since the cost involved in implementing SLMPs is varied. In view of these, empirical evidence on the use of combinations of SLMPs and their impact is rather scanty. Thus, this thesis sought to shed some light on these issues by providing empirical evidence from Bassonaworana district, Ethiopia.

This dissertation has three key objectives. The first objective is to analyze the extent of people's participation in WMPs and its relationship with socioeconomic and institutional variables. The reasons for this objective are the development of successful WMPs and practices depends on people's participation in programs activities. Besides, it is assumed that WMPs can be effective in reducing soil erosion only when there is a great use of SLMPs at the farm household level (Posthumus *et al.*, 2010). Thus, voluntary participation could pave a way for better use of SLMPs at household level.

The second objective is to investigate household characteristics, risk factors, resource-related factors, access to markets and information (policy environment) and plot specific characteristics influencing adoption decision of multiple SLMPs. This is because farm households are constrained to integrate these practices into farming system and adoption rate of these practices

is low (Girma, 2015). This problem can be explained by the fact that adoption of SLMPs is affected and constrained by many factors. Therefore, understanding factors conditioning adoption of SLMPs is quite important for a widespread of SLMPs use. The third objective is to evaluate impacts of use of SLMPs on crop net income. The reason is that understanding of adoption of a combination of SLMPs and their economic implications is still quite inadequate (Di Falco and Veronesi, 2013). This dissertation estimates the true effect of SLMPs adoption by controlling the role of selection problem on production and adoption decisions. To this end, the identification of effective SLMPs has a paramount importance in order to boost crop yields and improve the income of farm households.

The first chapter sets the stage and motivation for conducting the research presented in this dissertation. It describes background of the study and outlines statement of the problem, research questions of the dissertation. Chapter two reviews concepts of watershed management programs, and sustainable land management. Chapter two also presents the research conceptual framework for scrutinizing SLMPs adoption and their impacts on crop net income.

Chapter three estimates the extent of people's participation in WMPs and its relationship with household characteristics and institutional variables. To achieve this objective, first we employed principal component analysis (pca) to generate program participation index for each farm household and rotated via varimax rotation technique. Next, factors that influence extent of people's participation in WMPs were investigated using Tobit model. The result revealed that about 18.64%, 67.51% and 13.84% of households' exhibit low, moderate and high degree of participation in WMPs campaign respectively. Furthermore, the results confirmed that the level of people's participation in WMPs lies between moderate and low but participation in maintenance stage is moderate. The Tobit analysis indicated that levels of people's participation in WMPs are influenced by age of household head, gender, family size, participation in non-farm works, farm household's contact with extension agents, size of land holding, membership in multipurpose cooperatives, distance to roads, access to market center, joining WMPs forcibly and household perceptions about the impacts of WMPs (i.e. social, environmental and economic).

Chapter four examines factors determining adoption of multiple SLMPs. A multivariate probit approach was employed to model simultaneous adoption decisions of SLMPs. The result showed

that adoption decisions of SLMPs are interdependent. It was found that that adoption of SLMPs varies enormously across households and parcels. For instance, the results indicated that plot size positively and significantly affects the likelihood of adopting soil and water conservation (SWC), manure and inorganic fertilizer. Farm households' participation in non-farm income activities and tenure security increase the probability of investment in long term land management, but it reduces the chance of short term investment. Distance to market center also reduces the likelihood to adopt SWC but increases the probability of using inorganic fertilizer. Social capital is also found to be vital in the adoption decision of SLMPs. Moreover, the result of MVP analysis shows farm household participation in WMPs increase the likelihood of adoption of SWC practice but reduce use of manure.

Chapter five analyses impact of SLMPs on crop net income by estimating a multinomial endogenous switching regression using a cross-sectional survey of 354 farm households and 1305 plots from Bassanaworana district, north Shewa zone, Amhara Regional State. The study found farm households that adopted all the three SLMPs at a time earned significantly higher crop net income (7797.39ETB/ha) than households that practiced a piecemeal or parts of the SLMPs. Estimation of the treatment also showed that crop net income is significantly higher from plots treated with SLMPs than non-treated plots. Furthermore, the results revealed that the impact of individual sustainable land management practice: SWC, manure and inorganic fertilizer on crop net income are positive and significant when implemented in isolation. More importantly, in all counterfactual scenarios, the results of analysis revealed that had the non-adopters adopted SLMPs, they would have received greater crop net income.

In conclusion, the results confirmed that the extent of people's participation in watershed management programs activities was relatively low. Furthermore, a negative and significant link between joining WMPs unwillingly and the levels of people's participation in WMPs suggests that participatory and demand-driven approaches that empower local communities and fit into existing contexts is a paramount important for sustainability of watersheds. What's more, we found that enhancing people's knowledge about the multifaceted contributions of watershed development programs very likely increases the chances of people's voluntary participation in watershed management program activities and its success. Therefore, it important to design

program actions that ensure sustainability via providing the necessary technical assistances and information about the potential benefits to be derived from watershed management programs.

The result of this dissertation in chapter four indicated that the adoption of SLMPs is interdependent. As a result, policy-makers and development practitioners need to take into consideration that farm households adopt a bundle of technologies/practices that are either interdependent or complementary to each other's rather than adopting single once. The result further proved that the different sustainable land management practice would need specific intervention and promotion strategies. Essentially, this research showed that multiple factors influence adoption of SLMPs.

The results of the dissertation also confirmed that implementations of SLMPs either in combination or independently significantly increased crop net income; therefore, it is a payoff investment. Moreover, we found that a comprehensive approach (a joint adoption of all SLMPs considered) is the best income yielding portfolio. Thus, these suggested that the need for promoting the adoption of SLMPs practices while considering the influence of household, plot-level, policy, risk and resource-related factors in the study area.

CHAPTER ONE

1. GENERAL INTRODUCTION

1.1. Background

Productive land is a critical natural asset essential for agricultural productivity, biodiversity conservation and ecosystem services provision. However, these benefits of productive land are being adversely affected by land degradation, desertification, and drought, which pose serious challenges to sustainable development (UNCCD, 2013). Studies indicate that about 40% of the world's degraded lands happen in areas with the highest incidence of poverty (Le *et al.*, 2016) suggesting the linkages between poverty and land degradation. In fact, the causes and drivers of land degradation are complex, interactive and self-reinforcing both across space and generations (Gebreselassie *et al.*, 2016). As such, the estimates of the degree of land degradation vary based on the country's context, but many studies on land resources management suggested that land degradation is a main problem and a major factor contributing to declining agricultural productivity and increasing poverty.

Agriculture is the mainstay of the Ethiopian economy accounting for about 40.2% of GDP, 80% of employment and 70% of export earnings in 2013/14 (UNDP, 2015). However, in Ethiopia, this sector is challenged by land degradation. For instance, Berry (2003) stated that, in the highland parts of Ethiopia, the annual average soil loss by water erosion was 32 tons/ha. Similarly, Haregeweyn *et al.* (2015) reported soil erosion rates as high as 42 Mg ha⁻¹ year⁻¹ on cultivated lands across the country, and recent estimates by Hurni *et al.* (2015) showed rates of 20 Mg ha⁻¹ year⁻¹ on currently cultivated lands and 33 Mg ha⁻¹ year⁻¹ on formerly cultivated degraded lands. This implies land degradation in the form of soil erosion is a main threat to Ethiopian agriculture (Gebreselassie *et al.*, 2016).

Adopting and scaling up of Sustainable Land Management Practices (SLMPs), both in terms of area and effectiveness, and improving land use planning and governance structures at the national and local levels are often the most effective ways to overcome these challenges (UNCCD, 2013). Nevertheless, in the country, in spite of the enormous efforts, previous works focus towards building physical structures to control for soil erosion and preserving/ rehabilitate other natural resources on community lands, with minimal focus to individual farms (Dejene,

2003; Bewket, 2007). Basically, the emphasis has been on ‘technical fix’ and even when local institutions existed, they were used to enforce conservation measures, including community forestry, hillside closure, and labor demanding conservation measures(Amsalu, 2006). At an early stage, the programs have been fundamentally ‘top-down’ and follow ‘one-size-fits-all’ approach, with little involvement of local societies (Beshah, 2003; Bewket, 2007; World Bank, 2008; Shiferaw *et al.*, 2009); assuming that smallholder farmers can adopt the technologies sooner or later. But, the whole effort was disappointing (Bewket, 2007; Yesuf and Köhlin, 2009).

As a consequence, currently Ethiopia faces the challenges of continuing food insecurity, and rural poverty while at the same time slowing or reversing agricultural land degradation to ensure sustainability of future agricultural production is becoming another challenge (Yesuf and Köhlin, 2009). Particularly, over the last two decades, recognizing the seriousness of its soil fertility problems and the necessity of improving agricultural productivity, the government and various international donors have initiated and invested in a myriad of sustainable land management programs that promote both Soil Fertility Management (SFM) and Soil and Water Conservation (SWC) practices (Gessesse, 2010). Although, the current SLM programs bear notable improvements, programs implemented have not yielded the expected results in reducing soil erosion. The adoption of smallholder farmers is also limited, and therefore, Ethiopia is challenged in triggering a widespread adoption of conservation practices and/or mitigating land degradation problems (Beshah, 2003; Yesuf and Köhlin, 2009; Merrey and Gebreselassie, 2011). Therefore, given the magnitude of land degradation and the vastness of degraded land as well as limited success of SLMPs in the country, further investigation into factors facilitating or hindering adoption of SLMPs and the impacts of conservation works on crop net income, is chiefly important.

1.2 Statement of the problem and justification of the study

Ethiopia is one of the most environmentally degraded countries in the world (Bai *et al.*, 2008; Gessesse, 2010; FAO, 2011; Kirui and Mirzabaev, 2014) in which a total of 228,160 km² (23%) land area was degraded (Le *et al.*, 2014). Particularly, the problem of land degradation is serious in the highlands where there is abundant rainfall and the topography further facilitates the runoff. In the country, land degradation is not only influenced by natural and socioeconomic factors, the heavy reliance of large growing population (85%) on unsustainable exploitative subsistence

agriculture and inappropriate and less attention to conservation has a greater contribution to the current state of land degradation (Zeleeke *et al.*, 2006).

Berry (2009) stated that the annual cost of loss of soil and essential nutrients due to unsustainable agricultural practices is \$139 million or 3-4% of its agricultural growth domestic product (GDP). Recognizing land degradation as a major environmental and socio-economic challenge from the first massive food-for-work programs of the mid-1970s to the present different conservations/watershed programs were implemented and consequently huge efforts have been put in place in order to rehabilitate degraded areas, and halt further degradation via control of soil loss and run-off, improved soil fertility management and reforestation. However, many of these watershed management practices such as soil and water conservation programs in the past were ineffective in either triggering voluntary adoption of conservation practices among farm households outside the project area or conserving the structures constructed (Shiferaw and Holden, 1998; Wolka, 2014). Unfortunately, no clear picture was drawn on what has been really working and what can be done to improve future watershed management programs interventions.

Furthermore, it is suggested that watershed management programs (WMPs) have an important influence on the adoption process of soil conservation practices, as these programs naturally provide or facilitate the information on the new technology, either using a knowledge transfer approach or a participatory technology development approach, and often try to reduce the investment costs or adoption risk by providing incentives (Posthumus *et al.*, 2010). Subsequently, realizing the aforementioned advantages the Ethiopian government and many agencies have introduced and promoted several SLMPs: soil and water conservation (SWC) and soil fertility management (SFM) practices via watershed management programs (Dejene, 2003; Amsalu, 2006; Zeleeke *et al.*, 2006). Nevertheless, in the country, in spite of the immense efforts of promoting the adoption of SLMPs, smallholder farm households are still constrained to integrate these practices into the farming system and limited to exploit its the full values (Kassie *et al.*, 2009a; Merrey and Gebreselassie, 2011; Teklewold *et al.*, 2013a; Wolka, 2014; Girma, 2015). Adoption of SLMPs is remaining low (Teklewold *et al.*, 2013a; Tesfaye *et al.*, 2014; Nigussie *et al.*, 2017).

Consequently, the country is challenged to reverse the current land degradation trends and to ensure adequate and sustainable food supply. The most common SLMPs that have been promoted in the study area, Bassonaworana district, include SWC practices (soil and stone buds) and SFM practice (inorganic fertilizers and organic inputs such as animal manure, and compost are the focus of this study. Accordingly, a systematic analysis is very fundamental to identify the reasons for low level people's participation in WMPs and to investigate main factors that influence adoption multiple SLMPs and their implication on household income. This dissertation sets out to investigate by focusing on three major issues that remain little investigated.

First, in Ethiopia, watershed management program has been part of the development effort since the 1970's. People's participation is considered as a major determinant of success or failure of a program. Particularly recently with the support of partners, the government is aggressively intensifying the campaign based integrated watershed programs in fragile and high-risk areas. However, the programs were poorly performed and adopted and people's willingness to participate in the watershed development activities has been very low (Wolka, 2014). Accordingly, in this regard, in spite of some literature still there is limited information on how exactly level of people's participation in WMPs are related to a set of socioeconomic and institutional factors. In the light of this, the objective of the first study of this dissertation is to investigate determinants of level of people's participation in WMPs.

Second, to understand the reasons for low adoption rate of SLMPs large size of adoption studies have been carried out. However, majority of past studies were mainly concentrated on the adoption of a single component of SLMPs, such as mineral fertilizer, manure and stone terrace in standalone and applying single equation estimation irrespective of the joint nature of decisions and the possibility of interdependence between these practices (Gebregziabher *et al.*, 2013). It is not uncommon for a smallholder farmer to practice one or more SLMPs, rather than just a single practice to manage their farmland (Teklewold *et al.*, 2013a). Failure to capture such interdependence could result in bias, inconsistency, and inefficiency of the estimates (Maddala, 1983; Dorfman, 1996; Greene, 2008; Ogada *et al.*, 2014); therefore, they offer little information about the complementary or substitutability of SLMPs that farm households can pursue so as to boost their cop productivity. In view of these, despite a large volume of adoption studies, the possibility of simultaneity of technology adoption has not been sufficiently explored.

Third, while there are many studies on the adoption of sustainable land management practices, there are fewer studies that document their impacts on outcomes such as net income. In addition to this a piecemeal impact studies that have been conducted so far are scanty. Some previous empirical studies have concentrated on the impact of use of single practice ignoring the multiple uses of SLMPs and their effects, for example (Kassie *et al.*, 2007; Kassie *et al.*, 2009a; Schmidt and Tadesse, 2014). Most of them assumed a single equation model and fail to account for the endogeneity of the technology and the self-selection problem and unobserved heterogeneity. Such studies do not adequately provide information for policy makers on the effect of conservation package. Above all, to the best knowledge of researchers, in Ethiopia, Teklewold *et al.* (2013b) is the only study that attempted to look into the impact of sustainable agricultural practices (SAPs) on maize income. However, thus far, empirical studies examining the impact of SLMPs on other crops in the country remain little investigated. Hence, the question of whether these practices are beneficial when they are adopted in isolation (individually) or as a combination (package) is yet to be answered in Ethiopia.

In general, in Ethiopia, studies that consider simultaneous multiple uses of SLMPs (SWC, manures and inorganic fertilizer) and their impact on net crop income are required. This study also examines the extent and determinants of farmers' participation in WMPs, in Basonaworana district, North Shewa Zone of Amhara Regional State, Ethiopia.

The study contributes to the existing literature on impact evaluation of land resource management practices in the following novel ways. First, we apply a more comprehensive and rigorous analysis technique to investigate factors that drive or hinder the simultaneous adoption of SLMPs (SWC practices, manure and inorganic fertilizer) using comprehensive household and plot-level survey data. As the factors associated with adoption have a high locational and technological specific the results of this study would help to improve the understanding of farm household's decision making behavior than commonly found in the literature. Second, the study controls the problem of selection bias and endogeneity by applying the selectivity correction methodology developed by Dubin and McFadden (1984) [and latterly modified by Bourguignon *et al.* (2007), using a multinomial endogenous switching regression (MESR) technique, to identify which sustainable land management technologies, and combinations of technologies, are fetching more economic benefits and therefore help to develop conservation program incentives

and/or instruments. Third, this study also provides information on the extent and factors that facilitate or discourage the success of farmers' participation in WMPs; this offers evidence on how sustainability of watershed management programs is attended.

1.3. General objective of the study

General objective is to analyze the simultaneous adoption of SLMPs and their impacts on crop net income in the Basonaworana district, the North Shewa Zone of Amhara National Regional State (ANRS), Ethiopia.

Specific objectives of the study are to:

1. identify determinants of the extent of people's participation in watershed management programs,
2. examine factors facilitating or impeding adoption of sustainable land management practices in the study area, and
3. analyze the impacts of sustainable land management practices on crop net income

1.4. Research questions

- 1) To what extent do people participate in WMPs' campaign (planning, implementation and maintenance phases)?
- 2) Which set of socioeconomic and institutional variables influence people's participation in WMPs?
- 3) Is there any correlation/interdependence between the different SLMPs?
- 4) Do household characteristics, plot specific attributes, risk factors, resource-related factors and policy conditions influence farm households' adoption of multiple SLMPs?
- 5) Are there significant differences in crop net income between plots with and plots without SLMPs?
- 6) Does implementing SLMPs in combination is more effective than implementing individually to improve farm income?
- 7) Which use of SLMP ensures more economic benefit than others?

1.5. Significance of the Study

Despite Ethiopia as a nation possess ample natural resources, presently the country is one of food-insecure and food aid dependent countries in the world. This is due to the fact that many farm households must deal with low and unpredictable crop yields and incomes, as well as continuing food insecurity, which is caused by many factors, among others acute land degradation, limited utilization of improved agricultural technologies, poor infrastructure, weak extension services and scientific research support (Shiferaw *et al.*, 2009). In addition, Ethiopian agriculture is largely rain-fed, and many depend on it for their principal livelihood. Any change in the amount and/or temporal distribution of rainfall during the growing season significantly contributes to lower production levels and associated poverty. However, increasing agricultural productivity and improving food security of the farming population remain the prime priority of the country. Recently, the government has placed large emphasis on SLM as a strategy to maintain ‘natural resource basis’ and improve resilience to climate change and thereby to enhance food security of the rural population.

Despite the high level of government interest and considerable investments into SLM programs, due to a number of reasons adoption by farmers remains limited in most regions (Merrey and Gebreselassie, 2011). In fact, still there is vast potential to scale up best practices as an integral component of agricultural development strategies. Nonetheless, it has to be supported by scientific evidence. Hence, it is very important to research farmers’ SLMPs adoption and their actual impact on farm household crop net income. The findings of the study help to identify effective SLMPs that generate a better outcome in terms of household income. Hence, the findings of such a study are also important to recommend policies and approaches to accelerate the adoption of these practices. Thus, evaluating factors that facilitate/hamper current SLMPs and its effect on crop net income as well as understanding levels of people’s participation in WMPs campaign is a good entry point.

1.6. Scope and limitation of the Study

This study is based on micro level analysis of SLMPs in the Basonaworana district, Northern Shewa Zone of Amhara National Regional State, Ethiopia. The findings of this study might be extended to other areas with similar agro-ecological zone and socioeconomic settings with a certain level of adjustment. Even though SLM has both on-site and off-site effects, only the on-

site economic aspects (crop net income) are dealt with. Disentangling the dynamics relating to crop net incomes heterogeneity requires studying the behavior of farm households over a period of time. Nonetheless, it is impossible to do this because this study relies on cross-sectional data. Types of SLMPs considered in this study are only SWC practices, manure and inorganic fertilizer.

1.7. Organization of the thesis

The rest of the dissertation is organized as follows. Chapter two reviews concepts of watershed management, land degradation and sustainable land management. It deals with land and water management policies, strategies and programs implemented in the country. It presents the reviews of related empirical evidence on SLMPs. Chapter two also presents the research conceptual framework for scrutinizing SLMPs adoption and their impacts on crop net income. The conceptual framework presents its potential linkage of variables with rural livelihood outcome (crop net income). Chapter three presents the determinants of level of people's participation in watershed management program campaigns. Tobit model that estimates the extent of people's participation in WMPs is discussed and used. In chapter four, the joint estimation of adoption of multiple SLMPs at plot level is discussed. Multivariate probit model that address the joint estimation of the simultaneous decision to use the practices is discussed and applied. Chapter five presents the impact of SLMPs on household income. This chapter presents the multinomial logit model as a starting point and develops multinomial endogenous switching regression model to analyze the data. Eventually, the last chapter reports the synthesis and conclusion of the study. It also forwards the policy implications of the research findings and the need for future researches.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Concepts and Theories

2.1.1. Participation in watershed management program

Watershed¹ development approach has evolved from a compartmental approach of conserving soil and water to a holistic and participatory livelihoods approach. It is adopted in developing countries as a drought proofing strategy for improving livelihoods (Wani *et al.*, 2008). It is a strategy to optimize the use of soil, water and vegetation in a watershed subject to local agro-climatic and topographic conditions, all for the purpose of strengthening the ‘natural resource base’, supporting more productive agriculture, and improving livelihoods (Kerr *et al.*, 2007).

Watershed management is a term used to describe the process of implementing land use practices and soil/water management practices to protect and improve the quality of the water and other natural resources within a watershed by managing the use of those land and water resources in a comprehensive manner (DEEP, 2015). In Ethiopia previous watershed management was simply considered as a practice of SWC; it neglected institutional arrangements. Similarly, the newly implemented SLM projects neither involved nor took effort to organize people to solve the problem collectively. Where village level participation was attempted they typically involved one or two key persons like village leaders. These projects failed due to their centralized structure, rigid technology and lack of attention to institutional arrangements (Tesfaye, 2011). Chisholm and Woldehanna (2012) suggested that realizing the full benefits from watershed-level investments require social capital and collective action; financial investment and technical support; and complementary investments at the household level.

Community participation has been a constant theme in development dialogues for the past 50 years. The concept became many things to different people; making it difficult to reach generally agreed definitions. For instance, program planners/professionals consider participation as a ‘panacea’ to development (Rifkin and Kangere, 2011). Burns and Heywood (2004) consider people’s participation as the engagement of individuals and communities in decisions about things that affect their lives. In the context of this study, participation is defined as the process

¹ A watershed is a catchment area from which all water drains into a common point or a single outlet (Kerr *et al.*, 2006; Bekele *et al.*, 2008).

through which farm households are involved in (planning, implementation and maintenance) and have influence on decisions related to watershed development and management activities (of private and common properties) that will affect them.

2.1.2. Land degradation and sustainable land management

The term land is described as “an ecosystem that comprises land, landscape, terrain, vegetation, water and climate” (Eswaran *et al.*, 2001). UNCCD (2014) defines land degradation as “any reduction or loss of the biological or economic productive capacity of the land resource base. It is generally caused by human activities (anthropic factors), exacerbated by natural (biogeophysical) processes, and often magnified by and closely intertwined with climate change and biodiversity loss.”

The concept of sustainability in sustainable land management (SLM) refers to a diverse and long running dispute over the direction of societal action and the management concept refers to anthropogenic activities in different contexts. For all the ambiguity and diversity involved in defining the term precisely, the Brundtland report definition is often mentioned as a general starting point. According to World Commission on Environment and Development (WCED), sustainable development is development that “meets the needs of the present without compromising the ability of future generations to meet their own needs”(WCED, 1987). The concept of SLM was introduced in the early 1990s as a response to land degradation, though SLM has different meanings to different people it has been promoted since then. SLM combines technologies, policies and activities aimed at integrating socio-economic principles with environmental concerns so as to simultaneously enhancing the productivity and protection of natural resources while being economically viable and socially acceptable (Smyth and Dumanski, 1993).

In the Ethiopian context SLM includes the ‘use of physical SWC measures, appropriate practices for soil fertility and agricultural water management, forestry and agro-forestry, as well as the application of these measures in a more integrated manner to satisfy present local community needs while solving ecological problems and maintaining the land in a condition for supporting future generations’ (Zelege *et al.* 2006). For the purpose of this study SLM includes SWC

practices ² (such as stone and soil bunds) and SFM practices (such as manure and inorganic fertilizers).

2.1.3. Theoretical approach to modeling adoption of SLMPs

Adoption behavior is undoubtedly a complex, multidimensional issue involving various aspects, which are not mutually exclusive (Oostendorp and Zaal, 2011). Adoption behavior and determinants of technology adoption have been guided mainly by three commonly used paradigms: innovation-diffusion paradigm, adopter perception paradigm and economic constraint paradigm (Adesina and Zinnah, 1993; Nyanga *et al.*, 2011). The literature asserts that these theoretical approaches to modeling technology adoption decisions depend on the specific objective of the study (Adesina and Zinnah, 1993). In what follows, a detail discussion of each approach (paradigm) is presented.

The economic constraint paradigm emphasizes the factors that affect the profitability or utility of innovations (Oostendorp and Zaal, 2011). According to the economic constraint paradigm, technology adoption is affected by household utility maximization behavior and economic constraints as a result of the disproportionate distribution of resources (Adesina and Zinnah, 1993; Posthumus *et al.*, 2010; Prager and Posthumus, 2010). The economic model simply tends to focus on the profitability of new technology. If a new technology is more profitable than an existing one, then rationality dictates it should be adopted (Duff *et al.*, 1990).

Farmers always try to maximize their benefits by considering resource endowment and predictable shocks that jointly influence investment decisions (Shiferaw *et al.*, 2009). In this regard, literature on farm level investment theory, such as Clay *et al.* (1998) and (Yesuf and Köhlin, 2009) documented that a farm investment can be modelled as a function of market access factors, physical incentives to invest, the capacity to invest; land tenure security, socio-institutional factors; and household demographic characteristics. In general, it is supposed that higher return on investment will stimulate a higher rate investment (Clay *et al.*, 1998). This paradigm acknowledges the importance of profitability and economic constraints (e.g. availability of assets, learning costs associated with innovation, or risk) to explain adoption behavior, but fail to capture the subjective perception of technology attributes that affect adoption decision (Adesina and Baidu-Forson, 1995; Prager and Posthumus, 2010). The

² Conveniently soil buds or stone bunds for soil erosion control or water harvesting, is called SWC practice.

paradigm also fails to recognize less tangible factors such as personal motivation or peers pressure (Prager and Posthumus, 2010). Therefore, economic theory alone does not provide much guidance in explaining the factors affecting the farmers' decision to undertake soil conservation (Asafu-Adjaye, 2008).

The second paradigm, the adopters' perception paradigm, suggests that the process of adoption starts from the adopters' perception of the problem and technology (Adesina and Zinnah, 1993). The paradigm also argues that the perceived attributes of the technology conditioning adoption behavior of smallholder farmers (Posthumus *et al.*, 2010; Prager and Posthumus, 2010; Oostendorp and Zaal, 2011). This means that, even with full farm household information, farmers may subjectively evaluate the technology differently than researchers (Uaiene *et al.*, 2009). Thus, understanding farm households' perceptions of a given technology is crucial in the generation and diffusion of new technologies and farm household information dissemination (Uaiene *et al.*, 2009). Farm households' perception of attributes plays an important role in influencing adoption decisions (Wossink *et al.*, 1997; Posthumus *et al.*, 2010; Prager and Posthumus, 2010). Depending on the decision-maker evaluations of the characteristics of the technology different preferences will be commanded (Wossink *et al.*, 1997).

Above all, the adopter perception paradigm argues that "the adoption process starts with the perception that there is a need to innovate"(Posthumus *et al.*, 2010). This perception is determined by personal factors (e.g. human values, education and experience) as well as physical factors of the land and institutional factors (e.g. raising awareness through extension) (Ervin and Ervin, 1982; Adesina and Zinnah, 1993; Shiferaw and Holden, 1998; Asafu-Adjaye, 2008; Posthumus *et al.*, 2010). Hence, a perception is 'context and location specific' (Kamruzzaman, 2015).

The third paradigm, the innovation-diffusion-adoption paradigm is based on the innovation-diffusion theory. The Rogers' innovation-diffusion-adoption paradigm emphasizes the key role of access to information in influencing technology adoption decision (Adesina and Zinnah, 1993; Prager and Posthumus, 2010; Oostendorp and Zaal, 2011). The underlying assumption of the innovation-diffusion model is that the technology is technically and culturally appropriate, but the problem of adoption is one of asymmetric information and very high search cost (Uaiene *et al.*, 2009).

A number of researches on soil conservation behavior have drawn extensively on the adoption-diffusion paradigm (Ervin and Ervin, 1982; Rogers, 1995, 2010). Through this theory, three explanations of adoptive behavior (psychological innovativeness, profitability orientation, or orientation to farming as a way of life) were proposed. But, measures of monetary incentives, farming orientation, and physical need for soil conservation were not adequately captured by the studies (Ervin and Ervin, 1982). Although the diffusion of innovations model recognizes that adoption is a multistage process of collecting information, revising opinions, and reassessing decisions, it fails to take into account the individual characteristics of the adopter (Ngwira *et al.*, 2014).

Generally, Posthumus *et al.* (2010) suggested that SWC programs have an important influence on the adoption process of soil conservation practices, as these programs naturally provide or facilitate the information on the new technology, either using a knowledge transfer approach (in accordance with the innovation-diffusion adoption paradigm) or a participatory technology development approach (adopter perception paradigm), and often try to reduce the investment costs or adoption risk by providing incentives (economic constraints paradigm). Moreover, studies revealed that in modeling SLMPs adoption using the three paradigms (innovation-diffusion adoption, economic constraints and adopter's perception paradigm) improves the explanatory power of the model as compared to a single paradigm (Adesina and Zinnah, 1993; Uaiene *et al.*, 2009). For instance, Shiferaw and Holden (1998), Ervin and Ervin (1982) and Asafu-Adjaye (2008) considered a range of factors that reflect not only the economic benefits and costs of technology adoption, but often also the knowledge and perceptions of the farm household. Most importantly, theoretical and empirical studies recognize adoption behavior is complex and often requires a combination of theoretical. Therefore, the theoretical background of this study is based on a blend of the three paradigms discussed earlier in this section.

2.2 Natural resource management in Ethiopia

Estimates show that about 66 % of the total land area of 112 million hectares is potentially suitable for agriculture (Dejene, 2003). Of this, only 15% is estimated to be cultivated (Awulachew *et al.*, 2010). However, because of natural and human-made problems, these resources are critically challenged by degradation. Soil erosion is the most visible form of land degradation affecting the agricultural land. In the country, to alleviate the multifarious effect of

land and water degradation, a series of policies, strategies and institutional reforms have been implemented.

In Ethiopia, despite the history of thousand years of human settlement and farming, the problem of land degradation recognized very lately in 1970s, during the Derg regime following great drought and famine (Shiferaw and Holden, 1999; Gebremedhin and Swinton, 2003; Amsalu, 2006). Then after, gradually, the Derg movement entered into mainstream natural resource management that included the introduction of SWC practices on arable and non-arable lands (Beshah, 2003). The approach focused on building physical structures to control soil erosion and to rehabilitate degraded lands (Dejene, 2003) using the food program as incentive (e.g. Food-for-work). Nonetheless, this gave a space for a top down approach and the total negligence of the educational process (Beshah, 2003). As a result, the installed conservation structures were usually left to deteriorate or be dismantled by farmers immediately after the project withdrawal, because they anticipated the incentive to sustain (Shiferaw and Holden, 1998; Beshah, 2003).

Later, a more participatory approach, the Local Level Participatory Planning (LLP) approach, was piloted in the early 1990s by the World Food Program (WFP) and the then Ministry of Natural Resources Development and Environmental Protection. However, this approach still focused primarily on soil conservation and reforestation. The efforts have remained ‘delivery oriented’ (Bewket, 2003; Chisholm and Woldehanna, 2012). In this approach, farm households’ perspectives, constraints, and local circumstances were inadequately considered (Shiferaw and Holden, 1999; Dejene, 2003; Amsalu, 2006).

In the last few years, globally, the approach for soil and water conservation has also slowly moved towards the concept of SLM both at the farm and landscape level (Robbins and Williams, 2005). In Ethiopia, also drawing lessons from the past practices, the government has acknowledged the need for participatory watershed management and in turn the then Ministry of Agriculture and Rural Development (MoARD) developed a national guideline known as Community Based Participatory Watershed Development (Desta *et al.*, 2005). The more recent and comprehensive strategy document, the Ethiopia Strategic Investment Framework for Sustainable Land Management (ESIF), aims to improve the livelihood and economic well-being of the farmers, herders and forest resource users by scaling up sustainable land management practices with proven potential to restore, sustain and enhance the productivity’s of country’s land resources

(MoARD, 2008). This framework demonstrates a shift from conservation as the primary goal, to improving livelihood (Girma, 2015; Haregeweyn *et al.*, 2015).

Despite the fact that current approaches to promoting SLM are far more participatory and community-driven than in the past, mostly focusing on technological solutions and construction of conservation structure as an end (Tesfaye, 2011). But, farmers' knowledge and indigenous practices policy and institution related factors were overlooked (Merrey and Gebreselassie, 2011; Wolka, 2014). In general, a number of growing literatures supported that many previous SWC programs were unsatisfactory for different reasons (Shiferaw and Holden, 1999; Dejene, 2003; Amsalu, 2006; Kassie *et al.*, 2009a; Bekele and Mekonnen, 2010; Wolka, 2014).

2.3 Empirical evidence of adoption and impacts of sustainable land management practices

2.3.1 Impact of SLMPs on the rural livelihoods

Empirical evidences indicate that returns to adoption of SLMP were mixed. Most studies have suggested that investments in SLMPs have a positive effect on agricultural outputs (Bekele, 2005; Nyssen *et al.*, 2007; Pender and Gebremedhin, 2007; Kassa *et al.*, 2013; Schmidt and Tadesse, 2014). While some studies revealed that SWC intervention did not offer a significant effect (Abebe and Bekele, 2014) and others also suggested negative influence on crop yield (Kassie *et al.*, 2007, 2008; Adimassu *et al.*, 2012).

Plot-level analysis conducted in the Blue Nile Basin reveals that plots that received sustainable land and watershed management investments (terraces, bunds, check dams) for 10 years has a 24% higher value of production (Schmidt and Tadesse, 2014). However, the same source suggested that SLMP must be installed at least for seven years, so as to bear a positive and increasing value of production. In light of this, Schmidt and Tadesse (2012) reported that the marginal benefit of sustaining the land and watershed management investments increases over time at an increasing rate.

Pender and Gebremedhin (2007) from the highlands of Tigray, Ethiopia, noted that several land investments and land management practices have a statistically significant impact on the value of crop production. For instance, they found that crop productivity is 18%, and 64% higher in plots with and stone terraces, and reduced tillage, respectively. The same source also stated that the use of fertilizer and manure respectively, results in 16% and 14% higher yields as compared to non-use. In the same vein, in eastern Ethiopia, Bekele (2005) using the first order stochastic

dominance analysis found that adopting SWC practice results in more high yield and net return than non-adopting.

Moreover, Kassa *et al.* (2013) reported that the integrated SWC program participant has on average gained 21.2% more annual gross income and earned 8.3% more production value per hectare as compared to non-program. In the same line, in northern Ethiopia, Nyssen *et al.* (2007) taking the farm land occupied by conservation structures into account, found that stone bunds increased cereal and teff yields by 8 and 11%, respectively. Their analysis indicates that a mean crop yield increased by 0.58-0.65 tone/ha in plot covered by the stone bunds aged 3-21 years.

On the contrary, Abebe and Bekele (2014) revealed that SWC intervention did not bring a significant difference between program participant and non-participant households in terms of total crop and household income, and crop yield in Adama district. In the central highlands of Ethiopia, Adimassu *et al.* (2012) also suggested that the soil bund increased yield of barley by 1.7%, but when the space occupied by the structures is taken into consideration the yield is reduced by 7%. Furthermore, Kassie *et al.* (2008) from high-rainfall areas of the Ethiopian highlands found that the value of crop production for plots with bunds was lower than for plots without bunds. In contrast, Kassie *et al.* (2007) conformed that stone bunds offered higher returns in semi-arid areas, but not in higher rainfall areas. This is due to the immediate productivity benefit resulting from soil moisture conservation in semi-arid areas (Pender, 2009). The mixed literature results indicated that the impacts of adoption of SLMPs vary across space and households' context. Hence, these variations call for micro-level studies.

2.3.2. Determinants of sustainable land management practices

Meta-analyses asserted that the influence SLMPs is very mixed and inconsistent; almost none of investigated factors applied 'universally' (Knowler and Bradshaw, 2007; Wauters and Mathijs, 2014). A reason for this is the fact that adoption is "highly context and case specific" (Wauters and Mathijs, 2014). However, based on the exiting large size of earlier research on farmers' adoption of new technologies (Ervin and Ervin, 1982; Shiferaw and Holden, 1998; Bekele and Drake, 2003; Gebremedhin and Swinton, 2003; Amsalu and De Graaff, 2007; Tiwari *et al.*, 2008; Teklewold *et al.*, 2013a; Kassie *et al.*, 2015a) adoption of SLMPs is affected by various interrelated variables; these can be categorized into five broad variables: household characteristics, farm specific characteristics, enabling conditions, risk factors, and resource-

related attributes. The details of each factor that affect adoption of SLMPs are discussed in the subsequent chapters.

2.4. Conceptual framework

There are many perspectives involved in understanding farm households' views as to how and why they make decisions on whether or not to adopt the improved technology for land management (Thompson and Warburton, 1985). With the support of the existing literature, the conceptual framework for this study is adapted from the 'sustainable livelihoods framework', 'the economic constraint paradigm', the 'innovation-diffusion-adoption paradigm' and the adopter perception paradigm.

The 'sustainable livelihoods' framework Carney (1998) and Scoones (1998) which considers the broad set of physical, human, natural, social, and financial capital endowments of households and communities and their implications for household decision-making, as well as the role of such contextual factors as agro-climatic conditions, access to markets, and the development of local institutions. As illustrated in theoretical review part the 'economic constraint' paradigm underscores the factors that affect the profitability or utility of innovations, the 'innovation-diffusion-adoption' paradigm emphasizes the key role of access to information to understand the process of technology adoption. The 'adopter perception paradigm' also emphasizes the important role of farm households' attitudes and perception in the decision-making process. These apparently indicate that SLM adoption is not adequately explained by a simple model. Thus, the conceptual framework of this study is based on the blend of various theories and empirical evidence.

Empirical studies underscore farmers' SLM adoption decision involves a complex process that goes far beyond the household territory to supra household level. The global political and economic systems affect national policies. National policies (macro- economic environment) in turn influence policies of regional governments at micro level. Eventually, national and regional policies operate at the micro level. At this point resource characteristics, risk factors, household (human and social capital) and plot specific factors, and enabling condition (policy environment, infrastructure, and institutional) affects farm households' investment decision in SLMPs.

The conceptual framework (as depicted in Fig.1) noted that to enable poor households to overcome their poverty, development projects can take three broad lines of action: they can help poor households to build up their assets – especially their human and social capital; they can transform the policy and institutional context from one that disables the poor to one that is more pro-poor, or they can reduce vulnerability (Stewart and Crowley, 2005). In either case, this may also exacerbate the situation of the poor if the intervention is not in line with local specific circumstances and needs. SLM is one of the project intervention mechanism through which farm households intensify their agriculture. The SLM projects/programs motivate farmers to adopt land management technologies and to diversify their product mix. These technological changes expected to improve farm production and productivity and, consequently, transform rural livelihoods. It is supposed that the more the households participate in SLM programs the greater experience they gain in turn the likelihood of adoption of SLMPs on own farm plot is high. This study is based on the assumption that adoption of SLMPs advances change in the rural livelihood outcome (crop income).

However, households' decisions for land management in agriculture are likely to be influenced by several interrelated factors. It is important to understand the relationship between these factors and the process of adoption of SLMP to improve rural livelihood. In the subsequent paragraphs the perspective of this study and the linkage between SLMPs and determining factors and its implication on livelihood outcomes (crop net income) outlined in depth.

2.3.1. Enabling conditions

Farmers make decisions within broad context: policies and institutions. The conceptual framework illustrates the farm households' adoption decisions are derived or hindered by the prevailing socioeconomic and policy environment, including institutional changes and investments in infrastructure, markets services, and access to information.

A wide range of policies and institutions may influence adoption decisions of SLMP. Government policies can act as both incentives and disincentives to investment in SLMPs (Boyd *et al.*, 2000; Shiferaw *et al.*, 2009). An enabling macro-economic environment, better access to markets and to public services, better infrastructure, and extension services to farm households' may increase the adoption of SLMPs (Kirui and Mirzabaev, 2014). Enabling policy also facilitates

credit and savings and effective extension services (Robbins and Williams, 2005). Explicitly, the framework illustrates how development interventions and promotion of agricultural technology (SLMPs) impact livelihood outcomes. Adoption of SLMPs requires a conducive policy environment that stimulates innovation and effective investments in infrastructure and communication to improve market access for inputs and produce (Robbins and Williams, 2005; Nkonya *et al.*, 2008; Shiferaw *et al.*, 2009; Yesuf and Köhlin, 2009); these in turn determine relative input-output prices and access to new technologies and markets at the local level (Shiferaw *et al.*, 2009).

2.3.2. Risk factors

Risk factor comprises plot distance from the homestead, profitability of technology, tenure arrangement, plot size and water logging and presence of disease and pests. Literature evidence indicated that the adoption of locally fit and efficient farming practices and technologies that conserve the resource base are instrumental in achieving economic growth, food security and poverty alleviation.

The framework shows that farm households may undertake decisions and invest in their farm plots, if more profitable and compatible SLMPs are available; and capital and institutional constraints are not limiting (Shiferaw *et al.*, 2009). This partly implies that the households' adoption decision is affected by the characteristics of the technologies and vulnerability context. In this regard, it can be argued that an agricultural technology may dramatically increase yields, but that does not necessarily mean that it should be adopted. Some technologies may require large private and public investments, for instance, certain SWC need intensive labor and capital to enable the adoption of the technology. Some technologies may take a parcel of land out of production, harbor pest and expensive; while, other practices may require additional intensive labor to transport to farm plots. Naturally, households will compare the advantages and the appropriateness of different SLMPs, based on the available resources at their disposal and their opportunity for profit. Moreover, farm households will be more motivated to make medium- to long-term land investment, if their tenure is secure. These illustrate that the household decision making process is partly enhanced/impeded by inherent attributes of the technology and risks associated with the technology.

2.3.3. Household and Plot specific characteristics

This study postulated that household SLMPs adoption decision is triggered or hindered by human capital (education level, family size, age, gender etc.) and social capital (membership in rural organization and trust). Households with better human capital and strong social capital will most likely motivated to install and maintain SWC practices, and adopt fertility enhancing technologies. Households with more human capital (education or in other forms) may have greater access to non-farm income and more capable to purchase inputs. Greater ‘human capital’ may raise farmers’ awareness and knowledge of the benefits of technologies and efficiency in their farming practices. Conversely, households with more human capital (e.g. education) may have more opportunities to involve in none-farm activities which compute with conservation investments.

The framework also depicts that the social institutional structure may also facilitate knowledge sharing, greater cooperation, coordination and monitoring of effective public service delivery and ameliorate resource constraints such as credit, markets, and farm equipment all important for the adoption and diffusion of agricultural technologies (Birungi, 2008). Households with larger ‘social capital’ possibly through involvement in agricultural related organizations (e.g. cooperative) and rural informal organizations may have better access to information about new technologies (including SLMPs) and farmers’ timely access to inputs. In consequence farmers’ use of technologies will be enhanced and in turn increase their productivity and ability to earn high returns. Moreover, plot specific characteristics (plot slope, soil depth, plot fertility, severity of soil erosion etc.) enhance or discourage use SLMPs.

2.3.4. Resource-related characteristics

In this study, the framework used to depict the influences of assets that farm households own or have access to (natural and financial, physical assets) on the adoption of SLMPs –a component of livelihood strategy and their contributions to people’s livelihood outcomes (crop net income). The resource related factors expected to affect farmers’ capacity to invest SLMPs include livestock holding, non-farm income, farm size and access to credit. Restricted access to these resources and other form of assets limits poor households’ livelihood options. Lack of assets in the face of additional emergency makes them more vulnerable to shocks. Shocks contribute to

negative livelihood outcomes and further depletion of household assets, leading to a downward spiral of deepening poverty.

The framework also shows that the indirect relationship between livelihood outcomes and households' resources and the role of socio-political structures and livelihood strategies (e.g. SLMPs). On the other hand, the framework can depict forward and backward interplay³, improved livelihood outcomes are also in turn enhancing the assets available and future investment decisions of smallholders. This shows how the interaction of encouraging political and economic conditions (household and plot specific attributes, resource characteristics, policy environment and risk factors) and locally-fit SLMPs enable households to use a more sustainable intensification strategy that will also help them to earn better farm income and thereby to escape poverty and food insecurity as well as to sustain natural resource use.

Above and beyond, this framework can also assist to understand the processes that underlie net farm income and how the asset values or access to; exposure to stress and risks, and the sociopolitical structure conditioning and shaping the context and opportunities for people to take action (SLM decisions).

³ For simplicity only forward and direct interactions are depicted in the framework

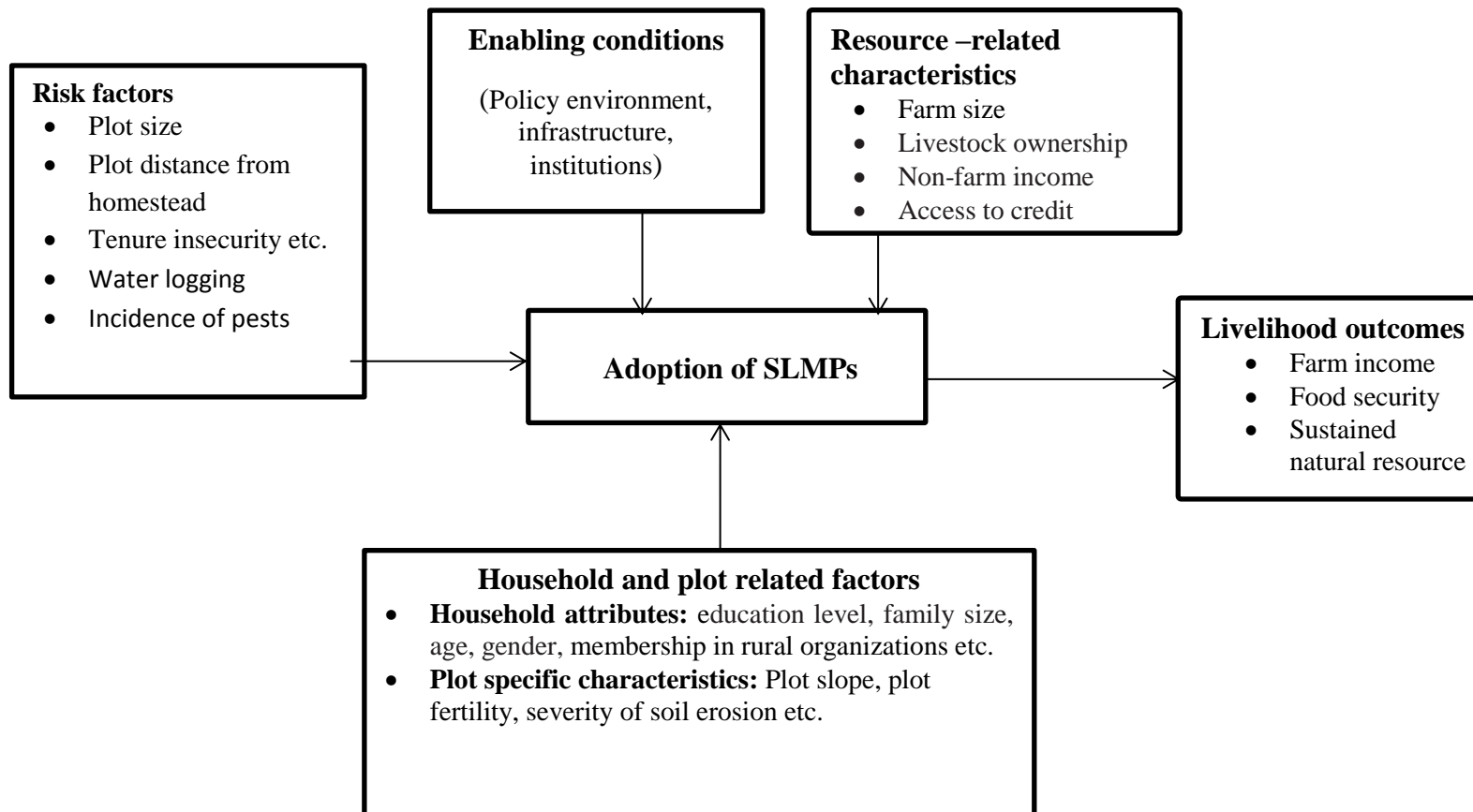


Fig 2.1: Conceptual framework of the study

Source: own construction

CHAPTER THREE

3. LEVEL OF PEOPLE'S PARTICIPATION IN WATERSHED MANAGEMENT PROGRAMS: MICRO LEVEL EVIDENCE FROM BASSONAWORANA DISTRICT, ETHIOPIA⁴

Abstract

In this paper, we examine the level of people's participation in watershed management programs (WMPs) and its links with socioeconomic and institutional factors in Bassonaworana district, Amhara region. A multistage sampling technique was employed to collect data from 354 households. Principal component analysis was used to construct indices that capture level of people's participation. Its Cronbach's alpha value is 0.93. The data analysis has been undertaken using descriptive and inferential statistics (Tobit regression). The results revealed that the level of people's participation in WMPs is relatively low. Similarly, while participation in watershed planning and implementation stage is low, participation in maintenance stage is moderate. The Tobit regression results indicate that age, non-farm works and joining WMPs against will had negative significant influence on households' participation in WMPs at the three stages (planning, implementation and maintenance). Farm households' contact with extension agents and farm size had a positive significant effect on their level of participation in planning and implementation stages. Family size was also found to be positively and significantly related only to the level of participation in the planning stage. The model results indicated that the best chances of voluntary participation in WMPs activities can be achieved among farm households who perceived change with respect to environmental, social and economic impacts. Thus, for better households' participation in WMPs, these factors need be included when targeting WMPs.

Key words: watershed management program, level of participation, Tobit model, Ethiopia

⁴ Kidane Tafa, Bamlaku Alamirew and Aklilu Amsalu, 2018. (submitted). Level of people's participation in watershed management programs: A micro level evidence from Bassonaworana district, Ethiopia

3.1. Introduction

The natural resources which are the base of agriculture and other economic activities are under threat of degradation in many forms (FAO, 2011; Le *et al.*, 2016). Many watershed management programs (WMPs) have been developed to overcome this challenge, and plan to avoid future problems and sustain the major important natural resources for agricultural by promoting sustainable land management practices. In Ethiopia, WMPs have been part of the development effort since the 1970's to tackle water caused soil erosion impacts and water shortage and to sustain productivity and the production potential. However, all of the attempts have proven unsustainable and unsuccessful (Wolka, 2014). Subsequently, currently the country faces the challenges of continuing food insecurity, and rural poverty while at the same time slowing or reversing agricultural land degradation to ensure sustainability of future agricultural production (Yesuf and Köhlin, 2009). Over recent years, as part of the solution to these problems Ethiopia has made the WMPs a central component of two major national-level undertakings i.e. the Productive Safety Net Program and, more recently, the Climate-resilient Green Economy Strategy (Chisholm and Woldehanna, 2012). Accordingly, with the support of partners, the government is aggressively intensifying WMPs through an approximately thirty-day public campaign strategy since early 2011 in the country.

Literature evidenced that participation by local people is crucial to the success of an integrated approach and it is a main concern for policy makers (Kumar and Palanisami, 2009; Chisholm and Woldehanna, 2012). Although some studies have been conducted on people's participation in natural resource management programs such as watershed development (Kumar and Palanisami, 2009; Nasrabadi *et al.*, 2013) and grazing land management (Gebremedhin *et al.*, 2004), to the knowledge of researchers there is no empirical evidence on levels people's⁵ participation in watershed management program in the country in general and Bassonaworana district in particular. So that, still there is a huge gap in the literature in terms of reasons for success and failure of people's participation in WMPs⁶. Therefore, there is a great need to know these reasons to improve the performance of WMPs.

⁵ People mean men and women who are involved in a watershed management programs.

⁶ In the present study, participation is defined as the process through which farm households are involved in (planning, implementation and maintenance) and have influence on decisions related to watershed development and management activities (of private and common properties) that will affect them.

The present study adds to the conservation literature by providing empirical evidence on the extent of people's participation in WMPs campaigns (in planning, implementation and maintenance phases). The study also comes back with how the extent of households' participation in WMPs and a set of socioeconomic and institutional variables is linked. Understanding these aspects of WMPs can improve the understandings of planners, researchers and policy makers to ensure sustainability of watersheds and also gives an insight into developing a useful strategy that possibly would potentially address large-scale non-sustainability of new WMPs in developing countries.

In the next section we first present description of the study area, data sources and collection procedures, sampling design, and empirical methods. Following, results and discussion section deals with descriptive statistics of explanatory variables used in econometric analysis, farm households' level of participation in WMPs, component of participation before it engages in discussion of factors influencing farm households' participation and extent of participation.

3.2. Context of the study and sampling techniques

3.2.1. Descriptions of the study area

The study carried out in Bassanaworana district of the North Shewa Zone, Amhara region of Ethiopia. More specifically, the study was undertaken in four Kebeles/peasant associations (PAs). The Kebeles are part of the central highlands of Ethiopia, located in the upper Blue Nile. The capital town of the district, Debre Berhan, which is also the North Shewa zone capital, is situated approximately at a distance of 130 km northeast of Addis Ababa. The study area covers 1,399 km², with altitudes ranging between 1,980 and 3,350 meters above sea level. Average annual rainfall is 1,100 mm (BWOA, 2018). According to the 2007 population census, the total population is 119,660 people, of whom 58,331 are women. The study area is also characterized by a high population density of over 110 people km⁻². The demand for agricultural land has been exceptionally high due to increasing population pressure (Amsalu, 2006).

In terms of topography, the study areas are predominantly mountainous and undulating slopes and partly flat in dawn streams (Tizale, 2007). Undulating slopes divided by valleys of seasonal and/or relatively permanent streams characterize the topography of the study areas. The settlements are scattered and inhabitants are dominantly smallholder subsistence farmers. The topography of the district is mountainous (50%), rugged (27%), and plain landscape (23%)

(BWOA, 2018). The major soil types of the area include Andosols, Regosols and Cambisols (Tizale, 2007).

On the road to counteract the effect of land degradation, different land management programs were initiated and implemented in the study area since the 1980s. Physical SWC measures such as stone and soil bunds and SFM practices such as manure and inorganic fertilizers etc. have been promoted and exercised in the study area. Moreover, in communal land gully rehabilitation, area closure and hillside construction of physical structures have been adopted. The conservation efforts have focused on highly degraded communal lands than individual farmers' plots.

Farming in the district is as old as the history of settled agriculture in the area several thousands of years ago (Amsalu, 2006). The area is characterized by a mixed-farming system specifically; it is barley-based crop-livestock farming, whereby farmers are involved in rain-fed agriculture and livestock keeping activities. Agriculture, like in other parts of Ethiopia, is the mainstay of the community. The major food crop varieties that are growing in the district are barley (*Hordeum vulgare* L.), wheat (*Triticum aestivum*), teff (*Eragrostis tef*), faba bean (*Vicia faba*) and field pea (*Pisum sativum*). The major types of animal kept in the study area are cattle, sheep and equine. Cattle deliver the draught power for cultivation and threshing, and manure for fertilization, household energy, and to obtain cash income from sales.

In the study areas there are two main institutions involved in the promotion of SLMPs. Participation in these institutions depends on the household characteristics and influence the use of SPLMPs. In the study area, the respondents participate in farmer-based organization and the government extension services. Farmers participate in farmer-based organization (multipurpose cooperatives, dairy cooperatives, rural credit and saving cooperatives etc.) to for the daily life irrespective natural resource management activities. Therefore, Promotion of these organizations for learning and labor sharing could be an entry strategy in the natural resource management (Girma, 2015). In addition, the local government offices at Kebeles and district level are the other important actors in the promotion of SLMPs in the study area. More specially, the development agents, kebele administration, district experts and administration are responsible for the planning and implementation of the practices.

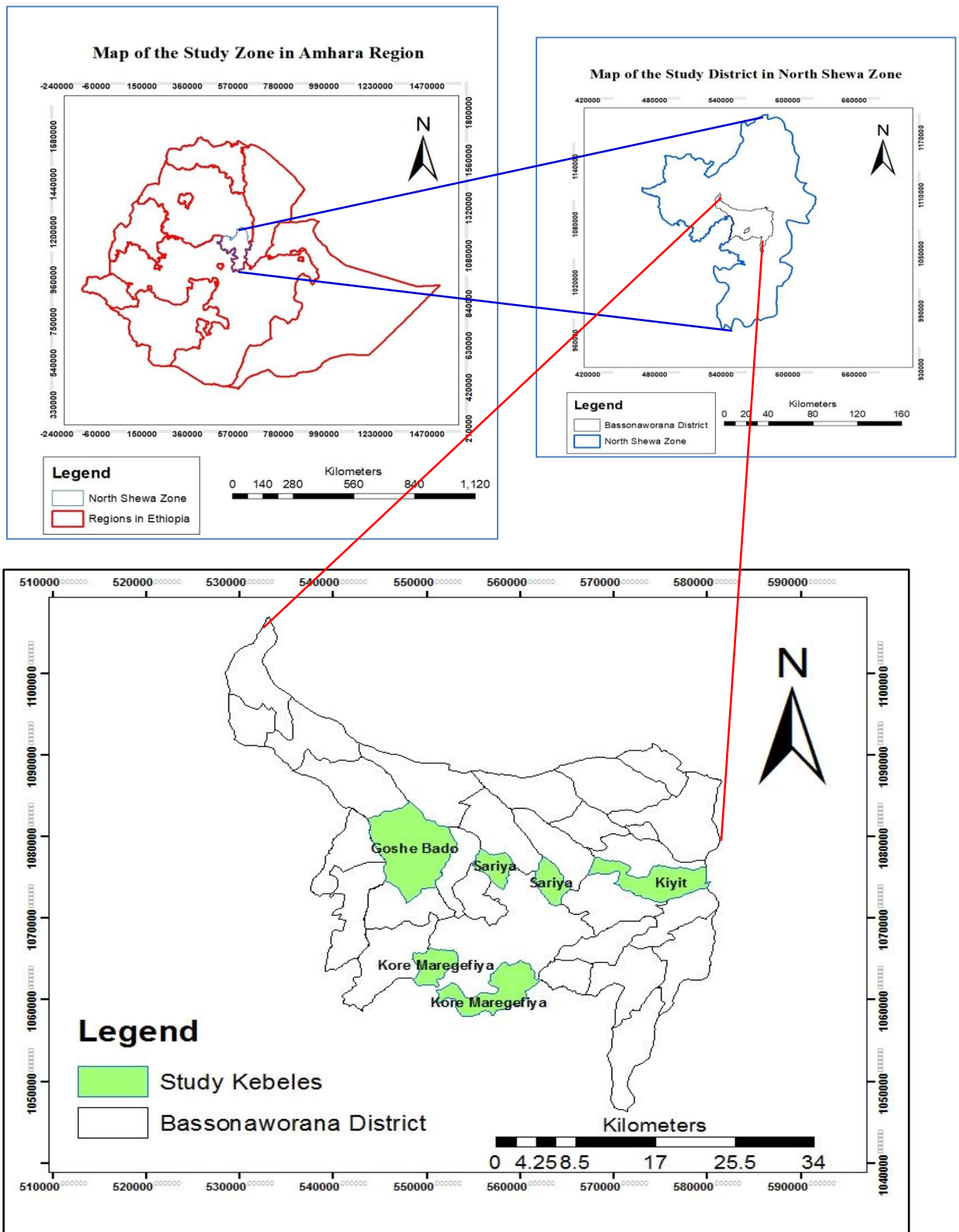


Fig. 3.1 Map of Study areas

3.2.2 Data sources and Sampling techniques

The study was based on cross-sectional data in which both quantitative and qualitative types of data were gathered from March to June 2016. Key informant interview, focus group discussions, and household survey were employed to collect comprehensive and pertinent information. The questionnaire for household survey was include detailed inquiries about household data such as age, sex, marital status, education level, livestock holding, family size, non-farm income, distance to market center, distance to car road, membership multipurpose cooperatives, perception of WMPs impacts, frequency of household contact with extension agents and others.

Using the list of participation indicators collected during the focus group discussions and evidence adapted from literatures (Bagdi, 2012; Bagdi and Kurothe, 2014), structured interview schedule for data collection was developed to assess the extent of people's participation in the watershed development program. Data were collected through personal interview technique with the help of structured schedule. All the activities of the watershed development were classified by their stages, i.e. planning stage, implementation stage, and the maintenance stage. Thus, households' participation was assessed and measured in relation to these three levels of participation included program planning and decision-making, implementation, and maintenance through a five-point Likert type scale (4=very high, 3=high, 2= moderate, 1=low and 0=very low/ never) was used for each level.

The sampling procedure was a mix of purposive and random sampling techniques. First, Bassonaworana district where soil erosion is severe and many conservation strategies of land management have been undertaken was purposely selected. Following four Kebeles namely Kiyit and Kore margefiya (from upper highlands) Sariya and Goshe bado (from mid highlands) were selected randomly from the district and proportionate sampling technique was adopted. Lastly, a total of 354 sample respondents were selected from four sample Kebeles.

3.3. Analytical Framework

Descriptive statistics such as percentage mean, and standard deviation were used to describe the data. Data were also subjected to Tobit model.

3.3.1. Evaluating level people's participation in watershed management programs

Individual watershed activities were considered to assess the extent of participation in the program. Participation Index of each farm household, (PI), was calculated following Badal *et al.* (2006) using formula (1).

$$PI = \left(\frac{P_i}{\text{Maximum participation score}} \right) 100 \quad \text{Equation 1}$$

$$P_i = \sum_{j=1}^m (PP_j + PI_j + PM_j)$$

PP_j = Total scores obtained by a respondent due to participate in the program planning,

PI_j = Total scores obtained by a respondent due to participation in program implementation,

PM_j = Total scores obtained by a respondent due to participation in program maintenance,

P_i = Total participation scores obtained by individual respondents in planning, implementation and maintenance, and

m = Total number of statements on which responses of the respondents were recorded.

Similarly, the overall extent of people's participation in watershed management program was measured by the people's participation index (PPI) as specified below following Bagdi (2012) and Bagdi and Kurothe (2014).

$$PPI = \left(\frac{\text{mean participation score (P)}}{\text{maximum score}} \right) 100 \quad \text{Equation 2}$$

$$\text{Where, } P = \frac{\sum_{i=1}^N P_i}{N} \quad N = \text{number of respondents}$$

For descriptive analysis, using the participation index generated by equation 1 and 2, households were classified into three categories, namely, low, moderate, and high participants. The quantitative data were analyzed using techniques like frequency distribution, percentage, standard deviations and tables to illustrate data and facilitate analysis.

3.3.2. Modeling level of households' participation in WMP- a Tobit model

Following Dolisca *et al.* (2006), participation in WMPs is measured by a composite score derived from participation in program activities. In this study, the level of households' participation was measured using the participation components (planning, implementation and

maintenance) adopted by varimax rotation. Principal component analysis (pca) was used to identify the latent participation components underlying the different variables that measured farm households' participation. pca allows clustering and identification of variables on the basis of mutual correlations. When the loading of a variable is greater, its effect on the formation of the principal component score is also high (Shiferaw *et al.*, 2012). Indices obtained from pca are examined further by regression analyses to investigate the determinants of the level of households' participation in WMPs.

The level of participation in WMPs is a censored continuous variable; this censoring arises due to the fact that not all sample households participate in WMPs. Application of ordinary least squares (OLS) to such censored data renders the estimates biased. Often to overcome this problem, literature suggests the Tobit model. Therefore, the study adopts this approach to analyze factors influencing people's participation in WMP.

3.3.2.1. Model specification

A Tobit model was used to examine determinants of participation and extent of participation in WMPs (program planning, implementation and maintenance) in Bassonaworana district from 2011-2016 using the value estimated for each household via pca as the dependent variable. The dependent variable has a participation threshold (τ) which is indicative of censoring of an underlying variable for non-participants and therefore requires Tobit estimators. Because, in such cases, where the distributions of the observations are censored as the observed values are close or equal to zero, can be analyzed using the Tobit model (Greene, 2000). The econometric model applied for analyzing factors influencing people's participation and level of participation in WMPs is (Tobit model) shown in equation (3). The decision of a farm household to participate and extent of participation in the watershed development programs may be influenced by different socioeconomic and institutional variables (Badal *et al.*, 2006). Summary descriptive statistics and a-priori hypotheses for the explanatory variables used for the analysis are presented in appendix Table 3.1.

Following McDonald and Moffitt (1980) and Maddala (1997), the Tobit model can be derived based on defining a new random variable PI^* that is a function of a vector of variables X can be defined as:

$$PI_i^* = \beta_1 X_i + \varepsilon_i$$

⁷ PI_i^* is a latent variable that is observed for values greater than τ and censored otherwise⁸. The observed PI is defined by the following measurement equation.

$$PI_i = PI_i^* \text{ if } PI_i^* = \beta_1 X_i + \varepsilon_i > \tau \quad \text{Equation 3}$$

$$= PI\tau \text{ if } PI_i^* = \beta_1 X_i + \varepsilon_i \leq \tau$$

Where:

$i = 1, 2, 3 \dots N$,

N = is the number of observations,

PI_i = is participation index for i^{th} farm household,

τ = unobservable value

X_i = Vector of factors influencing program participation and intensity of participation,

β = Vector of unknown parameters, and

ε_i = is the error term which is normally distributed with mean 0 and variance σ^2 .

The model, therefore, measures not only the probability farm household's program participation but also the intensity of participation. The above model follows Amemiya (1985) and many previous analyses and that it assumes censoring at τ (although most previous studies are censored at 0). The model coefficients are estimated by maximizing the Tobit likelihood function of the following form (Amemiya, 1985; Maddala, 1997; Greene, 2008).

$$L = \prod_{PI_i^* > \tau} \frac{1}{\sigma} f\left(\frac{PI_i - \beta_i X_i}{\sigma}\right) \prod_{PI_i^* \leq \tau} F\left(\frac{-\beta_i X_i}{\sigma}\right) \quad \text{Equation 4}$$

Where f and F are respectively, the density function and cumulative distribution function of

PI_i^* . $\prod_{PI_i \leq \tau}$ means the product over those i for which $PI_i^* \leq \tau$, and $\prod_{PI_i > \tau}$ means the product

over those i for which $PI_i^* > \tau$ as cited in Maddala (1997).

⁷ PI_i^* = is the latent variable and the solution to utility maximization problem of intensity of participation subjected to a set of constraints per household and conditional on being above certain limit.

⁸ The tobit model can be generalized to take account of censoring both from below and/or from above. It can also take account of interval censored data.

Nevertheless, the coefficients of the Tobit model may not be sensible to interpret in the same way as the coefficients in an uncensored linear model are interpreted (Greene, 2008). Hence, it is essential to compute the derivatives of the estimated Tobit model to predict the effects of changes in the exogenous variables (X_i). Accordingly, McDonald and Moffitt (1980) proposed the following techniques to decompose the effects of explanatory variables into participation decision and intensity effects. Thus: change in X_i (explanatory variables) has two effects. It affects the conditional mean of PI_i^* , and it affects the probability that the observation can fall in that part of the distribution. Similarly, in this study, the marginal effect of explanatory variables is estimated as follows.

1. The marginal effect of an explanatory variable on the expected value (mean proportion) of the dependent variable is:

$$\frac{\partial E(AI_i)}{\partial X_i} = F(z)\beta_i \quad \text{Equation 5}$$

Where, $\frac{\beta_i X_i}{\sigma}$ is denoted by z , following Maddala (1997) and (Greene, 2008)

2. According to McDonald and Moffitt (1980), the change in the probability of participating in WMPs as independent variable X_i changes is:

$$\frac{\partial F(Z)}{\partial X_i} = f(z) \frac{\beta_i}{\sigma} \quad \text{Equation 6}$$

3. The changes in the intensity of program participation with respect to a unit change in an explanatory variable among participants can be given by Equation (7)

$$\frac{\partial E(PI_i / PI_i^* > 0)}{\partial X_i} = \beta_i \left[1 - Z \frac{f(z)}{F(z)} - \left(\frac{f(z)}{F(z)} \right)^2 \right] \quad \text{Equation 7}$$

Where,

$F(z)$ is the cumulative normal distribution of Z ,

$f(z)$ is the value of the derivative of the normal curve at a given point (i.e., unit normal density). Z is the z-score for the area under the normal curve, β is a vector of Tobit maximum likelihood estimates and σ is the standard error of the error term.

A main concern with the maximum likelihood (ML) estimators of the Tobit model is its sensitivity to violation of the basic assumptions of homoscedasticity and normality of the disturbance terms. Violation of these assumptions renders the Tobit estimates biased and inconsistent (Greene, 2000). The Huber/White/sandwich estimator of variance was used to correct for possible heteroscedasticity of unknown form. In addition, before running the Tobit model all the hypothesized explanatory variables were checked for the existence of multicollinearity.

3.4. Results and discussion

3.4.1. Descriptive Statistics

3.4.1.1. Socioeconomic characteristics of farm households

Table 1 depicts the distribution of farm household characteristics and perceived impact of WMPs. In the study area, the average age of the head of the sample households was 46.4 years demonstrating that most of them were still in their middle age and likely to be receptive to new methods of farming. As shown in Table 1, survey results indicate that the overwhelming majority (88.7%) of respondents are male while only 11.3% of them are women. These women heading the households are either widowed or divorced. Results also indicate that 79.4% of the sample farm household heads are married. This group comprises the most important individuals and decision makers at the community and household levels. While it is vital to consider this influential group, care needs to be taken during the planning of WMPs as a result other groups are not marginalized. The mean household size of sample households in the study area is 4.53 members which are slightly less than the national average of 4.9 (CSA, 2012). In the study area it seems there was encouraging effort in family planning.

In the study areas, in average sampled households have 1.22 hectare, serving 4.53 members (Table 1). The result implies that arable crop production in the study district is basically a subsistence farming characterized by small land holdings. Furthermore, land holding size varies from 0.125 to 2.75 hectares. As a result, fallow land is now almost none and there is a growing

scarcity of grazing land. The survey result also indicates, in the study area, there is a sizeable difference in land holding among the farm households, this uncover there are inequalities in holdings among farm households. Moreover, the newly formed households are those most affected by the land shortage in which they are forced to share parent's land, and cultivation of gazing lands and steep slope areas. This further enhance soil erosion problem and thereby exacerbate the already scare land resources challenges.

Table 1: Distribution of farm household characteristics and perceived impact of WMPs

| Variables | Total (354) |
|---|----------------|
| Gender | |
| Male (%) | 88.7 |
| Female (%) | 11.3 |
| Age of a household head | 46.4 |
| Education level of farm household head | 1.45 |
| Family size | 4.53 |
| Member to cooperative | |
| No (%) | 27.5 |
| Yes (%) | 72.5 |
| Residence distance to market center in waking minutes | 66.5 |
| Residence distance to road in waking minutes | 43 |
| Extension contact | 1.9 |
| Joined WMP : | |
| Willingly (%) | 88.4 |
| Forcefully (%) | 11.6 |
| Marital status ^a | |
| Married (%) | 79.4 |
| Others (%) | 20.6 |
| Participation in Non-farm works | |
| No (%) | 90.40 |
| Yes (%) | 9.60 |
| Total cultivated farm size | 1.2 |
| Livestock holding (TLU) | 5.46 |
| Perceived social impact ^b | 0.72 |
| Perceived economic impact ^b | 0.56 |
| Perceived environmental impact ^b | 0.7 |
| Agro-ecological zone | |
| Upper highlands (%) | 54.5 |
| Mid highlands (%) | 45.5 |

Note ^b denotes index of participation

The great majority of households (90%) in the district are involved in livestock farming. Important types of livestock are cattle, sheep and equines. The main purposes of keeping

livestock are milk, meat, draft power, transportation, manure and cash income. The average livestock holding of sample households is 5.46 in tropical livestock units (TLU) see appendix Table 3.1.

The survey result also indicates about 72.5% of sampled farm household are members in multipurpose cooperative whereas 27.5% of the farm household heads are non-member; yet this number is very large. Hence, so as to advance membership in cooperative there is a need to enhance farm households' knowledge about the role of cooperatives. Non-farm job opportunities are generally limited in the study area. A few farmers in the study area have involved in various non-farm activities parallel to the main farming activities. The survey showed that 9.6% of the respondents and/or family members are engaged in non-farm income generating activities. The main activities were petty trade and crafts, pre-harvest and post-harvest agriculture (hired in other farm), casual work, trading grain and livestock, and selling local beverage. As presented in Table 1 the average walking minute for a farm household's residence distance to market center and distance to roads are 66.5 and 45 respectively. About 11.6% of the farmers were participated in past WMPs activities against their will (Table 1). This implies there is a tendency of forcing farm households to join the program. Yet, such condition surely affects the sustainability of WMPs.

3.4.1.2. Household perception of impact of WMPs

The perceived impact of WMPs is the result of farm households' own evaluative perception. The individual perception index relates to the impact of WMPs, based on a five-point scale questions developed. Responses to each of these questions were coded as strongly agree (4) to strongly disagree (0). Note that scoring was reversed for unfavorable statements. The Cronbach's alpha value computed was 0.855; which exceed the ideal alpha value 0.7.

According to the survey result shown in Table 2, farm households' perceptions about the impact of WMPs vary across different items. On average the lowest score is given to "WMPs increased net income from livestock production, and increased diversity of animal" followed by WMPs enhanced supplies of surface water, while the value given to "decreased runoff (soil erosion)" was the highest score, in which 98.03% of the farm households agreed "WMPs decreased runoff". In nut shell, the average perceptions of sample respondents about the impacts of WMPs

are moderate to high. The total sum of the sub-scores (environmental, economic and social) obtained from these items are used to explain their effects on the program participation in WMPs.

Table 2: percentage distribution of perception of environmental, economic and social change (impact) of WMPs

| Items | Strongly agree | Agree | Neutral | disagree | Strongly disagree | mean | S.D |
|---|----------------|-------|-------------------------|----------|-------------------|------|------|
| Environmental (ecological) | | | | | | | |
| 1 decreased in runoff (soil erosion) | 70.06 | 27.97 | 1.13 | 0.56 | 0.28 | 3.7 | 0.56 |
| 2 reduced downstream siltation | 49.86 | 46.15 | 3.42 | 0.57 | 0 | 3.5 | 0.59 |
| 3 improved soil fertility | 53.26 | 41.36 | 3.68 | 1.42 | | 3.5 | 0.66 |
| 4 increased irrigated area | 15.54 | 38.14 | 23.45 | 18.93 | 0.28 | 2.4 | 1.08 |
| 5 raised water table (new/abandoned springs are originated) | 22.03 | 48.31 | 16.67 | 11.02 | 3.95 | 2.8 | 0.98 |
| 6 enhanced supplies of surface water | 12.15 | 22.88 | 13.56 | 45.48 | 1.98 | 1.9 | 1.18 |
| 7 increased diversity of plant | 8.47 | 44.07 | 16.67 | 27.4 | 5.93 | 2.3 | 1.05 |
| 8 increased diversity of animal | 4.52 | 26.27 | 23.45 | 34.46 | 3.39 | 1.8 | 1.09 |
| 9 enhanced water retention capacity of soil | 21.75 | 68.36 | 5.37 | 3.95 | 0.56 | 3.1 | 0.69 |
| 10 endangered watershed areas are revived | 38.98 | 52.82 | 6.78 | 1.41 | 0 | 3.3 | 0.66 |
| Perception index | | | 0.7^a | | | | 0.14 |
| Economic | | | | | | | |
| 1 increased livestock feed | 15.86 | 52.69 | 11.33 | 18.41 | 1.7 | 2.6 | 1.01 |
| 2 created more employment opportunities | 11.58 | 27.12 | 20.9 | 31.07 | 9.32 | 2.0 | 1.2 |
| 3 increased crop yield | 25.42 | 52.26 | 11.02 | 8.76 | 2.54 | 2.9 | 0.97 |
| 4 promoted opportunities to harvest apiaries | 9.35 | 28.33 | 22.1 | 29.46 | 10.76 | 2.0 | 1.17 |
| 5 increased net income from livestock production | 7.91 | 23.16 | 23.16 | 29.66 | 16.1 | 1.8 | 1.2 |
| Perception index | | | 0.56^a | | | | 0.20 |
| Social | | | | | | | |
| 1 Reduced illegal extraction of resources | 16.67 | 60.17 | 11.58 | 11.58 | 0 | 2.8 | 0.85 |
| 2 raised knowledge of management of natural resources | 20.34 | 72.32 | 4.52 | 2.82 | 0 | 3.1 | 0.59 |
| 3 reduced conflict over common resources | 13.28 | 72.03 | 7.34 | 6.78 | 0.56 | 2.9 | 0.72 |
| 4 created agreed rules for an equitable share of benefits from common resources | 12.43 | 62.99 | 12.15 | 10.73 | 1.9 | 2.7 | 0.87 |
| Perception index | | | 0.72^a | | | | 0.12 |

Note: ^a sub-score (environmental, economic and social), S.D (standard deviation)

Accordingly, the value of perception scores for social impact is 0.72 and followed by environmental impact with the value of 0.7, but farm household's perceived economic impact was 0.56 which is relatively lower than the others (Table 1). Therefore, enhancing the economic contribution of WMPs would secure sustainability of watersheds.

3.4.2. Levels of people's participation in WMPs

People's participation was assessed and measured in relation to the three stages of participation: program planning and decision-making, implementation and maintenance through a five-point Likert type scale (4=very high, 3=high, 2=moderate, 1=low and 0=very low). In measuring farm households' participation, an instrument consisting of 16 items was developed and used. Hence, 5 items were employed to get information on participation in program planning, 6 items were for participation in program implementation, and 5 items were used to elicit information on participation in the maintenance. The study confirmed that the level of participation in WMPs is moderate to low. However, farm households preferred more involvement in maintenance rather than planning and implementation activities. A summary of the composite scores of the respondents' participation is presented in Table 4.

3.4.2.1. People's participation category

People's participation in a watershed management program can also be categorized into three categories based on the normal distribution curve values (Bagdi, 2012; Bagdi and Kurothe, 2014).

Table 3: People's participation categories based on the normal distribution curve values (N=354)

| S.no. | Distribution range | Participation score range ⁹ | Participation category |
|-------|--------------------|--|------------------------|
| 1 | <Mean- S.D. | 0 to 14.04 | Low |
| 2 | >Mean -/+ S.D. | 14.05-41.76 | Moderate |
| 3 | >Mean +S. D. | 41.77 and above | High |

S.D. = standard deviation

The potential score of participation to WMPs ranges from 0 to 64. The actual mean score of participation to WMPs is 27.93 and the standard deviation is 13.86 with minimum and maximum

⁹ actual scores of farm household heads,

score of 0 and 53, respectively. Subsequently, score 0 to 14.04, 14.05-41.76 and 41.77 and above are categorized respectively into low, moderate and high WMPs participants (Table 3).

As depicted in Table 4, in the overall, 18.64% of the respondents obtained a low score while the other 67.51% of the respondents exhibited moderate score. About 13.84% of the sample households scored a high level. The overall farm households' participation index (mean score) as described by farm households found to be 27.93, which is slightly lower than 32, (the midpoint between lowest possible score (0) and the highest possible score (64)). This revealed that the level of farm households' participation in watershed management program is relatively low.

Table 4: Level of sample farm households' participation in WMPs

| Level of people's participation (%) | Frequency | Percentage | Mean | S.D. |
|-------------------------------------|-----------|------------|-------------|---------------|
| Overall participation | | | 43.6(27.93) | 21.65 (13.86) |
| Low (<21.94) | 66 | 18.64 | | |
| Moderate (21.95-65.246) | 239 | 67.51 | | |
| High (65.247-100) | 49 | 13.84 | | |
| Participation in planning | | | 33.13(6.63) | 22.7 |
| Low <10.43 | 82 | 23.16 | | |
| Moderate 10.44-55.83) | 217 | 61.3 | | |
| High (55.84-100) | 55 | 15.54 | | |
| Participation in implementation | | | 45.5(10.92) | 24.2 (5.8) |
| Low (<21.3) | 69 | 19.49 | | |
| Moderate (21.31-69.74) | 221 | 62.43 | | |
| High (69.75-100) | 64 | 18.08 | | |
| Participation in maintenance | | | 51.7(10.35) | 26.0 (5.21) |
| Low (<25.7) | 60 | 16.95 | | |
| Moderate (25.71-76.7) | 235 | 66.38 | | |
| High (76.71-100) | 59 | 16.67 | | |

Note: number in parenthesis indicates the actual mean score and its standard deviation

3.4.2.1. Participation in WMPs planning stage

The mean score of farm households' participation in the program planning activities is ranging from 1.16 to 1.51. The result of the study indicated that respondent showed low level of

participation in the program planning activities such as participate in planning meeting of WMPs (1.51), suggest idea in the planning of agricultural crop cultivation in the watershed (1.16), suggest information during planning of selection of SWC measures (1.23), suggest idea during planning of land leveling works carried out in watershed(1.3), and give suggestion about primary needs such as fuel, fodder and food to be take care the watershed (1.43) (see Table 5).

The result of analysis, using the people’s participation index (PPI) Equation (2), indicated the overall level of the farm households’ participation in the program planning stage is 33.13% (Table 4). In this regard the analysis shows that 23.16 % of the respondents obtained low scores; 61.3% of the respondents scored moderately. On the other hand, 15.54% of the respondents scored high level of participation in planning. The mean score of the overall respondents was 6.63, and the standard deviation of the data was 4.53 which were lower than 10, the midpoint between lowest possible score and the highest possible score. This implies that farm household’s involvement in watershed program planning and decision-making process appears to be low.

Table 5: Item wise percentage distribution and mean score (intensity) according to the extent of households’ participation in program planning

| Items | Very low | Low | Moderate | High | Very high | Mean scores |
|---|----------|-------|----------|-------|-----------|-------------|
| Attend the planning meeting of WMPs | 24.01 | 37.85 | 6.78 | 25.99 | 5.37 | 1.51 |
| suggest idea in the planning of agricultural crop cultivation in the watershed | 27.12 | 46.61 | 10.45 | 14.97 | 0.85 | 1.16 |
| suggest information during the planning of selection of SWC measures | 30.51 | 38.98 | 8.76 | 20.06 | 1.69 | 1.23 |
| suggest an idea during planning of land leveling works carried out in the watershed | 27.40 | 40.68 | 7.63 | 23.16 | 1.13 | 1.3 |
| give suggestion about primary needs such as fuel, fodder and food to be taken care | 22.60 | 42.09 | 6.78 | 27.12 | 1.41 | 1.43 |
| sum of mean score | | | | | | 6.63 |

3.4.2.2. Participation in WMPs implementation stage

The sampled farm households scored moderate levels of participation in WMPs implementation activities such as provide equipment during the construction of SWC structures (2.1), involve in exposure visits of WMPs (2.2), and participate in a training program offered by the program

implementing agency (PIA) regarding SWC program (2.03). The farm households also showed that low level of participation in the WMPs implementation activities such as contribute labor towards construction of SWC structures on communal land, make supervision of the construction work each time during implementation and construct a conservation measure on private land with a lower mean score (intensity) values 1.53, 1.4 and 1.7 respectively (Table 6).

As illustrated in Table 4, the overall level of the sample farm households' participation in implementation stage is also found to be 45.7%. In general, 19.49% of the respondents exhibited low score, and 62.43% of the respondents obtained moderate score. Nonetheless, 18.68% of the respondents acquired high scores. The mean score of the respondents is 10.96 which is slightly lower than 12, (the midpoint between lowest possible score and the highest possible score (24). Therefore, the level of participation of farm households in the implementation stage is relatively low to moderate.

Table 6: percentage distribution and mean score of level of households' participation in program implementation by items

| Items | Very low | Low | Moderate | High | Very high | Mean scores |
|---|----------|-------|----------|-------|-----------|-------------|
| provide equipment during the construction of SWC structures | 17.80 | 26.55 | 3.11 | 37.29 | 15.25 | 2.1 |
| Involve in exposure visits of WMP | 20.06 | 14.41 | 3.11 | 50.56 | 11.86 | 2.2 |
| participate in training programs offered by the PIA regarding SWC program | 17.23 | 26.55 | 3.39 | 41.81 | 11.02 | 2.03 |
| contribute labor towards construction of SWC structures on communal land | 32.77 | 22.03 | 9.32 | 31.36 | 4.52 | 1.53 |
| Make supervision of the construction work each time during implementation | 23.45 | 41.53 | 8.19 | 25.42 | 1.41 | 1.4 |
| construct conservation measure on private land | 20.90 | 33.90 | 2.54 | 38.14 | 4.52 | 1.7 |
| Sum of mean score | | | | | | 10.96 |

3.5.2.3. Participation in maintenance stage

The mean score of farm households' participation in the program at the stage of maintenance ranged from 1.49 to 2.7. The respondents show moderate levels of participation in the activities such as prevent entrance of animal in to protected area, contribute own labor towards maintenance of SWC structure in your field, and contribute labor/money towards the desilting of the SWC structures with the mean score values 2.06, 2.17 and 2.7, respectively (Table 7). The respondents also exhibit low levels of participation during the maintenance stage only in the activities of, such as take care of the forest plants during the dry season and protect the SWC structures from natural calamities, with mean score values 2.52 and 1.92, respectively (Table 7).

The overall level of the sample farm households' participation in the program maintenance stage was also calculated with the help of the PPI (equation 2) and it is found to be 51.7%. It implies that the level of participation of farm households in the maintenance stage is moderate. Based on data presented in Table 5, in general, 16.95 % of respondents scored low, but 66.38% of the respondents scored moderate. However, 16.67% of the respondents scored high. The mean score of the overall sample farm households' participation in maintenance were 10.34, which was slightly higher than 10, (the midpoint between lowest possible score (0) and the highest possible score (20)).

Table 7: Percentage of mean score distribution and mean score (intensity) for each item based on farm households' participation in maintenance activities

| Items | Very low | Low | Moderate | High | Very high | Mean score |
|---|----------|-------|----------|-------|-----------|------------|
| prevent entrance of animal in to protected area | 13.84 | 29.10 | 5.93 | 39.27 | 11.86 | 2.06 |
| take care of the forest plants during the dry season | 24.01 | 39.83 | 5.65 | 23.45 | 7.06 | 1.49 |
| Protect the SWC structures from natural calamities | 16.95 | 29.10 | 3.67 | 45.76 | 4.52 | 1.92 |
| contribute own labor towards maintenance of SWC structure in your field | 15.82 | 25.99 | 1.98 | 37.57 | 18.64 | 2.17 |
| contribute labor/money towards the desilting of the SWC structures | 13.56 | 6.78 | 0.85 | 53.67 | 25.14 | 2.7 |
| Sum of mean score | | | | | | 10.34 |

3.4.3. Principal component analysis

To determine the suitability of the data for component analysis, coefficient of Kaiser-Meyer-Olkin (KMO) was used (Kaiser, 1960). In the present study, the Kaiser's overall measure of sampling adequacy -KMO value is 0.92 and indicates that the situation is appropriate for component analysis of data. Meanwhile, varimax rotation method was used to enhance interpretation of components for determining the number of operating components based on criteria Kaiser. Reliability of the instrument was estimated at 0.93¹⁰.

The Kaiser criterion (the eigenvalue-one criterion) was employed for determining the number of components to be retained. Components (factors) with eigenvalues less than 1.00 are regarded as trivial, and not retained. Only component with eigenvalues of 1.0 or greater are considered and then verified by a Scree test (Figure 1).

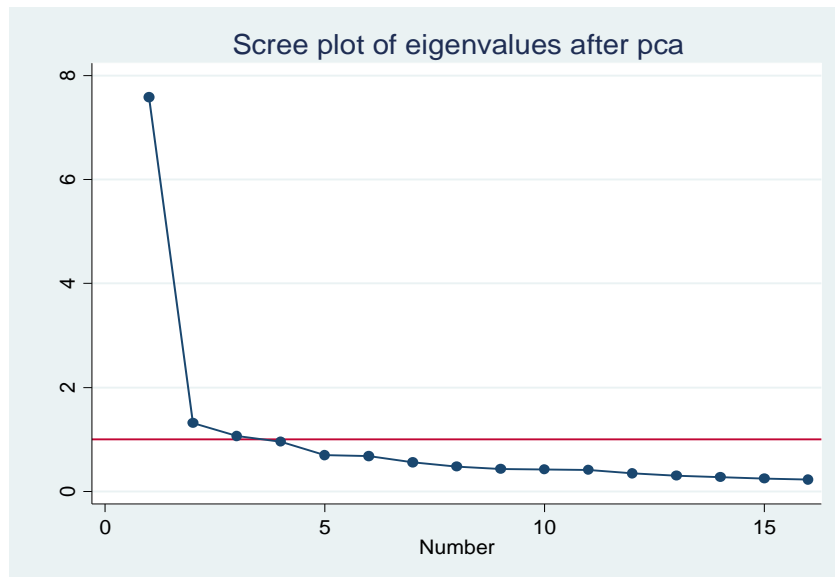


Figure 3.1: Scree plot of eigenvalue (pca)

The three-component loadings accounted for 62.3% of total variance as shown in Table 8. Factor loading values >0.4 are acceptable (Hair *et al.*, 1998) and therefore were considered in this study. Four attributes (participate in planning meetings, suggest idea in the planning of agricultural crop cultivation in the watershed, suggests information during the planning of selection of SWC and various forest trees planted in the watershed and gives suggestion about primary needs such as fuel, fodder and food to be taken care are loaded on factor one. Since

¹⁰The value of Cronbach alpha coefficient ranges between 0 and 1 and it increases with internal consistency between items. As a rule of thumb, a value higher than 0.7 means the internal consistency is higher.

these attributes focus on planning and decision making, factor 1 is called participation in program planning and decision making and accounted for 21.84% of the total variance.

Four participation variables, including preventing entrance of animal in to protected area, take care of the forest plants during the dry season, protect the SWC structures from natural calamities and contribute own labor towards maintenance of SWC structure in your field had cross-correlation with factor 2. Because factor 2 concerned about protection of the watershed, then it is labeled as maintenance and accounted for 20.25% of the total variance.

Table 8: Varimax rotation components (factors) pattern of farm households' participation in WMP, Bassonaworana district

| Items | Participation components | | |
|---|--------------------------|----------------|---------------|
| | Planning | Implementation | Maintenance |
| suggest idea in the planning of agricultural crop cultivation in the watershed | 0.4573 | -0.0444 | -0.0238 |
| suggest information during the planning of selection of SWC and various forest trees planted in the watershed | 0.4266 | 0.1174 | -0.1211 |
| suggest an idea during planning of land leveling works carried out | 0.3345 | 0.1948 | -0.0824 |
| Participate in planning meetings | 0.4077 | -0.0436 | 0.0650 |
| give suggestion about primary needs such as fuel, fodder and food to be taken care | 0.4847 | -0.1158 | 0.0386 |
| provide equipment during the construction of SWC structures | -0.0421 | 0.4106 | 0.1030 |
| Involve in exposure visits of WMPs | 0.1275 | 0.1096 | 0.1980 |
| participate in training programs offered by the PIA regarding SWC program | -0.0128 | 0.5216 | -0.0671 |
| contribute labor towards construction of SWC structures on communal land | 0.0034 | 0.5003 | -0.1246 |
| Make supervision of the construction work each time during implementation | 0.2255 | 0.0177 | 0.1631 |
| prevent the entrance of animal in to protected area | 0.0649 | -0.1734 | 0.5144 |
| take care of the forest plants during the dry season | -0.0911 | -0.0385 | 0.5141 |
| Protect the SWC structures from natural calamities | -0.0292 | 0.2188 | 0.4001 |
| construct conservation measure on private land | -0.0268 | 0.3524 | 0.0986 |
| contribute own labor towards maintenance of SWC structure in your field | -0.0458 | 0.1064 | 0.4037 |
| contribute labor/money towards the desilting of the SWC structures | 0.1027 | 0.1134 | 0.2928 |
| Eigenvalue | 7.6 | 1.1 | 1.3 |
| Percentage of variance | 21.84 | 20.24 | 20.25 |

Numbers in bold indicate the component loadings.

Three participation variables: provide equipment during the construction of SWC structures, participate in a training program offered by the project implementing agency (PIA) regarding

SWC program and contribute labor towards construction of SWC structures on communal land regarding implementation were loaded on Factor 3. This factor accounted for 20.24% of the total variance and is named participation in program implementation.

3.4.4. Determinants of level of people's participation in WMPs

Any effort that intends to increase participation levels must differentiate the relative strength of variables influencing farm households' level of participation decision. Furthermore, all variables that are found to influence the participation and intensity of participation in WMPs may not have equal effects in determining the participation decision of farm households and their level of participation. Hence, following a decomposition procedure suggested by (McDonald and Moffitt, 1980), the results of Tobit models are used to assess the effects of changes in the explanatory variables into a participation and intensity of participation in WMPs activities. Accordingly, the marginal effect of change in explanatory variables is presented in Table 10.

The parameter estimates from the Tobit models are presented in Table 9 to support the validity of using such a simple approach to analyze the determinants of households' decisions for participation in watershed management programs (planning, implementation and maintenance). Furthermore, the coefficient and standard error values for sigma show that there is a statistically significant censoring in the samples for the three dependent variables. The analysis further confirms that the signs of most of the coefficients are consistent with the hypothesis, and are statistically significant.

The results presented in Table 9 indicate that the age of the household head, perceived environmental impact, non-farm works and forced participation have significant influence on the participation of the three WMPs stages. The frequency of a household contact with extension agents, perceived social impact and size of landholding have a positive significant effect on participation behavior of the farm households with the exception of maintenance decision. Perceived economic impact is found to be a key determinant to participate in implementation and maintenance. Membership in cooperative, distance to market center and distance to roads have a significant effect on farm household maintenance decision behavior. Family size is also found to be significantly related only with participation in planning decision and level of participation in the planning stage. Interpretation of Table 9 produces a number of further insights about farm households' participation in watershed development programs. Next, the detail is explained.

Based on econometric findings, being a female headed household is significantly and negatively affect the participation and level of participation in WMPs planning and maintenance at less than 1% and 5% probability level respectively. The negative sign shows that female households are less likely to take part in the planning and maintenance of WMPs activities than male once. For female headed households the probability of participating in the planning and maintenance decision of WMPs decreased by 4.4% and 2.2% respectively. On average, being female headed household decreases the intensity of participation in planning and maintenance of WMPs activities by 0.76 and 0.79, respectively. The reason for low participation in planning and maintenance behavior of female headed households may be because watershed management activities are labor intensive that could not match with multiple role of female in farm households. This result is congruent with Bagherian (2013) who revealed male respondents were more likely to participate than females.

Age has a strong negative significant effect in explaining the level of participation in the three participation stages. This implies that younger farm households are more willing to participate in WMPs activities. Each additional year of age decreases the probability of participation in planning, implementation and maintenance decision of WMPs activities by 0.1%. On average, each additional year of age would result in decreases of 2.1, 1.7 and 1.8 in the intensity of participation in planning, implementation and maintenance of WMPs activities, respectively. This result is accordant to the results of Badal *et al.* (2006), Dolisca *et al.* (2006) and Faham *et al.* (2008).

Family size of households was found to be positive and significantly ($p < 0.05$) related to participation in WMPs planning implying that farm households who hold large family size are more likely participate in WMPs planning and decisions. It indicates that as family size increases the likelihood of the household to participate in planning stage tend to rise. Each additional change in family size brings about 0.8% increment in probability of participation in watershed planning and decisions. A unit change in family size also brings 0.14 increases in the level of participation in planning of WMPs activities.

Household residence distance to market center was negatively and significantly influences participation in maintenance decisions and extent of maintenance. This entails that farm households who reside far from market center are less likely involve in maintenances of WMPs

activities. In such case where distance affects participation negatively, the possible reason is the limited access to production inputs and the disincentive to output market. With each additional minute of traveling, the probability of maintenance decision decreased by 0.01%. On average, each additional minute of traveling has decreased the intensity of the maintenance of WMPs activities by 0.005. The households' residence distance to road is found to be positive and significantly correlated with the likelihood of participation in the maintenance and extent of maintenance. This indicates that farm households who are located far away from roads are more likely to involve in maintenances of WMPs activities. This result could be explained by the fact that the farther away from roads a household is, the less the opportunities to engage in alternative competing market driven activities, consequently, the likelihood of participating in watershed maintenance is increased as this makes farm households to give due attention to agricultural activities rather than other non-agricultural activities.

The analysis shows that farm households' membership in multipurpose cooperative is strongly and positively related to the likelihood of participation and level of participation in the maintenance of the watershed. Membership in multipurpose cooperative would result in a 1.7% increase in the probability of participation maintenance of WMPs activities. Membership in multipurpose cooperative would result in a 49.5% increase in the level of participation in the maintenance of the watershed. A farm household that belongs to a cooperative is more likely benefited from access to information about the potential gains from watershed development. Further, as a member of a cooperative society, farm households possibly will attend meeting at which participants meet and exchange experiences among each other. Therefore, a sense of responsibility to protect and maintain watersheds is increased.

Another important variable hypothesized in this study was the frequency of household contact with extension agents. The model result shows that this variable is positively and significantly influences the probability of participation and intensity of participation in planning and implementation of WMPs. These results are consistent with (Abdolmaleky *et al.*, 2011). Having targeted contact with extension agents allows farm households to make informed decisions. The direction of influence is also in line with the hypothesis that households who had more contact about watershed were more likely to participate in the planning and implementation of WMPs activities.

Table 9: Maximum Likelihood Estimates of Tobit Regression Model¹¹ (robust std. Err)

| Variables | Participation components (factors) | | | | | | | | | | | |
|--------------------------|------------------------------------|----------|-------|----------|----------------|----------|-------|----------|-------------|----------|-------|----------|
| | Planning and decisions | | | | Implementation | | | | Maintenance | | | |
| | Coef. | Std. Err | T | P> t | Coef. | Std. Err | T | P> t | Coef. | Std. Err | t | P> t |
| Gender | -0.892 | 0.34 | -2.63 | 0.009*** | -0.281 | 0.361 | -0.78 | 0.437 | -0.869 | 0.401 | -2.16 | 0.031** |
| Age | -0.024 | 0.007 | -3.45 | 0.001*** | -0.019 | 0.007 | -2.78 | 0.006*** | -0.02 | 0.008 | -2.58 | 0.01*** |
| Family size | 0.158 | 0.062 | 2.54 | 0.011** | 0.079 | 0.057 | 1.38 | 0.169 | 0.021 | 0.06 | 0.34 | 0.735 |
| Education level | 0.256 | 0.234 | 1.09 | 0.275 | -0.279 | 0.208 | -1.34 | 0.18 | -0.333 | 0.22 | -1.51 | 0.132 |
| Marital status | 0.194 | 0.29 | 0.67 | 0.504 | -0.074 | 0.289 | -0.25 | 0.799 | -0.097 | 0.317 | -0.3 | 0.761 |
| Access to market center | 0.006 | 0.003 | 1.64 | 0.102 | 0.005 | 0.003 | 1.58 | 0.116 | -0.005 | 0.003 | -1.71 | 0.088* |
| Access to roads | -0.002 | 0.003 | -0.63 | 0.53 | 0 | 0.003 | 0.11 | 0.911 | 0.009 | 0.003 | 2.82 | 0.005*** |
| Extension contacts | 0.146 | 0.048 | 3.02 | 0.003*** | 0.195 | 0.052 | 3.73 | .000*** | -0.03 | 0.047 | -0.63 | 0.53 |
| Multipurpose cooperative | 0.326 | 0.198 | 1.64 | 0.101 | 0.215 | 0.192 | 1.12 | 0.264 | 0.554 | 0.21 | 2.64 | 0.009*** |
| Social impact | 1.48 | 0.76 | 1.95 | 0.052* | 1.412 | 0.627 | 2.25 | 0.025** | 0.876 | 0.713 | 1.23 | 0.22 |
| Economic impact | -0.157 | 0.514 | -0.3 | 0.761 | 1.094 | 0.567 | 1.93 | 0.055* | 1.619 | 0.581 | 2.79 | 0.006*** |
| Environmental impact | 4.293 | 0.881 | 4.87 | 0.000*** | 3.366 | 0.886 | 3.8 | .000*** | 2.531 | 0.963 | 2.63 | 0.009*** |
| Joining WMPs unwillingly | -1.296 | 0.317 | -4.09 | 0.000*** | -1.413 | 0.312 | -4.54 | .000*** | -1.159 | 0.405 | -2.86 | 0.005*** |
| Farm size | 0.426 | 0.215 | 1.98 | 0.049** | 0.451 | 0.224 | 2.01 | 0.045** | 0.291 | 0.223 | 1.3 | 0.194 |
| Non-farm income | -0.539 | 0.262 | -2.06 | 0.041** | -0.64 | 0.287 | -2.23 | 0.027** | -0.68 | 0.32 | -2.13 | 0.034** |
| Livestock | 0.054 | 0.039 | 1.38 | 0.167 | -0.018 | 0.036 | -0.5 | 0.616 | -0.018 | 0.04 | -0.46 | 0.648 |
| Agro-ecological zone | -0.23 | 0.205 | -1.12 | 0.262 | 0.018 | 0.203 | 0.09 | 0.929 | 0.164 | 0.211 | 0.78 | 0.437 |
| _cons | -4.008 | 0.759 | -5.28 | 0.000*** | -4.198 | 0.804 | -5.22 | .000*** | -1.987 | 0.865 | -2.3 | 0.022** |
| Log likelihood | -628.7*** | | | | -626.4*** | | | | -650.8*** | | | |

¹¹ For comparison, OLS was also estimated for participation components (see appendix Table 3.2)

Each additional visit of a farm household by the extension agent increases the probability of the participation decision by 0.7% for both for planning and implementation. On average, each additional visit has also increased the intensity of participation in planning, and implementation of WMPs by 0.124 and 0.17, respectively. Suggesting that farm households' contact with extension agents enhances their participation in WMPs during planning and implementation stages. However, the insignificant effects of frequency of household contact with extension agents for watershed maintenance implies that watershed development campaign didn't give due attention to the maintenance.

The results of Tobit models indicated that joining WMPs forcibly (involuntary participation) has a strong negative and significant effect on peoples' participation in WMPs activities at all stages. The possible reason is that compulsory approaches discourage households' involvement in the program and sense of worship. This suggests voluntary participation would promote levels of participation in watershed development and its sustainability. For those farm households who joining WMPs unwillingly the chance of participating in planning, implementation and maintenance of WMPs decreased by 11.2% 10.2% and 5.4%, respectively. On average, forced participation in watershed development activities decreased the intensity of participating in planning, implementation and maintenance of WMPs by 1.0, 1.13, and 1.22 units, respectively.

Farm size of households was positively and significantly correlated with participation decision and extent of participation in the planning ($p < 0.05$) and implementation ($p < 0.05$) of WMPs activities, suggesting that farm households who hold large farms are more likely engaged in planning and implementation. Each additional hectare of land increased the likelihood of participation decision in planning and maintenance by 2.1 and 1.6%, respectively. On average, each additional hectare of land holding size has increased the intensity of participating in planning and maintenance by 0.36 and .399, respectively.

Participation in non-farm works and farm household's participation decision in WMPs (for the three stages) had negative and significant relation. This is due to the fact that participation in non-farm works leaves them with little time for being involved in the watershed activities (Badal *et al.*, 2006). This suggested that since watershed activities are long-term investment, farm households who involved in other short-term profitable activities, like trading, was likely to ignore investing their labor and capital in watershed development works which is a relatively

unprofitable venture in the short-term and shows less willingness to participate. Moreover, those farm households who engaged in non-farm their dependence on watershed resources might be minor as compared with counterparts. The result of this study identified that, for farm households who engaged in non-farm activities, the likelihood of participating in planning, implementation and maintenance of WMPs would be lower by 3.4%, 3.2% and 2.5% respectively. On average, participation in non-farm activities decreased the intensity of participating in planning, implementation and maintenance of WMPs by 0.44, 0.54 and 0.596 respectively. The finding of this study is in line with (Badal *et al.*, 2006), however, oppose to the finding of (2006) who suggested that farm households with different sources of income are more likely to participate in forest management.

In this study, different economic contributions of WMPs were made to be evaluated by the farm households so as to understand the influence of perception on economic change (perceived impact) on WMPs. The total score for each respondent was analyzed and the result found to be significantly and positively associated with initial participation and intensity of participation in implementation and maintenance of WMPs activities respectively. This implies that farm households that perceived WMPs had higher economic importance would be more likely to participate in implementation and maintenance watersheds and also had immense concern about the environment. The results of Tobit models also revealed that the probabilities of participating in the implementation and maintenance of WMPs would increase by 3.9% and 4.2% respectively. On average, each additional unit of change in economic impact score has raised the intensity of participating in the implementation and maintenance of WMPs by 0.967 and 1.47, respectively. Therefore, this study suggested that increasing opportunities for generating economic returns would be one of the most important factors in stimulating participation in WMPs.

Perceived environmental impact is positive and significantly related to the participation and level of participation in WMPs activities. This suggests that if farm households had a favorable environmental impact perception, the likelihood of participation in WMPs would increase. The more farm households understand the WMPs contribution to the environment, the better will be participating in WMPs activities at the three stages. The likelihoods of participating in the planning, implementation and maintenance of WMPs would be higher by 21.2%, 12.1% and

6.5% respectively. On average, each additional unit of change in environmental impact score has increased the intensity of participating in planning, implementation and maintenance of WMPs by 3.65, 1.26 and 2.3 respectively.

Table 10: Marginal effect of level of participation by components, Bassonaworana district

| Variable | Planning | | Implementation | | Maintenance | |
|--------------------------|-----------|-----------------------|----------------|-----------------------|-------------|-----------------------|
| | Intensity | Change in probability | Intensity | Change in probability | Intensity | Change in probability |
| Gender | -0.757 | -0.044 | -0.248 | -0.01 | -0.789 | -0.022 |
| Age | -0.021 | -0.001 | -0.017 | -0.001 | -0.018 | -0.001 |
| Family size | 0.135 | 0.008 | 0.07 | 0.003 | 0.019 | 0.001 |
| Education level | 0.219 | 0.012 | -0.244 | -0.011 | -0.299 | -0.01 |
| Marital status | 0.166 | 0.009 | -0.065 | -0.003 | -0.087 | -0.003 |
| Access to market center | 0.005 | 0.000 | 0.004 | 0.000 | -0.005 | -0.0001 |
| Access to roads | -0.002 | 0.000 | 0.0001 | 0.00 | 0.009 | 0.0001 |
| Extension contacts | 0.124 | 0.007 | 0.172 | 0.007 | -0.027 | -0.001 |
| Multipurpose cooperative | 0.273 | 0.018 | 0.189 | 0.008 | 0.495 | 0.017 |
| Social impact | 1.257 | 0.073 | 1.249 | 0.051 | 0.795 | 0.023 |
| Economic impact | -0.133 | -0.008 | 0.967 | 0.039 | 1.47 | 0.042 |
| Environmental impact | 3.646 | 0.212 | 2.977 | 0.121 | 2.298 | 0.065 |
| Joining WMPs unwillingly | -0.995 | -0.112 | -1.134 | -0.102 | -0.988 | -0.054 |
| Farm size | 0.362 | 0.021 | 0.399 | 0.016 | 0.264 | 0.007 |
| Non-farm income | -0.44 | -0.034 | -0.543 | -0.032 | -0.596 | -0.025 |
| Livestock | 0.046 | 0.003 | -0.016 | -0.001 | -0.016 | 0.000 |
| Agro-ecological zone | -0.195 | -0.012 | 0.016 | 0.001 | 0.149 | 0.004 |

Source: model output

Perceived social impact of watershed development programs also positively and significantly influences the participation and level of participation in planning and implementation of WMPs activities at less than 10% and 5% level of significance. These indicate farm households that have better perception about the social contributions of WMPs are more likely involve in in planning and implementation. The chances of participating in planning and implementation stages would be higher by 7.3% and 5.1% for household that favoring the social impact compared to a household who did not perceive such social impact of WMPs. On average, each

additional unit of change in perceived social impact score has increased the intensity of participating in planning and implementation by 1.26 and 1.25 respectively.

3.5. Conclusions and policy implications

In Ethiopia, the government with the support from partners have implemented a community based integrated watershed management programs in recent years, but many fail to attain the intended objectives due to different reasons. We examine the level of people's participation in watershed management programs (WMPs) and its' links with socioeconomic and institutional factors. A survey was carried out in four PAs and 354 households within the Bassonaworana district, the Amhara region. Using empirical data, this study has shown that people's participation in watershed management programs can be captured through a set of variables that indicate households' active involvement in watershed planning and decisions, and their use of local resources (financial and labor) in the implementation and maintenances stages.

The result of descriptive analysis reveals that overall participation is generally low to moderate- only a few people have succeeded higher level participation in watershed programs. The findings also show that about 18.64%, 67.51% and 13.84% of households' exhibit low, moderate and high degree of participation in WMPs campaign respectively. Participation of people in watershed program planning and implementation stage is found to be low, while participation in maintenance stage is moderate.

The Tobit analysis indicated that age, participation in non-farm works and joining WMPs unwillingly have negative significant influence on households' participation in WMPs at the three stages (planning, implementation and maintenance). Farm households' contact with extension agents and size of landholding had a positive significant effect on level households' participation in planning and implementation stages. Membership in multipurpose cooperative and distance to roads had significant positive effects on the level of maintenance; but distance to market center had a negative significant impact. Family size was also found to be positively and significantly related only to the level of participation in the planning stage. The survey results indicate that household's perceived WMPs impacts (social, environmental and economic) have a positive and significant effect on the participation and the extent of participation in WMPs activities at all stages.

Household contact with extension agents has positive and significant effect only on participation in planning and implementation. Indicating there is limited focus on protection and maintenances of watersheds. Therefore, extension services need to target not only people mobilization and construction of conservation structures in watersheds but also their sustainability. The study also confirmed that participation in non-farm activities and level of participation has inverse relationship. Suggesting that watershed activities are long-term investment and households that involved in other short-term profitable activities are likely to ignore investing their labor and capital in watershed development (which require a longer gestation period to generate returns) and shows less willing to participate. Another variable, joining WMPs unwillingly is significantly and negatively correlated with people's participation and extent of participation suggesting that there is an urgent need to promote the voluntary participation rather than compelling people. Voluntary participation develops a sense of ownership over the resources being managed in the program. In addition, we found that age a household negatively correlates with the levels of participation in all stages. This implies that younger households are more willing to participate in WMPs. The probable reason is that they may have a long-term planning horizon and therefore about natural resources degradation and future productivity of the lands.

This study shows that the best chances of voluntary participation in WMPs activities can be achieved among households who perceive the positive impact of WMPs in terms environmental, social and economic returns. This signifies that the programs will need to create tangible economic, social and environmental benefits that are directly linked to people's participation in WMPs otherwise participation comes slowly. Therefore, the state should support policy and program actions which ensure sustainability via providing the necessary technical assistances and information about the potential benefits to be derived by people from watershed development. Policy and development programs that underlining on these important factors would lead to genuine participation in Bassonaworana or other similar areas.

CHAPTER FOUR

4. ADOPTION OF MULTIPLE SUSTAINABLE LAND MANAGEMENT PRACTICES IN BASSONAWORANA DISTRICT, CENTRAL HIGHLANDS OF ETHIOPIA¹²

Abstract

Over the past four decades, the government of Ethiopia has made efforts to address the problem of land degradation through large-scale implementation of a myriad of sustainable land management practices (SLMPs). In spite of these efforts, adoption of SLMPs still remains low. This paper examines factors determining adoption of multiple SLMPs by farm households using comprehensive household and plot-level data. A multivariate probit approach was employed to model simultaneous adoption decisions of SLMPs. The result shows that family size of a household, Social capital, plot size, household residence distance to market center, participation in non-farm income, tenure insecurity of plot, participation in watershed management programs, incidence of pests and diseases, livestock holding, access to credit and total cultivated farm size, all determine investment in SLMPs. is also imperative to the decision of adopting SLMPs. Finally, our analyses indicate that adoption of SLMPs is interdependent, hence, any activity that promotes these practices need to consider these interdependencies.

Key words: sustainable land management practices, joint adoption, multivariate probit, Ethiopia

¹²Kidane Tafa, Bamlaku Alamirew and Aklilu Amsalu, 2018. (under review). Adoption of multiple sustainable land management practices in Basonaworana district, central highlands of Ethiopia

4.1. Introduction

Land degradation is one of the most substantial problems creating formidable challenges through its impact on the sustainability of agricultural production and productivity (FAO, 2011). It affects about 30% of the total global land (Nkonya *et al.*, 2016). The cost is worth US\$450 billion per year (UNCCD, 2013). In Ethiopia, effects of land degradation have afflicted the bulk of the rural population. Particularly, land degradation by soil erosion has been a key constraint to agricultural production and food security (Amsalu and De Graaff, 2007; Gebreselassie *et al.*, 2016).

From the earliest massive food for work programs of the mid-1970s to the present sustainable land management (SLM) programs, huge efforts have been put in place in order to restore degraded and depleted lands and halt further degradation through control of soil loss and run-off, improved soil fertility management and reforestation interventions. Accordingly, in the central highlands of Ethiopia (including North Shewa zone of Amhara Region), government and many other agencies have promoted several sustainable land management practices (SLMPs) such as soil and water conservation (SWC) and soil fertility management (SFM) practices (Amsalu, 2006). However, earlier studies show that the endeavors of many of the former SWC programs were disappointing for a number of reasons (Shiferaw and Holden, 1999; Amsalu, 2006; Wolka, 2014). As a consequence, currently Ethiopia faces the challenges of continuing food insecurity, and rural poverty while at the same time slowing or reversing agricultural land degradation to ensure sustainability of future agricultural production (Yesuf and Köhlin, 2009).

Researches indicate that farm households have awareness about soil erosion problems. Besides, increasing efforts have been made by national and international organizations to motivate farm households to invest in sustainable land management practices (SLMPs). Nevertheless, in the country, adoption of SLMPs remains far below expectation (Teklewold *et al.*, 2013a; Wolka, 2014). In fact, the degree of adoption of such practices substantially varies within the country (Bewket, 2007). This study concentrates on the most important practices that are implemented in Bassanaworana district which includes SWC (soil and stone buds), organic inputs such as compost and animal manure (hereafter manure) and inorganic fertilizers.

Several studies have been undertaken to investigate the major determinants of adoption of land management practices. However, most of them are based on strong assumptions. Moreover,

these studies fail to analyze the potential relations and interactions among various types of technology adoption (Yesuf and Köhlin, 2009). Some studies gave more emphasis to the adoption of a single component of SLM practices, such as inorganic fertilizer (Eba and Bashargo, 2014) and stone terraces (Tadesse and Belay, 2004; Amsalu and De Graaff, 2007; Ketema and Bauer, 2012). They used single equations. However, univariate (ordinary binary probit or logit) models overlook the potential correlation among unobserved disturbances in the adoption equations and the relationships between the adoptions of different SLMPs. If simultaneity decision is detected and/or unobserved heterogeneities are correlated, single equation estimation could result in biased, inconsistent, and inefficient estimates (Maddala, 1983). From such studies, information as to how multiple practices can comply with the existing conservation package is not readily available for policy makers (Teklewold and Köhlin, 2011). So, such univariate models ignore valuable economic information with regard to an interdependent and joint adoption decisions (Dorfman, 1996; Teklewold *et al.*, 2013a). Therefore, it is important to consider sustainable land management adoption decision as multivariate variables.

Accordingly, we are particularly interested in two research questions that were not sufficiently addressed in previous studies. Firstly, do farm households adopt SLMPs jointly (simultaneously) or independently? Secondly, what factors facilitate or hinder the adoption of multiple SLMPs? In so doing, this study intends to make a more comprehensive and rigorous analysis of factors influencing simultaneous adoption of SLMPs by recognizing the interdependence between different practices using a wide-ranging of household and plot-level data. Factors related to adoption are highly location and technology specific. As such, the results of this study will improve the understanding of farm households' decision-making behavior than commonly found in the literature.

4.2. Econometric estimation

4.2.1. Modeling adoption of sustainable land management practices

This study aims at identifying factors that govern adoption of SLMPs. The foundation of a methodological framework for this study is that farm households are more likely to implement a bundle of SLMPs rather than a single practice (Dorfman, 1996; Kassie *et al.*, 2013). However, a number of previous studies treated SLMPs as independent adoption decisions in a single equation model irrespective of the joint (simultaneity) nature of decisions and the possibility of

correlation/interdependence between them (Gebregziabher *et al.*, 2013). In real world, farm households are faced with alternative but correlated and interdependent technologies in their adoption decisions (Kassie *et al.*, 2013). Hence, farm households may consider some combination of SLMPs as complementary and others as competing. Such interdependence needs to be detected. Otherwise, it will possibly result in biased, inconsistent, and inefficient estimates (Maddala, 1983; Dorfman, 1996; Greene, 2008; Ogada *et al.*, 2014).

4.2.2. Multivariate probit (MVP): adoption of sustainable land management practices

Some earlier adoption studies applied a multivariate probit (MVP¹³) (Gillespie *et al.*, 2004; Bezabih *et al.*, 2013; Gebregziabher *et al.*, 2013; Kassie *et al.*, 2013; Teklewold *et al.*, 2013a; Kassie *et al.*, 2015a). This model accounts for simultaneous adoption of multiple SLMPs and the potential correlations among them and the coefficient estimates are less biased and more efficient than those generated by the independent-single-models. It does not only capture the influence of covariates on each of the various SLMPs but also “allows the error terms to freely correlated” (Greene, 2008). Due to this advantage, a MVP model is adopted in this study to examine factors influencing farm households’ use of the following SLMPs: SWC practices (SWC), manure (M) and inorganic fertilizers (F). The model is depicted as follows:

$$Y^*_{hpj} = \beta_j X'_{hj} + \varepsilon_{hpj} \quad \text{Equation (1)}$$

$$Y_{hpj} = \begin{cases} 1 & \text{if } Y^*_{hpj} > 0 \\ 0 & \text{otherwise} \end{cases} \quad \text{Equation (2)}$$

Where: the Y^*_{hpj} for $j= 1 \dots m$ denotes unobserved latent variable of the j^{th} SLMPs adopted by a farm household h on a particular plot p . While β_j a parameter to be estimated. Y^*_{hpj} is affected by observed explanatory (X_{hj}) and a multivariate normally distributed stochastic error term (ε_{hpj}). Some recent studies employed Mundlak’s (1978) approach to control for unobserved heterogeneity for cross-sectional multiple plot observations (Teklewold *et al.*, 2013a; Di Falco and Veronesi, 2014; Kassie *et al.*, 2015a). Hence, vector of the mean value of plot varying covariates (e.g. plot soil erosion, soil fertility, slope, depth, plot distance from the residence, pest problem, water logging etc.) included in this model.

¹³ MVP model does not permit for the analysis of the chance of use of more than one practice at a time.

A multivariate probit estimator permits the covariance between the errors to be correlated across practices, but not across observations within a given practice (Bezabih *et al.*, 2013). Equation (2) gives an MVP model the chance to jointly represent decisions while one adopts a particular SLMP. The non-zero value of the off-diagonal elements in the covariance matrix K allows for correlation across the unobserved disturbances of several latent equations. These error terms govern the choice of different SLMPs (Teklewold *et al.*, 2013a). The covariance matrix K is given by:

$$\varepsilon_{hpj} \sim MVN(0, K)$$

$$K = \begin{bmatrix} 1 & \rho_{SWCM} & \rho_{SWCF} \\ \rho_{MSWC} & 1 & \rho_{MF} \\ \rho_{FSWC} & \rho_{FM} & 1 \end{bmatrix} \quad \text{Equation (3)}$$

4.3. Study Area, data and sampling procedure

4.3.1. Study area and data collection procedures

Bassonaworana district covers 1,399 km² with altitudes ranging between 1,980 and 3,350 meters above sea level. Average annual rainfall is 1,100 mm with a mean maximum temperature of 22⁰C and a mean minimum temperature of 10⁰C. The district has 30 Kebeles consisting of 28,939 farm household heads with a total human population of 134,837 (BWOA, 2017). The study was based on cross-sectional data collected from March to June 2016. The research was carried out in three main stages. First, transect walk was undertaken to observe farm plots to get physical information and clear picture about the study Kebeles regarding the type of SLMPs being employed and plot specific characteristics (area, slope position, erosion level, and soil texture etc.). Informal discussion with key informants and extension personnel were also used to obtain information and views about the farming systems and existing SLMPs. The information from the informal survey provided useful insights regarding the farming system of the area and subsequently used as the basis for refining data collection tools and their preparation, administration and conducting a formal survey.

The second stage was a formal household survey using pre-designed survey forms. This helped collect detailed quantitative data. Before starting the actual data collection, the questionnaire was pre-tested in the field on farm households that are out of the main survey. The third stage used

focus group discussions (FGDs) to verify the data collected during the formal and informal survey and substantiate arguments.

The household survey questionnaire included detailed inquiries about household and plot level data. Household attributes includes age of a household head, gender, education level and family size, various sources of income, participation in credit markets; household's distance to market centers, residence distance to roads, membership in formal and informal organizations, perception on SLMP's attributes, and participation in extension services. A wide range of plot-specific characteristics for each plot, the type of SLM practices (such as SWC practices, animal manure/compost, and inorganic fertilizer) practiced during the sample year were gathered. Information on perceived plot level soil fertility, soil depth, slope, plot size in ha, and distance of the plot from the household dwelling (in minutes of walking), tenure status of plots, erosion status etc. were also collected.

4.3.2. Sampling design and sample size determination

The study employed a multi-stage sampling procedure. In the first stage, Bassonaworana district where soil erosion is severe and many conservation strategies have been carried out was chosen purposely in consultation with the North Shewa Zone Natural Resource Development Office. Soil and water conservation and soil fertility technologies were widely promoted in the in this district by government and non-governmental organizations (NGOs). Second, the district was stratified into upper highlands and mid highlands. This was followed by a random selection of Kebeles. Accordingly, four Kebeles (Goshebado and Saryia—from mid highlands and kormargefiya and Keyit- from upper highlands) were randomly selected; two from each stratum. Finally, probability proportional to size random sampling technique was used to select 354 sample respondents working on 1305 plots. Prior to data collection, lists of farm households were solicited, reviewed and updated from the respective offices of agriculture.

4.4. Empirical studies and variables

Dependent variables (adoption of SLMPs): SWC practices, manure and inorganic fertilizer adoption by farm households indicate whether farm households have adopted or used technology/practice in a given plot. SWC manures/compost and inorganic fertilizer is coded with the value 1 to indicate the presence of practice on a farm plot and zero otherwise.

Table 1: summary of definition of selected variables employed in MVP model

| Variable | Description | Mean | Std. Dev |
|---|---|-------|----------|
| Dependent variables | | | |
| Soil and water conservation (SWC) | 1= Plot received SWC practice | 0.46 | |
| Manure (M) | 1= Plot received manure | 0.30 | |
| Inorganic fertilizer (F) | 1= Plot received inorganic fertilizer | 0.38 | |
| Independent variables | | | |
| Education | Year of education a household head | 1.42 | 2.9 |
| family size | family size | 4.75 | 1.7 |
| Age | age of the household head | 0.47 | 12.69 |
| Gender | 1=if male household head | 0.91 | |
| Membership in multipurpose cooperatives | 1= if member in multipurpose cooperative | 0.73 | |
| Membership in dairy cooperatives | 1= if member in dairy cooperative | 0.27 | |
| Membership WMPs groups | 1= if member in WMPs group | 0.73 | |
| kinship network | Number of relatives that households has relay on | 1.79 | 1.23 |
| Flat slope (ref.) ^a | 1= if flat to gentle slope plot | 0.41 | |
| moderate slope | 1= if moderate slope plot | 0.31 | |
| Steep slope | 1= if steep slope plot | 0.29 | |
| low plot fertility (ref.) ^a | 1= if low fertile soil | 0.12 | |
| Medium plot fertility | 1= if medium fertile soil | 0.61 | |
| high plot fertility | 1= if good fertile soil | 0.27 | |
| Low erosion (ref.) ^a | 1= if low soil erosion | 0.51 | |
| moderate plot erosion | 1=if medium plot erosion | 0.33 | |
| high plot erosion | 1=if high plot erosion | 0.16 | |
| Shallow soil depth | 1= if shallow soil depth | 0.56 | |
| medium soil depth | 1= if medium soil depth | 0.30 | |
| Deep soil depth (ref.) ^a | 1= if deep soil depth | 0.30 | |
| Improved seeds | 1= if a plot planted improved seeds | 0.04 | |
| Legume | 1= If precursor crop was a legume | 0.45 | |
| Water logging | 1= if water logged plot | 0.14 | |
| Plot size | Plot size, ha | 0.30 | 0.17 |
| Disease and pest | 1= if disease and pest incidence | 0.11 | |
| Tenure insecurity | 1= if shared/rented plot | 0.12 | |
| Access to road | walking distance to car road (minute) | 43.42 | 41.16 |
| distance to market | Walking distance to main market (minute) | 66.02 | 41.56 |
| Extension services | Frequency of extension contact on SLMPs (day/year) | 1.98 | 1.79 |
| Radio | 1= if radio information on SLMPs | 0.48 | |
| Extension field visit | 1= if field visit | 0.18 | |
| SMPs training | 1= if participate in SLMPs training in the last three years | 0.70 | |
| Farm size | Total cultivated farm size (ha) | 1.22 | 0.48 |
| Livestock | livestock owned by farm household(TLU) | 5.46 | 2.95 |
| Dung cake income | 1= if sale dung cake | 0.22 | |
| non-farm income | 1= if involved in non-farm activities | 0.21 | |
| Credit | 1= if use credit | 0.17 | |
| Agro-ecology | 1=mid highlands (Weinadega) | | |
| Number of observations (plots) | 354 (1305) | | |

Note: (ref.)^a - denotes reference category.

Table 1 provides definitions and descriptive statistics for the variables included in the empirical specification of the MVP model. The percentage of farm plots in the sample treated with SWC is 46%. Farm plots that are treated with manure and are inorganic fertilizer comprise 30% and 38% of the sample, respectively. A review of earlier studies is vital because it provides conceptual and theoretical basis to pinpoint the relevant variables that can be included in the analysis.

Based on the findings of empirical adoption studies (Ervin and Ervin, 1982; Pender and Kerr, 1998; Shiferaw and Holden, 1998; Benin *et al.*, 2002; Bekele and Drake, 2003; Gebremedhin and Swinton, 2003; Illukpitiya and Gopalakrishnan, 2004; Amsalu and De Graaff, 2007; Asafu-Adjaye, 2008; Tiwari *et al.*, 2008; Teklewold and Köhlin, 2011; Gebregziabher *et al.*, 2013; Teklewold *et al.*, 2013a; Kassie *et al.*, 2015a) and researchers' observations, variables hypothesized to explain adoption decision of SLMPs are summarized under five categories, (1) household characteristics, (2) plot specific attributes, (3) risk factors, (4) resource factors and (5) enabling conditions.

4.4.1. Household characteristics

We control for household characteristics heterogeneity such as age, family size, gender, education level of the farm household head, membership in multipurpose cooperatives, dairy cooperatives, participation watershed management programs and kinship networking. **Education level of farm household:** a variable representing the formal years of schooling of the household head. Large size of the literature showed that education of a household enhances decisions of SLM investment (Ervin and Ervin, 1982; Shiferaw and Holden, 1998; Anley *et al.*, 2007; Asafu-Adjaye, 2008; Tiwari *et al.*, 2008; Fentie *et al.*, 2013). Whereas others indicated that education discourages adoption of SLMPs (Alamirew, 2011; Alufah *et al.*, 2012; Mugwe *et al.*, 2012; Tesfaye *et al.*, 2014). Therefore, the effect of education is ambiguous. **Family size:** is the total number of members of a household. The effect of family size has mixed result, some revealed negatively correlation (Bekele and Drake, 2003; Alamirew, 2011) while others report a positive association with SLMPs (Pender and Kerr, 1998; Gebregziabher *et al.*, 2013). Accordingly, the impact of family size on adoption could not be predicted *a priori*. **Age:** the effect of age of the farm household on adoption decision may be either negative or positive (Bekele and Drake, 2003). Some studies have shown positive correlation (Alufah *et al.*, 2012; Heyi and Mberengwa, 2012; Mugwe *et al.*, 2012) while others have shown a negative

association (Gebregziabher *et al.*, 2013; Kabubo-Mariara, 2015). Hence, the effect of age on SLM use is ambiguous. **Gender:** literature supported that the propensity of adopting land SLMPs by male headed households is more likely than the female one (Anley *et al.*, 2007; Yesuf and Köhlin, 2009; Barungi and Maonga, 2011). Hence, female headed households are expected to be less likely to use SLMPs. Bezabih *et al.* (2013) found that social capital has mixed effect depending on the type of social capital indicator used and SLM activities. It is therefore difficult to decide its effect beforehand.

4.4.2. Plot attributes

We also control for plot level heterogeneity by including plot fertility, erosion hazards, slope, soil depth, legume crop rotation and use of improved seed. **Plot fertility:** refers to households' perceived soil fertility status of a farm plot (categorized into low, medium and high fertile). The influence of fertility of the plot on SLM adoption decisions may be either positive or negative. For instance, Bekele (2003) revealed that households that perceive their farm plot is fertile are more likely to make a conservation investment. In contrast some studies indicate inverse association (Amsalu and De Graaff, 2007; Fentie *et al.*, 2013). Hence, the effect of soil fertility is ambiguous. **Perception of erosion hazards:** the perceived actual degree of soil erosion or potential erosion on the farm plot may motivate farm households more to adopt a particular soil management technology (Asafu-Adjaye, 2008). Therefore, it is expected that as most rural household livelihoods rely on agriculture, the extent of their perception of the severity of the problem would be positively associated with the adoption of SWC and manure but inversely related to the use of inorganic fertilizers. **Slope of a plot:** configuration that relates to topography is described interns of slope. It is expected that farm households who have relatively more sloping fields, which are more vulnerable to soil erosion, are more likely to adopt physical SWC practices while flat and moderate slop relatively receive more soil fertility management practices. **Soil depth:** soil depth refers to the thickness of the soil cover (rated as shallow medium and deep). Deep soils are easier to till than shallow soils and are more responsive to technologies. Study in North West of Ethiopia noted that farm households build SWC practices mostly on shallow plots to avoid further decline of the soil depth (Teshome *et al.*, 2014).

Nonetheless, farm households apply manure on deep and medium soil depth plots. Consequently, it is hypothesized that shallow soil plots positively related to use of SWC, but use of SWC is expected inversely related to deep and medium depth plots. On the other hand, manure and

inorganic fertilizer applications are expected to positively correlate with deep and medium soil depth plots. **Use of improved seeds:** this is to refer to the use of improved seeds on a farm plot. This variable takes a value of 1 if the household has made use of improved seeds 0, otherwise. The use of improved seeds is expected to positively influence the adoption of inorganic fertilizers and manure, since improved seeds are said to be more responsive to these inputs. Similarly, relatively in plots covered by SWC practices, the incidence of soil erosion tends to be minimal. **Legume:** is measured as dummy variable indicating 1 if the precursor crop on a plot was a legume and 0 otherwise.

4.4.3. Risk factors

Risk-averse and poor farm households are often reluctant to adopt conservation measures because they need a stable income and consumption stream, especially when the returns from the adoption of conservation technologies are not clear and uncertain (Shiferaw, 2002). We consider plot distance from residence, plot size, tenure security, water logging and presence of disease and pests as risk factors. **Plot distance:** is measured in walking minutes of the farmland from the homesteads. Farm households whose plots are near their residence use SLMPs because time and energy spent are relatively lesser than distant plots. As a result, distant plots usually receive less attention and less frequent monitoring (Teklewold and Köhlin, 2011), because plot distance increases production costs thereby hinders adoption of SLMPs (Gebremedhin and Swinton, 2003). It is, thus, hypothesized to have a negative relationship with the use of SLMPs. **Tenure security (ownership):** is refers to whether farm a household is operating on his/her own plots or form other arrangements such as rented in/out and shared in/out. Owners invest more in their own land as they could directly enjoy the net benefit of these investments (Illukpitiya and Gopalakrishnan, 2004). For plots that are rented-in/shared in farm households' have a shorter-term planning horizon and they are less willing to invest in long-term conservation practices. Plot owned and cultivated by the household is hypothesized to have a positive effect, but rented in/out and shared in/out plots expected to have an inverse relationship for adoption of SWC practice and manure. However, shared-in/shared in plots received more short-term investment. Hence it is expected positively correlated with a use of inorganic fertilizer. **Water logging:** it is a dummy variable that takes a value of 1 if there is incidence of water logging in a farm plot, 0 otherwise. The existence of water logging problem in a given plot is hypothesized to influence the adoption decision of inorganic fertilizers and manure positively. However, it is expected

inversely related to use of SWC practices. **Presence of pests and diseases:** in the presence of pests and diseases, farm households incline to use practices that involve smaller cash outlays and low-risk technologies (Kassie *et al.*, 2013). Therefore, the probability of the use of manure and SWC practices by farm households would be more likely, unlike the use of inorganic fertilizer. **Plot size:** it is an indicator of land fragmentation. According to Teklewold and Köhlin (2011) the size of the plot area is positively influences the adoption of soil conservation practices. Therefore, it is hypothesized to have a positive relation with SLMPs.

4.4.4. Enabling environment

Variables reflecting access to markets and information services are included under enabling conditions. **Distance to market centers:** is measured by distance of residence in walking minutes to market where most products are sold and input is purchased. Alamirew (2011) pointed out that access to markets positively and significantly affects the probability of soil fertility enhancing (SFM) practices but significantly reduces the probability of adopting SWC practices. Contrary to this, Nkegbe *et al.* (2011) indicated a negative relation with the probability of adoption of compost. Hence, the influence of distance to a market center is not clear beforehand. **Access to a road:** it is measured by walking minutes. It is associated with the transaction costs of input and output marketing activities (Teklewold and Köhlin, 2011). For instance, in Ethiopia, a study Worku and Mekonnen (2012) found that increase in walking minutes from a household's residence to the nearest road decreases significantly the probability to adopt SWC practices. However, some studies noted that better access to road reduces investment in labor-intensive land management (Pender *et al.*, 2006). Therefore, the effect of residence-to-road distance is undetermined ahead of time. **Contact with extension agent:** this refers to the number of times the extension agents visit farm households to give extension advices on SLMPs. Different studies in developing countries, including Ethiopia, documented a strong positive relationship between access to information and adoption behavior of farm households (Nkegbe *et al.*, 2011; Alufah *et al.*, 2012; Heyi and Mberengwa, 2012). Therefore, the greater number of contacts with extension agents is expected to have a positive effect on adoption of SLMPs. **Participation in training:** refers to farm households' participation in SLMPs training. The information obtained and the knowledge and skills gained through training accelerates farm households' decision on conservation practices (Shiferaw and Holden, 1998). **Access to radio:** refers to whether farm households have access to information on SLMPs from

radio or not. It's expected that the information obtained from a local radio program enhances the probability of adoption of SLMPs. **Extension field visit:** this indicates farm households' involvement in field visit regarding SLMPs in other areas. In field visit, farm households can observe the real experience and gain knowledge and skills about resource management. Hence, it is hypothesized to affect the use of SLMPs.

4.4.5. Resource-related factors

Farm size: Farm size is defined as the total size of cultivated farm in hectare that a household uses and manages during the survey year. Several empirical studies indicated that farm size has positively and significantly influenced conservation decisions (Shiferaw and Holden, 1998; Amsalu and De Graaff, 2007; Yesuf and Köhlin, 2009). On the other hand, it is reported that more land reduces the need to conserve land (Clay *et al.*, 1998; Gebremedhin and Swinton, 2003; Worku and Mekonnen, 2012). Consequently, it is very difficult to determine the sign of the farm size effect *a priori*. **Livestock ownership:** it is the total number of livestock owned by farm households measured in tropical livestock units (TLU). The effect of livestock ownership is mixed. Hence, the influence of livestock size on the adoption decisions could not be predicted *a priori*. Some empirical studies reported a positive correlation (Amsalu and De Graaff, 2007; Fentie *et al.*, 2013) while other revealed a negative relation with the adoption of SLMPs (Odendo *et al.*, 2009; Barungi and Maonga, 2011). **Non-farm income:** participation in non-farm work could keep the labor force needed for land management activities away. Further, the income obtained from off-farm work may obscure the benefits to be accrued from practices adopted (diverting labor from on-farm activities and working on SLMPs (Clay *et al.*, 1998; Bekele and Drake, 2003). On the other hand, a great deal of empirical works reported that non-farm income may also provide incentive to invest on SLMPs by allowing them to hire labor and to buy farm implements in an underdeveloped credit market setting (Holden *et al.*, 2004; Tiwari *et al.*, 2008). Thus, the role of non-farm income on the decision to adopt is not clear. **Access to credit:** credit institutions in rural Ethiopia provide short-term credit only for productive inputs or consumption (Yesuf and Köhlin, 2009). Nevertheless, conservation investments that often bring benefits in the medium to long term are poorly served in credit markets (Shiferaw, 2002; Bekele, 2003; Yesuf and Köhlin, 2009). Hence, access to credit is hypothesized to have negative associations for SWC and M but positive for inorganic fertilizer. **Income from dung cake:** it refers to the income generated from the sale of dung cake. Dung cake is prepared from animal wastes. Sale of

dung cake competes with application of animal manure. On the other hand, the income obtained from the sale of dung cake may help farm households invest in SWC practices and inorganic fertilizers. Consequently, it is expected the income obtained would positively influence adoption of SWC practices and inorganic fertilizers, but is inversely related to manure use.

4.5. Result and discussion

4.5.1. Joint adoption decision of SLMPs

The MVP model was estimated jointly for three dependent variables: SWC, manure, and inorganic fertilizer. In this study, the option ‘robust’ was used to minimize the influence of outliers. The maximum likelihood estimates of the MVP model of adoption of SLMPs are presented in Table 3. The Wald test of the hypothesis that all regression coefficients in each equation are jointly equal to zero is rejected. The p-value of the Wald test statistics for the overall significance of the regression is very low ($p= 0.000$), supporting the appropriateness of the application of an MVP model as opposed to a separate univariate Probit model.

Furthermore, the likelihood ratio test ($\text{Chi}^2(3) = 12.632$, $p\text{-value} = 0.006$) for independence between the disturbances is also rejected as reported in Table 2. The estimated correlation coefficients among the error terms are statically significantly different from zero, suggesting that the decision to adopt one SLMP governs the decision to adopt the other. A positive coefficient suggests complementarity between the two practices, meaning that adoption of one practice is associated with the adoption of the other. Subsequently, the estimated coefficients account for unobserved correlation among the adoption decisions. A negative correlation coefficient suggests that the two practices concerned are substitutes rather than complementing. In this case, the correlation coefficient between SWC and manure is positive and significant at 1%. Similarly, the correlation coefficient between the SWC and inorganic fertilizer is positive and significant at the 10% probability level. This suggests interdependence in the adoption of SLMPs.

Table 2: covariance matrix of the regression equations between SLMPs using the MVP joint estimation model

| | SWC | Manure | Inorganic fertilizer |
|----------------------|---------------------|-----------------|----------------------|
| SWC | | | |
| Manure | 0.147***** (0.0449) | | |
| Inorganic fertilizer | 0.079* (0.0469) | 0.0101 (0.0471) | |

Likelihood ratio test of $\rho_{21} = \rho_{31} = \rho_{32} = 0$: $\text{chi}^2(3) = 12.632$ Prob > $\text{chi}^2 = 0.006$

Note: *** $p < 0.01$, * $p < 0.1$, standard errors in parenthesis.

The MVP model revealed that the adoption decisions of different SLMPs are responding differently to independent variables considered (see Table 3). Consequently, factors determining the adoption decision of each of SLMPs are found to be unlike. This implies the heterogeneity in the adoption decisions of the different SLMPs. So, merging them into one adoption variable is inappropriate. Differences in the estimated coefficients across equations further substantiate the appropriateness of sorting out between technology (practice) options. As presented in Table 3, all hypothesized variables except the age of farm household, gender, steep slope and fertility status of a plot significantly influenced the likelihood of using SLMPs.

4.5.1.1. Household characteristics

The coefficient for educational attainment of the household head is negative and highly significant for SWC model. This suggests an increase in household heads' years of schooling highly discourages adoption of SWC practice. Therefore, the effect of illiteracy is not the main determinant of farm households' investment in the SWC (perhaps suggesting that the adoption of this practice does not require basic knowledge unlike others). One of the reasons for the low adoption behavior of sampled educated farm households was that they might have better opportunity to involve in non-farm income generating activities. This indicates that educated farm households were more likely to be involved in non-farm activities than their counterparts. This result corroborates with some recent works on SWC technologies (Alufah *et al.*, 2012; Mugwe *et al.*, 2012; Tesfaye *et al.*, 2014). However, this result contradicts with other findings (Ervin and Ervin, 1982; Asafu-Adjaye, 2008), which found that farm household heads with a better formal education are more likely to adopt SWC practices, as they anticipate the magnitudes of soil degradation complications and benefits of SWC practices.

The MVP model result shows that family size is negatively and significantly related to the adoption of both SWC and inorganic fertilizers. These results suggest that households with large family size are less likely to invest in SWC and inorganic fertilizers. This can be explained by the fact that a household with more number of mouths to feed will be forced to divert part of the labor force to off-farm activities in an attempt to make income so as to ease consumption pressure induced by large family size. Particularly, in such circumstances, when it is related to food insecurity problem, for most part of the year farm household is preoccupied with survival or coping mechanisms and have less time to invest in their own farms. Hence, they spend the tiny

resources at their disposal to purchase food rather than farm inputs such as inorganic fertilizers. They might also have more expenses to meet the needs of household members. Therefore, large family size discourages such labor-intensive long-term investments. This negative effect of family size on SWC is consistent with (Bekele and Drake, 2003; Alamirew, 2011).

The effect of farm household membership in multipurpose cooperatives turned out to be strongly positive and significant for the adoption of manure and inorganic fertilizers. However, it was insignificant and negatively correlated with SWC practices. The strong positive coefficients imply that farm households who are members of multipurpose cooperatives are better placed to adopt manure and inorganic fertilizers than their counterparts. Membership in such organizations enables farm households to acquire information on credits, productive inputs and agricultural activities. Further, as a member of a cooperative society, farm households are expected to attend seminars and meetings through which they exchange information.

Membership in dairy cooperatives has a positive and significant influence on the adoption of SWC practices and inorganic fertilizers, whereas the coefficient for manure is negative and statistically insignificant. This implies that the income generated from the sale of dairy products to the cooperative triggers households to invest in the aforementioned interventions than non-members. This shows that the income generated from dairy could relax farm households' liquidity constraints so that they would invest in their land, as greater income would mean more cash available to hire labor and buy inputs for land management. Moreover, as a member of a dairy cooperative, a farm household may have the chance to attend formal and informal meetings through which they exchange information with their peer groups. Hence, dairy farming has a positive and significant effect on farm households' decision to adopt SWC practices and inorganic fertilizers. On the other hand, the negative correlation with manure may emanate from the fact that farm households which specialize in dairy farming may keep some improved dairy cows at the expense of their number. This, in turn, will result in limited opportunities for manure preparation. Dung cake is also made from animal waste for firewood consumption, which typically competes with manure use.

Participation of farm households in WMPs group significantly affects the adoption of SWC and manure. The positive and significant result for SWC suggests that via participation in WD group farm households will gain practical technical knowledge and experiences on SWC. Such

cooperative engagement may also increase households' motivation. Hence, encouraging participation of households in WMPs would play an important role in increasing the likelihood of SWC practice adoption. On the other hand, participation in WMPs is also found to have a significant negative correlation with the adoption of manure, indicating that membership in such programs discourages the adoption of manure. This negative impact might be attributed to the fact that involvement in WMPs diverts labor forces from manure use to the implementation of physical conservation practices to circumvent further land degradation. Hence, there is a need to urge farm households about the importance of soil fertility enhancing practices.

Another important variable considered to measure social capital was the number of people on which farm households rely for critical support at times of difficulty. The result shows that number of people that farm households rely on during difficult times would increase significantly the likelihood of adoption of SWC practices. The higher the number of people a farm household has during slack times, the higher the probability of adoption of SWC practices. However, the reverse is found to be true for inorganic fertilizers suggesting that farm households with more persons are more likely to invest in long-term conservation measures. This result is consistent with (Teklewold *et al.*, 2013a) who reported that the number of relatives farm households rely on for critical support at times of need positively and significantly governs farming practices they adopt.

4.5.1.2. Plot attributes

In addition to household characteristics the survey collected plot related variables such as perceived plot slope, fertility, soil depth and level of erosion hazards. Legume crop rotation and use of improved seeds are also included in the model. The relationships between slope of plots and the use of SLMPs are complex (Clay *et al.*, 1998). The result of this study confirms the same, indicating that the coefficients for moderate slope are found to be positive for the three SLMPs, whereas the coefficients for steep slope are mixed and insignificant i.e. negative sign for manure and inorganic fertilizer, but positive for SWC. This is contrary to Teklewold *et al.* (2013a) which found that inorganic fertilizer has positive and significant relation with plots with a steep slope. The result denotes that the slope of farm plot is positively linked to the adoption decision of SWC and statistically significant only for moderate slope land category. This study shows that farm households who operate on plots with moderate slope are more likely to invest

in SWC than the others. This implies that farm households make investment greatly on moderate steepness, but not on steep plots. The possible reasons for this maybe it is expensive to maintain conservation measures on so steep slopes; the soil on steep slopes is thin and light making them more prone to erosion and frosts affecting yield performance, which then undermines long-term investment.

Furthermore, the negative coefficients for manure and inorganic fertilizer indicate that due to runoff and limited responses to farm inputs, steep slopes are less likely to receive fertility management practices. This implies that farm households who think their plots are steep do not put measures in place to conserve the soil due to the low immediate returns. This surely indicates the need for further provision of agricultural extension services. For the evaluation of severity of soil erosion, households' perception of degree of soil erosion problem was measured as low, medium and high erosion hazard. The sign of this variable turned out to be positively related with SWC and inorganic fertilizers. However, it is negatively related to manure. The coefficients of perceived high and medium soil erosion problem are significant for the adoption of SWC practices. The MVP model result shows that a farm household that perceived that its plot is severely and moderately subjected to erosion is more likely to adopt SWC practices than otherwise. This implies that farmers who perceived the extent of erosion on a plot are more likely to adopt SWC practices. A similar result in SWC practice was reported by several studies (Shiferaw and Holden, 1998; Bekele and Drake, 2003; Tadesse and Belay, 2004).

The present findings agree with theories that argue that farm households who perceive soil erosion as a problem and its adverse influences on productivity as well as who presume positive returns from SWC investments are more likely to make a sound decision to construct conservation technologies. This suggests that soil depth has a mixed impact on adoption decisions for the SLM practices (SWC, manure and inorganic fertilizer).

This study shows that the shallow soil depth is positively and significantly correlated with adoption of SWC practices, but a study (Teshome *et al.*, 2014) indicated an insignificant relationship. This could be explained by the fact that in the study area investment in SWC has been undertaken to regenerate the degraded and depleted soil. On the other hand, the effects of moderate soil depth found to be negative and statistically significant for inorganic fertilizer. This might be due to the risks in yield performance associate with inorganic fertilizer use. This result,

Table 3: Coefficient estimates of MVP model (Robust standard error): adoption of SLMPs

| Variables | SWC | | Manure (M) | | Inorganic fertilizers (F) | |
|-------------------------------|-----------|-----------|------------|-----------|---------------------------|-----------|
| | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. |
| Gender | 0.045 | 0.145 | -0.211 | 0.155 | -0.034 | 0.158 |
| Education level | -0.042*** | 0.014 | -0.013 | 0.015 | 0.013 | 0.014 |
| Family size | -0.072*** | 0.028 | -0.013 | 0.028 | -0.065** | 0.027 |
| Age | 0.002 | 0.003 | 0.004 | 0.003 | -0.002 | 0.004 |
| Self-help group | -0.137 | 0.084 | 0.008 | 0.087 | 0.057 | 0.085 |
| Multipurpose cooperative | -0.085 | 0.095 | 0.315*** | 0.104 | 0.244*** | 0.102 |
| Dairy cooperative | 0.294*** | 0.101 | -0.058 | 0.104 | 0.302*** | 0.098 |
| Kinship | 0.178*** | 0.052 | 0.044 | 0.029 | -0.067** | 0.033 |
| Participation in WMPs | 0.168* | 0.09 | -0.155* | 0.092 | -0.121 | 0.092 |
| Moderate slop | 0.175* | 0.102 | 0.049 | 0.103 | 0.042 | 0.104 |
| Steep slop | 0.116 | 0.128 | -0.12 | 0.14 | 0.004 | 0.138 |
| High erosion | 0.590*** | 0.145 | -0.05 | 0.161 | 0.091 | 0.155 |
| Moderate erosion | 0.213** | 0.098 | -0.061 | 0.103 | 0.057 | 0.102 |
| Medium soil fertility | -0.034 | 0.126 | 0.112 | 0.135 | -0.122 | 0.134 |
| High soil fertility | 0.046 | 0.147 | 0.056 | 0.155 | -0.164 | 0.154 |
| Shallow soil depth | 0.479*** | 0.13 | 0.006 | 0.143 | -0.137 | 0.139 |
| medium soil depth | 0.156 | 0.097 | -0.002 | 0.104 | -0.21** | 0.103 |
| Pests and disease | 0.012 | 0.122 | -0.078 | 0.12 | -0.519*** | 0.136 |
| Improved seeds | 0.251 | 0.194 | 0.264 | 0.209 | 0.88*** | 0.216 |
| Legume | 0.08 | 0.077 | 0.103 | 0.08 | 0.277*** | 0.079 |
| Plot distance | 0.001 | 0.002 | -0.012*** | 0.003 | 0.003* | 0.002 |
| Water logging problem | -0.218* | 0.118 | -0.123 | 0.128 | 0.006 | 0.125 |
| Plot size | 1.142*** | 0.253 | 0.866*** | 0.241 | 1.223** | 0.255 |
| Tenure insecurity (ownership) | -0.389*** | 0.126 | -0.517*** | 0.152 | -0.109 | 0.13 |
| Access to road | 0.01*** | 0.002 | 0.005*** | 0.002 | -0.007*** | 0.002 |
| distance to market center | -0.007*** | 0.002 | -0.003** | 0.002 | 0.004*** | 0.001 |
| extension contact | 0.054** | 0.025 | 0.004 | 0.026 | 0.028 | 0.026 |
| Training on SLMPs | 0.023 | 0.104 | -0.022 | 0.107 | 0.323*** | 0.112 |
| Access to radio | 0.211*** | 0.081 | 0.233*** | 0.084 | 0.005 | 0.085 |
| Extension visit on SLMPs | 0.124 | 0.107 | 0.228** | 0.108 | 0.061 | 0.11 |
| cultivated land size | -0.021 | 0.101 | -0.298*** | 0.102 | -0.276*** | 0.1 |
| Livestock holding | -0.043** | 0.021 | 0.045** | 0.019 | 0.031 | 0.019 |
| Access to credit | 0.063 | 0.104 | -0.222** | 0.11 | 0.331*** | 0.105 |
| Dung cake income | -0.161 | 0.115 | -0.197* | 0.116 | 0.328*** | 0.114 |
| Non-farm income | 0.264* | 0.136 | -0.027 | 0.152 | -0.273* | 0.145 |
| Agro-ecology | 0.036 | 0.094 | -0.198** | 0.096 | 0.572*** | 0.099 |
| _cons | -0.957*** | 0.294 | -0.536* | 0.307 | -0.818** | 0.308 |

Chi2 (108) = 624.19, Prob > chi2 = 0.000, sample size = 1305

Note: *** p<0.01, **p<0.05 and * p<0.1.

perhaps suggests that farm households who operate on moderate soil depth are less likely to invest in inorganic fertilizers.

The coefficient for the use of improved seeds is positive and significant with regard to adoption of inorganic fertilizers indicating the complementarity of the two. The findings indicate that farm plots which treated with inorganic fertilizer have more chances of receiving improved seed varieties. Legume crop rotation stands out as an important predictor of adoption of inorganic fertilizer. The likelihood of using inorganic fertilizer is high for plots which were under legume rotations in the previous year than the plots that were not planted with a legume crop. The positive influence of legume crop rotation might be described by the fact that the higher output and lower risk of applying inorganic fertilizer on plots that benefited from legume crop rotation. Therefore, it appears that farm households consider legume crop rotation as a complementary input to adoption of inorganic fertilizer. This result is inconsistent with (Yirga and Hassan, 2013) who revealed that farm households consider legume rotations as a substitute input to the inorganic fertilizer.

4.5.1.3. Risk factors

In Ethiopia, agriculture is often operated under different risks. We also control for this risk related variables, including water logging problem, pests and diseases, plot size and tenure insecurity (ownership). Out of the risk factors considered, water logging is found to have a significant negative impact on the likelihood of using SWC practices. The result also showed that water logging has an insignificant impact on the use of manure and fertilizers; these results are similar with findings of (Teklewold *et al.*, 2013a). The possible explanation is that in high rainfall areas, water logging is common on flat plots. On such plots where SWC is practiced, water logging is aggravated, because this practice increases water infiltration.

The coefficient of water logging for manure is negative, implying farm households are less likely to treat plots that have water logging problem with manure/compost. This finding suggests that there is a knowledge gap on the role of manure in diminishing water logging problems and improving land quality. Therefore, the extension program needs to work on this issue to motivate farm households. Likewise, the incidence of pest and disease attacks, influences negatively and significantly adoption of inorganic fertilizers. This implies that farm households are highly to be

discouraged in using inorganic fertilizers where pests and disease attack is common. However, (2013a) found an insignificant relation between the two.

As expected, plot distance is negatively and significantly related to the application of manure. The use of manure involves more costs for transportation and distribution to distant farm plots. Plots located near dwellings are easy to manage and monitor harvests with less transaction costs. In addition, unlike distant ones, plots that are found near residence have minimal risk including subjectivity to robbery. This result agrees with the findings of other studies (Pender and Gebremedhin, 2007; Teshome *et al.*, 2014) who noted that plot distance is negatively and significantly related to the adoption of manure. Furthermore, results indicate a positive and significant effect of plot distance on the use of inorganic fertilizers. This implies that farm households are more likely to apply inorganic fertilizer on farther plots. The plausible reason for this is that comparatively, application of fertilizers demands low transaction costs and is easier to transport than labor-intensive SWC practices and manure.

The role of land tenure structure also seems central to the adoption of SLMPs. For this study, the dummy variable representing land ownership (managing land shared/rented through local mechanisms as opposed to own plots) indicated a significant negative effect on the likelihood of using manure and SWC, suggesting that farm households are less likely to adopt SWC and manure on shared/rented plots. This is because if farm households are not guaranteed receiving benefits for substantial times, they will not carry out long-term investment on farm plots. This finding corresponds with neo-classical economic theory which suggests that, all things being equal, longer planning horizons should increase expected returns and stimulate further investment.

The present study agrees with the results of previous studies that revealed tenure security (operating own plots) significantly increases the likelihood of adoption of the labor-intensive physical structures in particular (Teklewold *et al.*, 2013a; Teshome *et al.*, 2014; Kabubo-Mariara, 2015; Kassie *et al.*, 2015a). Its effect on manure is also in line with (Clay *et al.*, 1998). This indicates that tenure security increases the probability of farm households to use SLMPs that gradually reward the returns from the long-term investments. Whereas managing less secure plots will enhance short-term inputs use like inorganic fertilizer. In general, the implication is

that establishing secured land tenure system would be an incentive for the farm households to adopt the SLMPs in the study area.

The results further underscore the importance of plot size operated by a household in explaining adoption of SLMPs. As expected, we find that plot size positively and significantly affects the likelihood of adopting all types of SLMPs i.e. SWC, manure and inorganic fertilizer. This result puts forward that the larger farm plot size a household manages the more likely is the household to invest in SLMPs. In addition, the findings of this study indicate that the production input and transportation cost of the products are decreasing gradually with increasing farm plot size. Therefore, investments on large plots provide better return on investments, this implies that economies of scale influence the adoption of SLMPs. Implementation of SWC practices on small farm plots causes inconvenience to work with, for example, using oxen during ploughing (Shiferaw and Holden, 1998; Teklewold and Köhlin, 2011). Furthermore, physical structures such as stone and soil bunds take agricultural space (its effects are more noticeable on small plots), which otherwise could have been used to grow crops. This shows that plot size is a key resource factor that strongly and significantly influences agricultural intensification suggesting that adoption of SLMPs is not strictly scale neutral. The findings of this study are invariably in line with (Teshome *et al.*, 2014) in which the three practices have a similar effect. However, this result of inorganic fertilizer is found to be akin to Asfaw *et al.* (2013) suggesting larger farm plots appear to be treated with more short-term inputs. But contrary to this Kassie *et al.* (2015a) indicated that inorganic fertilizer use is inversely related to plot size. Moreover, the result on SWC is against (Asfaw *et al.*, 2013), which indicated that plot size had an inverse relation to adoption of the SWC. Therefore, results of this study support the Neo-Malthusian hypothesis which stated that land redistribution and fragmentation due to population pressure does not necessarily lead to more agricultural intensification.

4.5.1.4. Enabling conditions

Access to market

Distance to the nearest market center and access to all weather roads were used as proxies for market access. Both variables have the greatest impact on farm household adoption of SLMPs. The result of distance of homestead to the nearest major market tallied with our *a priori* expectation. A distance of homestead to the nearest major market has a significant negative

relation with the probability of adoption of SWC and manure, suggesting that farm households located far away from the major market is less likely to adopt these practices than those closer. The result denotes that farm households faced with high farm-to-market access costs or poor market access makes less investment in SWC practices and manure. These findings concur with the perspective that describes distance to major markets limits market participation as a result of the inconvenience of travelling long distances and extraordinary transaction costs thereby discouraging the production of market crop and diffusion of innovations. The negative effect of distance of homestead to the nearest major market is consistent with (Gebremedhin and Swinton, 2003; Asfaw *et al.*, 2013).

Surprisingly, households located far to markets are more likely to use inorganic fertilizers. This could be because inorganic fertilizers relatively require less transaction cost and easy to use. Information and search cost is relatively easy due to the fact that cooperative bring it closer to farmers. It also reveals that the constraint of remote households in accessing and applying technologies, mainly soil and water conserving measures. However, this result is inconsistent with (Beshir *et al.*, 2012) who disclosed inverse relation. This negative correlation revealed that nearness to a nearby market would lead to better access, less transportation cost, and timely delivery of inputs and disposal of output and better output price for farm households (Beshir *et al.*, 2012). Therefore, this finding reflects that it is indispensable to provide information on the prospective risk of relying profoundly on short term yield improving soil fertility management practices (like inorganic fertilizer) so as to enhance knowledge of farm households in making informed decisions on use of SLMPs.

To explore the impact of infrastructure, which influences market access for both inputs and outputs, on SLM use, this study includes access to road in walking minutes as a variable in the model. The increase in walking minutes from household residence to the nearest road increases significantly the likelihood of the SWC and manure adoption. The distance decreases both crop income and labor market opportunities during the off-season, and thereby promotes adoption of labor intensive SWC and manure. Accordingly, increasing walking minutes to the nearest car road encourages investment in labor demanding practices. Perhaps, the cheap family labor available could be responsible for this result. The findings of the present study contradict with the findings of other studies (Pender *et al.*, 2006), which suggested that increasing distance from

the households' residence to the nearest road undermine households' chance to adopt land conservation investment because they earn less from investing on plots with less transportation access.

As stated by Pender and Kerr (1998), the availability of family labor encourages adoption of labor-intensive SLMPs, where labor markets are imperfect. The positive effect of households' home distance to the nearest road on manure use may disclose that manure is less likely to be traded in distant areas. The labor market in the study area is likely to be inefficiently functioning perhaps due to high transaction costs. Hence, in the study area distance of households' residence from a road diverts family labor to agricultural activities thereby encourages adoption of SWC and manure.

Access to information

In order to capture the influence of access to information on adoption decisions, this study uses the following variables, including frequencies that the farm household was visited by an extension agent in a given time; whether or not the farm household attended training on SLMPs, extension field visit and had access to radio program on SLMPs. As expected, the coefficient for the frequency of extension contact is positive and significant in SWC practices. This suggests that an increase in household heads' contact with extension agents promotes adoption of SWC practices. An extension agent is expected to serve as change agents; therefore, increases in contact with farm households will lead to a change in farm households' attitude and increase adoption of SWC practices, suggesting the importance of information and the role extension agents in providing technical support in the study areas. Our finding on SWC agrees with (Teklewold and Köhlin, 2011; Alufah *et al.*, 2012; Heyi and Mberengwa, 2012). The coefficient of participation in SLMPs training is found to be positive and significant for inorganic fertilizers. This reveals that the technical knowhow required to apply inorganic fertilizers can be acquired through farm trainings, rather than frequency of contact with development agents. The findings of this study also reflect that for the last three years, most of the trainings were more focused on short term yield increment rather than long-term benefits. This implies that the issue of SWC practices and manure is rarely featured in extension trainings. The result of inorganic fertilizer concurs with similar (Paudel and Thapa, 2004) who noted that training had a positive significant effect on adoption of land management practices.

The coefficient for a radio information on SLMPs as expected is positive for SLMPs. Unlike Teklewold and Köhlin (2011) who indicated insignificant effect, attending a radio program on SLMPs positively and significantly influences adoption of SWC and manure in the study area. A possible explanation can be the available mass media organizations, particularly radio, might be provide information regarding the importance of investment in long-term measures (SWC and manure). These findings call for organizing and launching community radio programs that mainly focus on agricultural activities in general and SLMPs in particular.

4.5.1.5. Resource-related factors

The coefficient of access to credit is negative and significant in affecting manure use on farm plots. Like Yesuf and Köhlin (2009), the present study indicates that access to credit positively and strongly influences adoption of inorganic fertilizers. This result suggests that farm households who have access to credit are more likely to adopt SLMP that require cash outlay and less likely to apply manure on their cultivated plots. The result highlights, in the study area, that liquidity constraint appear to reduce adoption of inorganic fertilizers.

In the central highlands of Ethiopia, livestock is a source of traction, manure, cash and is a safety net against crop failures and other disasters. Consistent with previous works (Teklewold *et al.*, 2013a; Kassie *et al.*, 2015a), livestock holding shows a significant positive influence on the likelihood of using manure. Livestock waste is the main source of manure for farm households. On the other hand, livestock holding is found to have a significant negative effect on the adoption of SWC practices, suggesting that households with large livestock holding may give more priority to animal rearing than crop production, consequently their concern for land management is limited. This result supports findings of other studies (Shiferaw and Holden, 1998) which highlight more specialization in livestock may reduce crop production influence on soil erosion. Therefore, farm households may not be motivated to adopt SWC technologies. This result corroborates with (Amsalu and De Graaff, 2007) who revealed that livestock ownership has a negative influence to invest in the SWC practices. In the study district, perhaps due to the growing rewarding market for livestock, those households who receive a high income from livestock seemed unwilling to the adoption of SWC practice.

The result of this study indicates that participation in non-farm activities has positive and significant influence on the adoption decision of SWC practice. In addition, the effect of participation in non-farm activities is found to be negative and significant on adoption of inorganic fertilizers. The plausible justifications are non-farm income may serve as a buffer by allowing farm households to have long-term investments. Non-farm income may also provide incentive to invest in SWC practices by allowing them to hire labor and to buy farm implements; especially in underdeveloped credit market setting. In another way, it can be argued access to and dependence on non-farm income may promote financial security, but then again may decrease the tendency to adopt some practices that would require greater management demands. The result on SWC corroborates with previous studies (Holden *et al.*, 2004; Tiwari *et al.*, 2008; Teklewold and Köhlin, 2011) but it is inconsistent with findings from different parts of Ethiopia (Shiferaw and Holden, 1998; Amsalu and De Graaff, 2007; Alamirew, 2011; Tesfaye *et al.*, 2014; Teshome *et al.*, 2014) which reported that non-farm activities adversely affect the adoption of land management practices.

Moreover, the negative significant effect of non-farm income on inorganic fertilizer confirms that involvement in non-farm income activities discourages inorganic fertilizer application. This implies as an alternative source of income, it diminishes pressure on land; and thereby reduces crop intensification. Therefore, this suggests that farm households' involvement in non-farm income promotes investment in long-term land management practices (e.g. SWC); whereas participant farm households are far less likely to use short-term investment (e.g. inorganic fertilizer). This may be because non-farm income enables farm households to meet food needs; unlike subsistence farm households.

Consistent with (Kassie *et al.*, 2009c; Yirga and Hassan, 2013), access to credit has a positive and significant effect on inorganic fertilizer adoption. But farm households who received short term credit are less likely to use manure. Accordingly, the present results supports findings of (Tizale, 2007), who claimed that the availability of short term credit (especially in the form of input) may encourage farm households to adopt inorganic fertilizer to counterbalance for lost soil nutrients and hence suspend the adoption of manure. Moreover, it can be argued that lack of rural credit and insurance markets further aggravates the effect of risks and uncertainties on SLM decisions (Bekele and Drake, 2003). Therefore, even though appropriate technologies are

available for land management, farm households cannot adopt them where there is lack of credit markets.

The coefficient of total farm size is negative and significant for inorganic fertilizers and manure. The results signal that those farm households that own large farm sizes are less likely to adopt manure and inorganic fertilizer. This is likely because a farm household that owns a large farm is less resource-constrained and has better options to diversify its income, which in turn may negatively affect the incentive to invest in SLMPs. In addition, well-to-do farm households tend to make less conservation investment in their farm plots than poor smallholder farm households with large farm size. Nonetheless, small farm households with small land size may realize that such investments are crucial to their livelihoods both in short-term and long-run. As a result, agricultural intensification is encouraged. Furthermore, the negative correlation between farm size and SLMPs explained by the fact that farm households that own relatively larger landholdings after sometimes may go for fallow and thus may not be compelled to protect their land. The same result is revealed by (Clay *et al.*, 1998; Bekele and Drake, 2003; Gebremedhin and Swinton, 2003) who investigated that more land reduces the need to conserve land. However, contrary to this finding, some prior studies in different parts of Ethiopia revealed that farm size positively and significantly influences conservation decisions (Shiferaw and Holden, 1998; Amsalu and De Graaff, 2007; Yesuf and Köhlin, 2009; Tesfaye *et al.*, 2014).

The model results also figure out that dung cake income is an important variable that affect the likelihood of adoption of SLMPs. These results indicate that participation in dung-cake sales has negatively and significant influence on manure application and use of SWC practice. Nonetheless, the likelihood of using inorganic fertilizer was found to be positive and significant. The result of manure suggests dung-cake sale inversely related to manure application, as its compute with application of manure on farm plots. Besides, negative impact on the use of SWC practice might be attributed to the fact that those farm households engaged in dung cake sales have large livestock holding and animal husbandry is their prime focus than their counterparts. However, for those farm households who sale dung-cake the use of inorganic fertilizers is more likely, this perhaps implies that in the study area there is limited focus on long-term fertility management practices, rather the emphasis is on short term yield gains.

Another important variable included is agro-ecology. The dummy variable representing agro-ecology (1=mid-highlands and 0=upper highlands) is included in the model to control for unobserved agro-ecological variations. There is a significant difference between farm households in the two agro-ecology in terms of adopting fertilizers and manure. Compared to upper highlands, farm households in mid-highlands have more likelihood of adopting fertilizers; but less likely use manure than their counterparts. This is may be due to the fact that upper highland farm households keep relatively more livestock. Or because households in the mid-highlands are closer to the urban market for dung-cake, and thus the sale of dung-cake competes with use as manure. The disparity effect of agro-ecology on the probability of adoption of fertilizers might be explained by the relative agricultural potential differences and attitudes of the farm households. These results reveal that the role of agro-ecology such as geographic variations, production potential, culture, value, aspirations and attitudes of the farm households, as key determinants of disparities in adoption decisions.

4.6. Conclusions and policy implications

Over the past three decades, the government of Ethiopia has made tremendous efforts to address the problem of land degradation through large-scale implementation of a myriad of sustainable land management practices. In spite of these efforts, adoption of SLMPs still remains low. In this study, we examine the propensity of adoption of multiple SLMPs by farm households using comprehensive household and plot-level observations collected from 345 households operating 1305 plots. The MVP model results display that significant correlation and interdependence between SLMPs. This is in contrast to most of the prior work undertaken on the adoption of SLMPs, which characteristically investigated a single technology (practice) without taking into account the interdependence between technologies (practices). Our analysis shows that adoption of SLMPs is interdependent, hence any activity to promote these practices need to consider such interdependence.

Interestingly, the empirical results show that adoption of SLMPs are influenced (negative or positive) by a number of interwoven factors. For instance, we find that tenure security is a key for adoption of SWC and manure referring that policy which promote security in land tenure are likely enhance the adoption of long-term land management technologies as farm households can slowly earn returns from investment for over a long period of time. Plot distance is negatively

and significantly correlated to manure use. This signifies the use of manure involves more costs for transportation and distribution to distant farm plots. Therefore, in the study area, to encourage the application of manure on distant farm plots, introduction and provision of horse/donkey carts are chiefly important. Our result also reveals that membership in dairy cooperative has a significant role in determining the adoption of SLMPs, suggesting introducing high-yielding breeds and improved legume forages can boost dairy products and household income that can be invested in land management. The significant role of dung cake income in reducing adoption of manure implies there is a need to promote energy saving technologies both from farming households and urban population.

The empirical result shows that plot size is positively and significantly affected the likelihood of adopting SWC, manure and inorganic fertilizer. This reflects that plot size is a key resource that strongly and significantly influences agricultural intensification, suggesting adoption of SLMPs does not strictly scale neutral. Farm households that own large cultivated farm sizes are less likely to adopt manure and inorganic fertilizer. This is likely because a farm household that owns a large farm is less resource-constrained and has better options to diversify its income. The study reveals that farm households who are far away from market center are less likely to adopt SWC but more likely to use inorganic fertilizer. On the contrary, increasing walking minutes to the nearest car road encourages investment in labor demanding practices such as SWC and manure; this is may be due to the cheap family labor availability and non-marketability of dung cake. The model result also reflects that farm households are highly discouraged to use inorganic fertilizer where pests and disease attack is common.

Furthermore, we find that the coefficient of participation in SLMPs training is positive and significant only for inorganic fertilizer. Suggesting most of the trainings are more focused on short term yield increment as a result the issue of long-term investment in SWC and manure rarely features in extension trainings. Attending a radio program on SLMPs has also significantly increased the probability of adoption of SWC and manure. These findings call for organizing and launching a community radio program that mainly focus on agricultural activities specially SLMPs. In general, since subsistent farm households hesitate to use new SLMPs partly due to their suspicion about the benefits of the practices, and partly due to other factors, it is vital for extension workers and training programs to clarify whatever the doubts farm households may

have, and motivate them to adopt SLM practices. Often exposure to information reduces subjective uncertainty and, therefore, increases likelihood of adoption of SLMPs.

Farm households' participation in non-farm income promotes the likelihood of investment in long-term land management (e.g. SWC); but reduce the chance of short-term investment (like inorganic fertilizer), signifying as an alternative source of income; it diminishes pressure on land. Local institutions enable farm households to acquire information on credits, productive inputs and agricultural activities. Hence, information is found to be imperative to the decision of adoption of SLMPs. Therefore, a rural development policy that promotes the establishment of strong and vibrant rural associations is vital. This in turn strengthens and improves the existing rural institutions in terms of coverage, efficiency and building on existing social capital and networks. Besides, ensuring long-term tenure security is important to enhance long-term investment so as to increase agricultural productivity while conserving the natural resource basis. Finally, the study clearly shows that the adoption of SLMPs is location and technology specific.

CHAPTER FIVE

5. DOES ADOPTION OF SUSTAINABLE LAND MANAGEMENT PRACTICES PAYOFF? EMPIRICAL EVIDENCE FROM BASSONAWORANA DISTRICT, ETHIOPIA¹⁴

Abstract

Currently, there is growing robust empirical evidence on the impacts of adopting a single land management practice. The evidence on how combinations of sustainable land management practices (SLMPs) impact of adoption of such practices is rather scant. Unlike most empirical studies, we control for selection bias on unobservable characteristics to the adoption of SLMPs of households and analyze its impact on net crop income. This study estimates a multinomial endogenous switching regression model of adoption of SLMPs and their impacts on crop income by applying a counterfactual analysis using a cross-sectional survey of 354 farm households and 1305 plots from Bassonaworana district, Ethiopia. The results come up with four major findings. First, implementations of SLMPs either in combination or standalone significantly increase crop net income. Second, a more comprehensive approach (a joint adoption of all SLMPs considered) is the best income yielding portfolio. Suggesting this portfolio is the most successful land management strategy that makes the adopters to generate more crop net income. Third, when SLMPs are implemented in any combination (mix) with another practice, they provide higher crop net income than adopting each practice in isolation, except practicing combined SWC and manure. The last but not the least, had the non-adopters adopted SLMPs, they would have gained greater crop net income. Therefore, the study suggests investment in SLMPs is payoff venture, thus designing appropriate policies and strategies that promote adoption SLMPs is recommended.

Key words: counterfactual analysis, crop net income, Ethiopia, multinomial endogenous switching regression model, sustainable land management practices

¹⁴ Kidane Tafa, Bamlaku Alamirew and Aklilu Amsalu, 2018. (in review). Does adoption of sustainable land management practices payoff? Empirical evidence from Bassonaworana district, Ethiopia

5.1. Introduction

Ethiopia is one of the most environmentally degraded countries in the world (FAO, 2011; Kirui and Mirzabaev, 2014) in which a total of 228,160 km² (23%) land area was degraded (Le *et al.*, 2014). Sustainable land management practices (SLMPs) are instrumental to reverse the current land degradation trends, thereby ensuring adequate and sustainable food supply for the future (Kirui and Mirzabaev, 2014). However, a number of literatures supported that many previous SWC programs in the country that promote SLMPs were unsatisfactory for a number of reasons (Shiferaw and Holden, 1999; Dejene, 2003; Kassie *et al.*, 2009b; Wolka, 2014).

Government and different agencies have promoted several SLMPs: soil and water conservation (SWC) and soil fertility management practices to preserve soil and restore soil fertility and thereby to advance agricultural productivity in the central highlands of Ethiopia, including North Shewa Zone of Amhara Region (Dejene, 2003; Amsalu, 2006; Zeleke *et al.*, 2006). The major SLMPs that have been promoted include SWC practices (soil and stone bunds) and soil and fertility management practice (inorganic fertilizers and organic inputs such, animal manure, compost and crop residues). This study highlighted on the most common practices such as SWC (soil and stone bunds), inorganic fertilizers and organic inputs (compost and animal manure) in the study area, Bassonaworana district. In the Ethiopian context, sustainable land management includes the use of physical soil and water conservation measures, appropriate practices for soil fertility and agricultural water management, forestry and agro-forestry, as well as the application of these measures in a more integrated manner to satisfy present local community needs while solving ecological problems and maintaining the land in a condition for supporting future generations (Zeleke *et al.*, 2006). The use of these practices at plot level can both conserve natural resource and also increase soil fertility and soil organic matter without sacrificing yield levels (Kassie *et al.*, 2013).

The empirical analysis of the impact of SLMPs is challenged by methodological problems. Most of previous studies of choice and impact of adoption have focused on either a single practice or a set of practices considered as a single practice for example (Kassie *et al.*, 2009b; Di Falco *et al.*, 2012; Schmidt and Tadesse, 2012; Abdulai and Huffman, 2014; Schmidt and Tadesse, 2014). Despite the potential complementary or substitution among individual or combination of SLMPs, to our best knowledge, rigorous empirical works on impacts of SLMPs (SWC, manure and

inorganic fertilizer) are scantily available. However, existing few empirical studies, Teklewold *et al.* (2013b) in Ethiopia and Kassie *et al.* (2015b) and Manda *et al.* (2016) in Zambia have focused on the adoption and impacts sustainable agricultural practices on maize income (emphasis on maize growing regions). Nonetheless, impact of SLMPs on other crops is may be different. Hence, rigorous quantitative empirical evidence to better understand the effect of SLMPs on crop net income is still inadequate.

Since farm the households' adoption decision is often voluntary and based on self-selection, it can constrain outcome variable (crop net income) as well. At the same time, individuals that have higher motivation and expectation due to characteristics such as motivation, abilities, and experience are more likely to adopt a particular practice. This implies adopter are not a random sample of the population; they may have systematically different attributes of that did not adopt (Di Falco and Veronesi, 2013). In addition, unobservable characteristics of households and their farms may also influence both the adoption of SLMPs and their impact on crop net income (Asfaw *et al.*, 2012; Kassie *et al.*, 2015b) and causes a bias in estimates. Furthermore, observable variables may not have same marginal effect on crop net income for different SLMPs. Therefore, understanding self-selection into adoption and impact of SLMPs is important for policy making in developing countries. We address these distinctions by applying the selectivity correction methodology developed by Dubin and McFadden (1984) and latterly modified by Bourguignon *et al.* (2007).

This paper adds to existing literature on adoption analysis and impacts of technology using the following innovative approaches. First, the study controls the problem of selection bias and endogeneity using a multinomial endogenous switching regression (MESR) technique to investigate whether adoption of SLMPs in combination would provide more economic benefits than adopting them individually. Second, we used a comprehensive household and plot level data. Third, we identify the most profitable practice using a counterfactual analysis.

In the next section, the paper outlines a detailed description of context of the study, data and sampling procedure. A conceptual and econometric framework for a multinomial adoption selection model and estimation of average treatment effects are presented in section three. Section four presents the empirical specification and definitions of variables. This is followed by

discussions of empirical results. The last section concludes and draws implications of crucial findings.

5.2. Context and data

The study area, Bassonaworana district, covers 1,399 km², with altitudes ranging between 1,980 and 3,350 meters above sea level. Average annual rainfall is 1,100 mm (BWOA, 2017). According to the 2007 population census, the total population is 119,660 people, of whom 58,331 are women. The research area is characterized by a mixed-farming system specifically; it is barley based crop-livestock farming, whereby farmers are involved in rain-fed agriculture and livestock keeping activities. The major food crop varieties that are growing in the area: barley, wheat, faba bean and field pea. The major types of animal kept are cattle, sheep and equine. In terms of topography, the study areas are predominantly mountainous and undulating slopes and partly flat in dawn streams. It is mountainous (50%), rugged (27%) and plain landscape (23%) (BWOA, 2017).

A multi-stage sampling procedure was adopted for selecting farm households. At first stage, Bassonaworana district where soil erosion is severe and many land conservation strategies have been carried out was chosen purposely in consultation with North Shewa Zone Natural Resource Development Office. Second, based on traditional agro-ecological classification, the district was stratified into Weinadega (upper highlands) and Dega (mid highlands) agro-ecological zones. Four peasant associations (PAs) were selected using random selection; two from each stratum. Finally, 354 farm households operating 1305 plots were randomly chosen from each peasant association (PA¹⁵) using probability proportionate to size (PPS) technique.

The study was based on cross-sectional data gathered between March and June of 2016 in the Bassonaworana district. The research involved both formal and informal survey methods. In the first place, transect walk and farm field observations, informal discussion with key informants and extension personnel were conducted to get information and clear picture about the study area. The information stemming from such informal survey provided useful insight about the farming system of the area. This was used as the basis for refining proposal and for questionnaires preparation, administration and conducting a formal survey.

¹⁵ PA is the smallest administrative unit in Ethiopia.

Secondly, after pre-testing, a formal household survey was conducted using a structured interview schedule administered by well-trained enumerators who have knowledge of the farming system and the local language. The interview schedule for a household survey includes detailed inquiries about household and plot level data. Household level data include age of household head, gender, marital status, and education level, household family size, various sources of income, participation in credit markets; distance a household resides to market center, residence distance to car road, membership in formal and informal organizations, household perception of SLMPs attributes, and participation in extension services.

A wide range of plot-specific characteristics for each plot, the type of SLMPs (such as SWC practices, animal manure, compost, and inorganic fertilizer) practiced during the sample year were gathered. In addition to perceived data on plot level soil fertility, soil depth, slope and erosion hazards; information regarding plot's history, distance of the plot from the household dwelling, access to market center, access to all weather roads, tenure status of plots... etc. were collected. Further, the use of production inputs and output data at plot level for the Meher (long rainy) cropping season only were collected, as unfortunately in the study area for the last two successive seasons Belg (the short rainy season) was not available due to the El Nino effect.

5.3. Modeling impact of sustainable land management practices

Specification of the impact of sustainable land management practices is carried out in a two stage procedure. In the first stage, farm households' adoptions of individual and combined SLMPs are modeled using a multinomial logit selection model. In the second stage, the impacts of SLMPs on crop net income were estimated using ordinary least squares (OLS) with selectivity correction terms. One of the challenges in evaluation of the impacts of agricultural technologies is finding appropriate counterfactual. In experimental studies, this problem is addressed by randomly assigning SLMPs to treatment and control status, which assures that the outcome observed on the control households that adopt SLMPs are statistically representative of what would have occurred without adoption (Asfaw *et al.*, 2012). However, adoption of combinations of SLMPs may not be random, as farm households may endogenously self-select themselves into adoption/non-adoption decisions. So, decisions are likely to be influenced by unobservable characteristics (for example, expectation of yield gain from adoption, managerial skills, and/or motivation) that may be correlated with the outcomes of interest (Teklewold *et al.*, 2013b; Kassie

et al., 2015b). Farm households are likely to select SLMPs for their plots, based on the endowments and abilities of the farm household and the quality and attributes of their plots (both observable and unobservable). These would result in inconsistent estimates of their effect on the outcome variable (Di Falco and Veronesi, 2013) and faulty conclusions. This requires a selection correction estimation method (Teklewold *et al.*, 2013b). Accordingly, we model farm households' use of combinations of SLMPs and impacts of adoption using a multinomial endogenous switching regression framework¹⁶, a selection-bias correction method based on the multinomial logit model (Bourguignon *et al.*, 2007). This framework considers heterogeneity in both the observed and unobserved variables and other econometric problems and ensures robust results. In addition, this model also has the advantage of evaluating both individual and combined practices, while capturing the interactions between the choices of alternative practices (Kassie *et al.*, 2015b).

5.3.1. Multinomial adoption selection model

A multinomial model is applied to analyze farm households' interrelated adoption decisions of the SLMPs: physical SWC practices, manure, inorganic fertilizer and combinations of the practices. The observed outcome of an SLMP adoption can be modeled following random utility formulation. Consider the h^{th} ($h = 1 \dots N$) farm household which faces a choice of whether or not to adopt the available SLMP on plot p ($p = 1 \dots p$). The outcome of the adoption of SLMP is denoted by Y_{jh} and non-adoption (Y_{h0}). The farm household decides to adopt the j^{th} SLMP on plot p if $Y^*_{hj} = Y_{hj} - Y_{h0} > 0$. The net benefit (Y^*_{hj}) that a farm household realized from adoption of j^{th} SLMP is a latent variable; is influenced by observed household, plot and location characteristics (including mean of plot-variant explanatory variables) (X_{hj}) and stochastic error terms- unobserved characteristics (ϵ_{jh}) which capture all the variables that are relevant to the farm household decision maker, but are unknown to the researcher such as skills or motivation.

Thus,

¹⁶This approach allows getting both consistent and efficient estimates of the selection process and a fairly good correction for the outcome equations, even when the independence of irrelevant alternatives (IIA) assumption is not achieved (Bourguignon *et al.*, 2007).

$$\text{Regime } j: A_{jh} = \alpha_j Z_{jh} + u_{jh} \text{ if } I = j$$

Where, A_{jh} is the crop net income per hectare of household h in regime j , ($j = 1, \dots, M$), and Z_h represents a vector of exogenous variable; represents the unobserved stochastic component, which verifies:

$$E(u_{jh} | X, Z) = 0 \text{ and } \text{Var}(u_{jh} | X_h, Z_h) = \sigma^2$$

A_{Ij} is observed if, and only if, SLMP j is used, which occurs when $Y_{hpj}^* > \text{Max}(Y_{hpm}^*)$, $m \neq j$,

If the ε 's and u 's are not independent, ordinary least square (OLS) estimates in equation (4) is biased. A consistent estimation of α_j requires inclusion of the selection correction terms of the alternative choices in equation (4). To correct for the potential inconsistency, the model proposed by Bourguignon *et al.* (2007) is employed, which takes into account the correlation between the errors terms ε_{hj} from the multinomial logit model estimated in the first stage and the error terms from each net farm income equation u_{hj} . Hence, the equation of the multinomial endogenous switching regression in Equation (4) is expressed as:

$$\text{Regime } 1: A_{h1} = \alpha_1 Z_h + \sigma_1 \hat{\lambda}_1 + \omega_{h1} \text{ if } I = 1$$

$$\begin{matrix} \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \end{matrix}$$

Equation (5)

$$\text{Regime } j: A_{hj} = \alpha_j Z_h + \sigma_j \hat{\lambda}_{1j} + \omega_{hj} \text{ if } I = j$$

Where σ_j is the covariance between ε 's and u 's, and λ_j is the inverse Mills ratio computed from the estimated probabilities in Eq. (6) as:

$$\lambda_j = \sum_{m \neq j}^j \rho_j \left[\frac{\hat{p}_{hm} \ln(\hat{p}_{hm})}{1 - \hat{p}_{hm}} \right] + \ln(\hat{p}_{hj})$$

Where ρ is the correlation coefficient of ε 's and u 's, and ω 's are error terms with an expected value of zero. In the multinomial choice setting, there are $j - 1$ selection correction terms, one for each alternative SLM practice. The standard errors in equation (5) are bootstrapped to deal with heteroscedastic problems stemming from the two-stage estimation procedure.

In the literature, the use of exclusion restrictions or selection instruments is sustained to identify the causal effect (Di Falco and Veronesi, 2013; Manda *et al.*, 2016). A variable is considered as a

valid selection instrument, if it affects the adoption decision of SLMPs, but does not affect the outcome variables among non-adopters (Di Falco *et al.*, 2011). Information source variables have been used as valid instrumental variables for technology adoption studies (Di Falco and Veronesi, 2013; Kassie *et al.*, 2015b; Teklewold *et al.*, 2017). In this study for identification purposes some covariate variables are excluded from income equations such as distance to markets center in walking minutes, number of relatives that a farm household rely on during time of difficulty, membership in farm households' group (dairy cooperative, self-help group), frequency of contact with an extension agent, walking distance to an extension office, and farm households' access to radio information about SLMPs. The information regarding SLMPs is hardly expected to directly influence outcome variable (crop net income) except via the adoption decision. Following Di Falco *et al.* (2011) a falsification test is conducted. The result confirms the validity of selected instrumental variables. Information variables have statistically significant effects in most adoption equations (Table 2), but do not have any impact on the income equation of the non-adopters (Appendix Table 5.1).

Furthermore, recently, cross-sectional multiple plot level data have been used to construct a panel and control for farm-specific effects (Di Falco and Veronesi, 2013; Kassie *et al.*, 2015b; Manda *et al.*, 2016). Following Mundlak's (1978), in each equation, the average value of plot-varying covariate variables (plot characteristics, plot distance to homestead etc.) are included to control for the possible correlation of plot-invariant unobserved heterogeneity with observed explanatory variables. This approach assumes that unobserved effects are linearly associated with the mean values of plot-varying explanatory variables.

5.3.3. Counterfactual analysis and Estimation of Average Treatment Effects

Counterfactual analysis can be used to examine the average treatment effects (ATT) by comparing the expected outcomes of adopters with and without adoption. The effect of treatment on untreated (ATU) can also be computed using this framework by comparing the expected outcome of non-adopters with non-adoption with the expected outcome of non-adopters had they adopted SLMPs, but to save space this is not presented here. As per the suggestions of Bourguignon *et al.* (2007), the actual and counterfactual scenarios of ATT are computed. The expected crop net income of adopters that adopted (actual adoption observed in the sample), which in this study means $j = 2 \dots M$, ($j = 1$) is the reference category; a non-adoption, as:

Regime 1: $E(A_{h2}|I = 2) = \alpha_2 Z_h + \sigma_2 \lambda_2$ Equation (6a)

$$\begin{matrix} \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \end{matrix} \quad \text{Equation (6)}$$

Regime j: $E(A_{hj}|I = j) = \alpha_j Z_h + \sigma_j \lambda_j$Equation (6j)

Adopters, had they decided not to adopt (counterfactual): it is the counterfactual hypothetical case that households did not adopt ($j = 1$). It is expressed as:

Regime 1: $E(A_{h1}|I = 2) = \alpha_1 Z_h + \sigma_1 \lambda_2$ Equation (7a)

$$\begin{matrix} \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \end{matrix} \quad \text{Equation (7)}$$

Regime j: $E(A_{hj}|I = j) = \alpha_1 Z_h + \sigma_1 \lambda_j$ Equation (7j)

These expected values are used to derive unbiased estimates of the ATT. The ATT is defined as the difference between Equations (6a) and (7a) or Equations (6b) and (7b). For example, the difference between Equations (6a) and (7a) can be expressed as:

$$TT = E(A_{h2}|I = 2) - E(A_{h1}|I = 2) = Z_h (\alpha_2 - \alpha_1) + \lambda_2 (\sigma_2 - \sigma_1) \quad \text{Equation (8)}$$

5.4. Empirical analysis and variables

The outcome variable used in this study is crop net income¹⁷ per hectare in the 2015/16 agricultural production season. Because, in the study area, different major crops are cultivated and some farm households also planted more than one crop per plot. Based on the findings of similar empirical impact studies (Di Falco and Veronesi, 2013; Teklewold *et al.*, 2013b; Kassie *et al.*, 2015b; Manda *et al.*, 2016; Teklewold *et al.*, 2017) and other adoption studies (Pender and Kerr, 1998; Bekele and Drake, 2003; Gebremedhin and Swinton, 2003; Asafu-Adjaye, 2008) , the potential explanatory variables that influence farm households’ adoption decisions and in turn affect the outcome variable are selected. We summarized the variables into five categories, (1) household characteristics, (2) plot specific attributes, (3) risk factors, (4) resource-related

¹⁷ The crop produced by the household in a given plot is valued at market price and all variable inputs such as cost of fertilizer, seed, hired labor and oxen, and pesticides/ herbicides used are deducted.

factors and (5) enabling conditions. Appendix Table 5.2 depicts definition and descriptive statistics of explanatory variables by the combination of SLMPs.

5.4.1. Household characteristics

5.4.1.1. Human capital

We control for human capital heterogeneity such as age, family size, gender, and education level of the farm household head. Several literatures revealed that the education level of a household head enhances SLM investment decisions (Shiferaw and Holden, 1998; Anley *et al.*, 2007). Whereas, others (Alamirew, 2011; Alufah *et al.*, 2012; Mugwe *et al.*, 2012) indicated that education discourages adoption of SLM technologies. Therefore, the effect of education is ambiguous. The effect of family size has mixed results, some revealed a negative correlation (Bekele and Drake, 2003; Alamirew, 2011) while others report a positive association with SLMPs (Pender and Kerr, 1998; Gebregziabher *et al.*, 2013). Accordingly, the impact of family size on adoption could not be predicted *a priori*. The effect of age of the farm household on adoption decision may be either negative or positive (Bekele and Drake, 2003). Hence, the effect of age on SLM use is appearing to be ambiguous. Literature supported that the propensity of adopting land SLMPs by male headed households is more likely than the female one (Anley *et al.*, 2007). Hence, female headed households are expected less likely to use SLMPs.

5.4.1.2. Social capital

In this study Membership in multipurpose cooperative, dairy cooperative and watershed development (WD) group as well as kinship networking were used as indicators of social capital. In this regard Bezabih *et al.* (2013) found social capital has mixed effect; the effect depends on the type of social capital indicator used and type of SLM activities. It is therefore difficult to decide its effect at the beginning.

5.4.2. Plot attributes

We also control for plot level heterogeneity by including plot fertility, erosion hazards slope and soil depth, each of them categorized into three levels (classes). Legume crop rotation and use of improved seeds are also considered. The influence of fertility of the plot on SLM adoption decisions may be either positive (Bekele and Drake, 2003) or negative (Amsalu and De Graaff, 2007). Hence, the effect of soil fertility is ambiguous. The perceived actual degree of soil erosion or potential erosion on the farm plot may motivate farm households more to adopt particular soil

management technologies (Asafu-Adjaye, 2008). Therefore, it is expected that the extent of perception of the severity of the problem would positively associate with the adoption of SWC and manure but inversely related to use of inorganic fertilizer. It is expected that farm households who have relatively more sloping fields, which are more vulnerable to soil erosion, are more likely to adopt SWC practices while flat and moderate slope relatively receive more soil fertility management practices. Soil depth refers to the thickness of the soil cover (rated as shallow medium and deep). Teshome *et al.* (2014) noted that farm households use SWC practices mostly on shallow plots to avoid a further decline of the soil depth. But, they apply manure on plots with deep and medium soil depth. Subsequently, it is hypothesized that plots with shallow soils positively related to use of SWC, but use of SWC is expected to be inversely related to plots with deep and medium depth soils. On the other hand, the application of manure and inorganic fertilizer is expected to positively correlate with deep and medium soil depth plots. The use of improved seeds is expected to positively affect adoption of SLMPs, since a plot covered by SWC and/or soil fertility enhancing practices will either minimize the incidence of soil erosion or improve soil fertility. Therefore, such plots are responsive to use of improved technologies. Legume: is measured as dummy variable indicating 1 if the precursor crop on a plot was a legume and 0 otherwise.

5.4.3. Risk factors

We consider plot distance from residence, plot size, tenure security, water logging and presence of disease and pests as risk factors. Farm households whose plots are near to their residence use SLMPs because time and energy spent are relatively lesser than distance plots (Teklewold and Köhlin, 2011). It is hypothesized to have a negative relationship with use of SLMPs. Unlike rented-in/shared cropping, owners invest more in their own land as they could directly enjoy the net benefit of those investments (Illukpitiya and Gopalakrishnan, 2004). Plot owned and cultivated by the household is hypothesized to more likely receiving SLMPs. The existence of water logging problem in a given plot is hypothesized to influence the adoption decision of inorganic fertilizer and manure positively, but, it is expected to be inversely related to use of SWC practices. In the presence of pests and diseases, farm households would be inclined to use practices that involve smaller cash outlays and low-risk practices (Teklewold *et al.*, 2013a). Therefore, the probability of the use of manure and SWC practices by farm households would be more likely, unlike the use of inorganic fertilizer. According to (Teklewold and Köhlin, 2011)

the size of the plot area is positively influencing the adoption of soil conservation practices. Therefore, it is hypothesized to have a positive relation with SLMPs.

5.4.4. Enabling conditions

Variables reflecting access to markets and information services are included under enabling conditions. Access to markets positively and significantly affects the probability of soil fertility enhancing (SFM) practices but significantly reduces the probability of adopting SWC practices (Alamirew, 2011). Thus, the influence of distance to market center is expected to be positive for manure and inorganic fertilizer but negative in affecting SWC practice. On the other hand, (Genanew and Mekonnen, 2012) found that increase in walking minutes from the household's residence to the nearest road decreases significantly the probability to adopt SWC adoption. However, Pender *et al.* (2006) noted that better access to road reduce investment in labor-intensive land management. Therefore, residence-to-road distance effect is not determined ahead. Different studies in developing countries, including Ethiopia documented a strong positive relationship between access to information and the adoption behavior of farm households (Alufah *et al.*, 2012; Heyi and Mberengwa, 2012). Therefore, household contacts with extension agents expected to have a positive effect. Further, the information obtained from a local radio program and the knowledge and skills gained through training and extension field visits expected to accelerate farm household's decision on SLMPs.

5.4.5. Resource-related factors

Several empirical studies indicated that the total farm size has positively and significantly influenced conservation decision (Shiferaw and Holden, 1998; Amsalu and De Graaff, 2007; Yesuf and Köhlin, 2009). On the other hand, it is reported that more land reduces the need to conserve land (Gebremedhin and Swinton, 2003; Genanew and Mekonnen, 2012). Consequently, it is very difficult to determine the sign of the farm size influence *a priori*. The effect of livestock ownership is mixed. Some empirical studies reported positive correlation (Amsalu and De Graaff, 2007; Fentie *et al.*, 2013), while others (Odendo *et al.*, 2009; Barungi and Maonga, 2011), revealed a negative relationship with the adoption of SLMPs. Large size of the studies reported non-farm income provide incentive to invest on SLMPs by allowing them to hire labor and to buy farm implements in underdeveloped credit market setting (Holden *et al.*, 2004; Tiwari *et al.*, 2008). On the other hand, participation in non-farm income may divert labor from on-farm activities and working on SLMPs (Clay *et al.*, 1998; Bekele and Drake, 2003). Thus, the role of

non-farm income on the decision to adopt is not clear. Conservation investments that often bring benefits in the medium to long term are poorly served in credit markets (Bekele, 2003; Yesuf and Köhlin, 2009). Accordingly, access to credit is hypothesized to have negative associations for SWC and manure but positive for inorganic fertilizer. Sale of dung cake¹⁸ computes with application animal manure. On the other hand, the income obtained from the sale of dung cake may help farm households to invest in SWC practices and inorganic fertilizer. Consequently, it is expected that the sale of dung cake would positively influence adoption of SWC practices and inorganic fertilizer, but inversely related to manure use.

5.5. Result and discussion

5.5.1. Descriptive statistics

Table 1 summarizes combinations of SLMPs that were practiced by sample farm households in the study area. The SLMPs were implemented both in isolation and jointly. We found eight packages (combinations): (1) SWC (soil and stone bunds) practices only, (2) practicing manure/compost only-manure from this onwards); (3) implementing inorganic fertilizer alone, (4) SWC and manure, (5) SWC and inorganic fertilizer, (6) manure and inorganic fertilizer and SWC, (7) manure and inorganic fertilizer and lastly the base category which embraces none of the three SLMPs.

As shown in Table 1 implementing soil and water conservation alone and inorganic fertilizer in isolation are relatively the most popular practices, which respectively account about 17.16% and 15.1% of total plots. Whereas, in the study area, plots that received integrated soil and management practices (manure and inorganic fertilizer) are about 4.29%. From the total 1305 sample plots, 6.44% of plots received the most comprehensive practice of SLMPs (soil and water conservation, manure and inorganic fertilizer). On the other hand, 25.52% of sample plots were not treated with any of the SLMPs.

¹⁸ Dung cake is prepared from animal wastes.

Table 1: Distribution of combinations of SLMPs that are implemented by sample farm households

| Choice (j) | SLMPs | SWC | | Manure | | Inorganic fertilizer | | Frequency (N) | (%) |
|---------------|--|------------------|------------------|----------------|----------------|-------------------------|----------------|------------------|-------|
| | | SWC ₁ | SWC ₀ | M ₁ | M ₀ | F ₁ | F ₀ | | |
| 1 | No use of SLMPs | | √ | | √ | | √ | 133 | 25.52 |
| 2 | Soil and water conservation alone | √ | | | √ | | √ | 224 | 17.16 |
| 3 | Manure alone | | √ | √ | | | √ | 119 | 9.12 |
| 4 | Inorganic fertilizer alone | | √ | | √ | √ | | 197 | 15.1 |
| 5 | Soil and water conservation and manure | √ | | √ | | | √ | 137 | 10.5 |
| 6 | Soil and water conservation and inorganic fertilizer | √ | | | √ | √ | | 155 | 11.88 |
| 7 | Manure and inorganic fertilizer | | √ | √ | | √ | | 56 | 4.29 |
| 8 | Soil and water conservation, manure and inorganic fertilizer | √ | | √ | | √ | | 84 | 6.44 |
| Total | | | | | | | | 1305 | 100 |

Note: soil and water conservation (SWC), manure (M) and Inorganic fertilizer (F), where the subscript denotes 1= if a plot treated with a practice and 0 = otherwise.

5.5.2 Factors influencing adoption of SLMPs

Table 2 reports the estimated results of the multinomial logit model¹⁹ for the combination of SLMPs. The study applies the Mundlak's approach. The fixed-effect of plot-variant explanatory variables was assessed to control for the unobserved characteristics. Almost all equations reject the null hypothesis that all coefficients of the mean of plot-varying covariates are jointly statistically equal to zero. Accordingly, the existence of a correlation between unobserved household fixed effects and observed covariates is confirmed. In general, the model fits the data. The Wald Chi-square (273) = 839.75 and $p = 0.000$, therefore, the null hypothesis that indicates that the fitted model was statistically equivalent to a null model is rejected.

The results indicate that the estimated coefficients differ substantially across various combinations of SLMPs. The base category is non-adoption of all practices against which results are compared. Table 2 shows seven sets of parameter estimates, one for each mutually exclusive

¹⁹Following Bourguignon *et al.* (2007), the model is estimated using the Stata `semlglog` routine.

combination of practices. Results show that farm household characteristics influence adoption of various SLMPs. For instance, consistent with Pender and Kerr (1998) and Gebregziabher *et al.* (2013) family size is significantly and negatively related to SLMPs adoption, including SWC only and all practices (comprehensive package). Because, a farm household with large family size, may more likely concentrate on day to day consumption of the family to meet their present urgent needs and subsequently they may not avoid erosion-prone practices. This would suggest that as Merrey and Gebreselassie (2011) stated the interventions and development programs should focus even much more on providing the means for people to raise their productivity in the short run, while encouraging longer term investments that are complementary and phased in over time.

Farm households with more education may have better access to non-farm income and subsequently have limited time to invest in land management technologies. The result also reveals that a comprehensive combination (all SLMPs that are considered) is less likely to be adopted by farm households with greater education level. The result of this study also shows that household age has a positive impact on adoption of manure.

The farther a household is away from an extension office, the less is the likelihood of using inorganic fertilizer. This is probably because the chance of information access and supervision by the development agents about new technologies declines. The results also disclose participation in SLMPs training increase the probability of adoption of inorganic fertilizer individually or its combination with SWC practices. Results further indicate that farm households who attend a radio program on SLMPs are more likely to implement manure alone, SWC alone, a combination of SWC along with manure or inorganic fertilizer and all the three SLMPs jointly. This underlines the positive role of rural radio programs in promoting SLMPs.

Social capital and networking variables have mixed effects on adoption of SLMPs. We found that both memberships in dairy cooperative and self-help groups have a positive and statistically significant effect on some of the strategies. The membership in self-help group significantly increases the likelihood of adopting the combination of SLMPs: manure only, inorganic fertilizer only, SWC and inorganic fertilizer, manure and inorganic fertilizer and all SLMPs. Results reveal that farm households who are members in dairy cooperatives are more likely to implement the following practices in isolation or combinations (SWC practice alone, inorganic fertilizer in

isolation or SWC practice and inorganic fertilizer in conjunction). The positive impact of membership in dairy cooperative, explained by the fact that farm households could invest in SLMPs using return accrued from the sale of dairy products.

Participation in WMPs significantly increase the propensity of adoption of SWC practices, this may indicates watershed management programs mainly focus on construction of SWC measures. Therefore, this result suggests that there is positive links between watershed management programs and use of SWC practices. On the other hand, surprisingly, Participation in WMPs is negatively and significantly associated with other two packages such as inorganic fertilizer in isolation and manure in combination inorganic fertilizer. This is perhaps households who participate in the watershed development campaign may not have time to invest in their own plots. Furthermore, the result indicates that farm households' membership in the rural saving group (e.g. Equb²⁰, rural saving and credit association) have a positive and significant effect on adoption of certain combinations SLMPs. Specifically, membership in this group has a higher positive impact on adoption of manure in isolation and manure with SWC or inorganic fertilizer. This underscores the importance of farm households' saving in promoting technology adoption.

Tenure insecurity (cultivating shared/rented plots) reduces the adoption of some of SLMPs. Model estimates from cultivated plots operated by farm households who own and rented/sharecrop land in the study area provide support for the hypothesis of Marshallian inefficiency. Pertinent to these facts, the likelihood of adoption of labor intensive SLMPs and purchased inputs are statistically significantly lower on rented/sharecropped as compared to owned plots implying that sharecropping/rented in contracts are affected by Marshallian inefficiency. The benefits from investment in labor intensive conservation practices on the farm accrue overtime; this inter-temporal characteristic implies that insecure land tenure will negatively influence the adoption decisions. This result is consistent with Clay *et al.* (1998), Manda *et al.* (2016) and Teklewold *et al.* (2013a) who indicated that tenure insecurity has a negative significant role in adoption decisions.

²⁰Equb is an Ethiopian variant of a rotating saving and credit association.

Table 2: Parameter Estimates of Multinomial Logit selection model for Sustainable Land Management Practices

| Variables | SWC only | | Manure only | | Inorganic fertilizer only | | SWC and manure | | SWC and inorganic fertilizer | | Manure and inorganic fertilizer | | SWC, manure and inorganic fertilizer | |
|---------------------------------------|----------|-------|-------------|-------|---------------------------|-------|----------------|-------|------------------------------|-------|---------------------------------|-------|--------------------------------------|-------|
| | Coef. | SE | Coef. | SE | Coef. | SE | Coef. | SE | Coef. | SE | Coef. | SE | Coef. | SE |
| Education level | -0.039 | 0.037 | 0.034 | 0.044 | 0.053 | 0.035 | 0.005 | 0.046 | -0.002 | 0.040 | 0.046 | 0.057 | -0.142** | 0.065 |
| Family size | -0.16** | 0.070 | 0.046 | 0.083 | -0.096 | 0.070 | -0.102 | 0.084 | -0.108 | 0.079 | -0.084 | 0.114 | -0.356*** | 0.107 |
| Age | 0.010 | 0.008 | 0.016* | 0.010 | 0.006 | 0.009 | 0.014 | 0.010 | -0.001 | 0.010 | 0.004 | 0.015 | 0.005 | 0.012 |
| Gender | -0.004 | 0.332 | -0.224 | 0.476 | 0.003 | 0.392 | -0.421 | 0.430 | 0.230 | 0.466 | -1.23** | 0.544 | -0.116 | 0.565 |
| Multipurpose cooperative Saving group | -0.181 | 0.224 | 0.479 | 0.312 | 0.362 | 0.257 | 0.153 | 0.308 | -0.044 | 0.275 | 0.632 | 0.441 | 1.536 | 0.481 |
| Plot size | 0.359 | 0.245 | 1.003*** | 0.299 | 0.038 | 0.269 | 1.73*** | 0.286 | 0.397 | 0.289 | 1.14*** | 0.418 | 1.787*** | 0.348 |
| Farm size | 0.301 | 0.703 | 0.464 | 0.839 | 1.87*** | 0.679 | 3.05*** | 0.749 | 3.41*** | 0.718 | 2.290** | 1.007 | 5.182*** | 0.832 |
| Livestock | 0.213 | 0.246 | -0.890*** | 0.334 | -0.116 | 0.249 | -0.008 | 0.314 | -0.635** | 0.298 | -0.481 | 0.425 | -1.210*** | 0.392 |
| Credit | -0.114* | 0.066 | 0.121* | 0.068 | 0.101* | 0.061 | 0.054 | 0.068 | 0.014 | 0.069 | 0.057 | 0.096 | 0.077 | 0.086 |
| Dung cake income | 0.288 | 0.267 | -0.347 | 0.392 | 0.74*** | 0.271 | -0.431 | 0.384 | 0.656** | 0.284 | 0.081 | 0.449 | 0.510 | 0.370 |
| non-farm income | -0.451 | 0.300 | -0.772** | 0.344 | 0.604** | 0.283 | -0.799** | 0.344 | -0.203 | 0.333 | 0.649 | 0.452 | -0.120 | 0.396 |
| Ln access to road | 0.064 | 0.314 | -1.000* | 0.578 | -0.589 | 0.404 | 0.439 | 0.399 | -0.157 | 0.387 | 0.009 | 0.559 | -0.556 | 0.568 |
| Ln access to market | 0.32** | 0.133 | -0.144 | 0.151 | 0.042 | 0.118 | 0.58*** | 0.203 | 0.286** | 0.144 | -0.320* | 0.188 | 0.271 | 0.200 |
| Mean plot distance | -0.092 | 0.140 | 0.354* | 0.196 | 0.168 | 0.143 | -0.451** | 0.197 | 0.098 | 0.168 | -0.085 | 0.222 | 0.091 | 0.213 |
| Mean medium slope ^c | 0.000 | 0.004 | -0.031*** | 0.008 | -0.002 | 0.005 | -0.015** | 0.007 | 0.010** | 0.005 | -0.015 | 0.010 | -0.010 | 0.008 |
| Mean steep slope ^c | 0.491* | 0.263 | 0.289 | 0.299 | 0.204 | 0.259 | 0.407 | 0.307 | 0.421 | 0.302 | 0.401 | 0.402 | 0.370 | 0.376 |
| Mean high erosion ^a | 0.227 | 0.313 | -0.214 | 0.404 | -0.278 | 0.361 | -0.004 | 0.373 | 0.369 | 0.376 | 0.544 | 0.627 | -0.253 | 0.488 |
| Mean medium erosion ^a | 1.03*** | 0.347 | -0.375 | 0.517 | -0.059 | 0.446 | 0.264 | 0.462 | 0.630 | 0.405 | -0.500 | 0.764 | 1.282** | 0.521 |
| Mean medium fertility ^b | 0.452* | 0.248 | -0.265 | 0.307 | 0.470* | 0.258 | 0.439 | 0.298 | 0.240 | 0.291 | -0.276 | 0.429 | 0.364 | 0.371 |
| Mean high fertility ^b | 0.202 | 0.315 | 0.614 | 0.474 | 0.032 | 0.337 | 0.147 | 0.395 | 0.009 | 0.351 | 1.342 | 1.027 | -0.308 | 0.439 |
| Mean shallow soil ^d | 0.461 | 0.368 | 0.301 | 0.517 | 0.076 | 0.384 | 0.200 | 0.454 | 0.007 | 0.417 | 1.345 | 1.057 | -0.573 | 0.522 |
| Mean medium soil ^d | 0.76** | 0.333 | -0.358 | 0.464 | 0.296 | 0.361 | 0.941** | 0.412 | 0.257 | 0.378 | -2.33** | 1.106 | 0.354 | 0.495 |
| Mean medium soil ^d | 0.386 | 0.255 | -0.342 | 0.298 | -0.068 | 0.252 | 0.430 | 0.316 | -0.446 | 0.291 | -0.556 | 0.395 | -0.100 | 0.397 |

| Variables | SWC only | | Manure only | | Inorganic fertilizer only | | SWC and manure | | SWC and inorganic fertilizer | | Manure and inorganic fertilizer | | SWC, manure and inorganic fertilizer | |
|---|-----------|-------|-------------|-------|---------------------------|-------|----------------|-------|------------------------------|-------|---------------------------------|-------|--------------------------------------|-------|
| | Coef. | SE | Coef. | SE | Coef. | SE | Coef. | SE | Coef. | SE | Coef. | SE | Coef. | SE |
| Mean water logging | -0.539* | 0.312 | -0.323 | 0.354 | -0.114 | 0.289 | -0.988** | 0.419 | -0.191 | 0.333 | 0.029 | 0.451 | -0.743 | 0.475 |
| Mean pest problem | 0.342 | 0.267 | -0.045 | 0.350 | -0.694** | 0.349 | -0.206 | 0.362 | -0.901** | 0.406 | -1.68** | 0.817 | -0.599 | 0.500 |
| Mean tenure security | -0.319 | 0.283 | -1.104** | 0.505 | -0.071 | 0.313 | -1.64*** | 0.548 | -0.988* | 0.391 | -0.484 | 0.599 | -1.346** | 0.602 |
| Mean type of crop | 0.108 | 0.209 | -0.239 | 0.252 | -0.62*** | 0.218 | -0.155 | 0.248 | -0.088 | 0.241 | -1.0*** | 0.356 | 0.008 | 0.316 |
| Mean improved seed | 0.485 | 0.784 | 1.685** | 0.822 | 1.636** | 0.679 | 0.158 | 1.211 | 2.53*** | 0.653 | 2.50*** | 0.805 | 2.691*** | 0.750 |
| Mean legume | 0.360* | 0.205 | 0.839*** | 0.259 | 0.411* | 0.220 | 0.81*** | 0.257 | 0.90*** | 0.243 | 1.29*** | 0.387 | 1.239*** | 0.341 |
| Frequency of extension contact | 0.092 | 0.068 | -0.100 | 0.091 | 0.072 | 0.066 | 0.083 | 0.077 | 0.101 | 0.075 | -0.029 | 0.110 | 0.065 | 0.099 |
| Ln distance from extension office | 0.009 | 0.147 | 0.081 | 0.180 | -0.39*** | 0.136 | 0.201 | 0.220 | -0.169 | 0.156 | 0.134 | 0.232 | -0.450 | 0.217 |
| Training on SLMPs radio program | 0.171 | 0.257 | 0.332 | 0.320 | 0.563* | 0.293 | -0.047 | 0.303 | 0.772** | 0.326 | 0.988* | 0.538 | 0.278 | 0.386 |
| Field visits | 0.390* | 0.201 | 0.615** | 0.258 | 0.034 | 0.222 | 0.72*** | 0.256 | 0.489** | 0.234 | 0.180 | 0.362 | 0.758** | 0.309 |
| Dairy cooperative | -0.252 | 0.297 | 0.260 | 0.352 | -0.412 | 0.298 | -0.034 | 0.345 | 0.246 | 0.304 | -0.143 | 0.449 | 0.677* | 0.372 |
| Self-help group | 0.63** | 0.285 | -0.420 | 0.347 | 0.471* | 0.270 | 0.210 | 0.341 | 0.757** | 0.304 | 0.303 | 0.430 | 0.438 | 0.365 |
| Kinship network | 0.318 | 0.207 | 0.666** | 0.263 | 0.384* | 0.229 | 0.209 | 0.261 | 0.532** | 0.25 | 1.232** | 0.379 | 0.668** | 0.309 |
| Participation in WMPs | 0.171 | 0.195 | -0.240 | 0.240 | -0.230 | 0.208 | 0.323 | 0.230 | -0.069 | 0.23 | 0.207 | 0.333 | 0.249 | 0.295 |
| Weinadega | 0.037** | 0.235 | -0.073 | 0.303 | -0.8*** | 0.229 | -0.552 | 0.284 | 0.230 | 0.27 | -0.79** | 0.363 | -0.320 | 0.346 |
| _cons | -0.244 | 0.238 | -0.609** | 0.306 | 0.42* | 0.255 | -1.2*** | 0.308 | 0.88*** | 0.28 | 1.082** | 0.438 | 0.498 | 0.370 |
| Wald test on instrumental variables $X^2(10)$ | -2.79*** | 0.889 | -2.496** | 1.202 | -0.706 | 0.968 | -3.9*** | 1.140 | -4.2*** | 1.09 | -2.503 | 1.788 | -3.78*** | 1.401 |
| | 26.57 *** | | 20.06 ** | | 84.47 *** | | 40.86 *** | | 18.79 ** | | 34.64 *** | | 23.49 *** | |

Note: non-adoption of SLMPs is base category. SE represents robust standard errors. Sample size: 1,305 plots. * Significant at the 10% level; ** significant at the 5% level; and *** significant at the 1% level. ^a Low erosion, ^b medium fertile, ^c gentle slope, ^d deep soil depth are reference variables.

Plot size is mainly positively associated with inorganic fertilizer alone, SWC and inorganic fertilizer, SWC and manure, manure and inorganic fertilizer and all the three practices. This suggests households that have larger plot size are more likely to adopt SLMPs than those with less plot size, more especially for multiple SLMPs (such as SWC and manure, SWC and inorganic fertilizer and all the three practices) and inorganic fertilizer in isolation. The possible explanation is that marginal returns from small plots may not compensate investment costs and sacrificed yield loss due to space occupied by some structures. This shows the larger plot size increases the chance of adopting multiple SLMPs, implying the larger plot size enhances agricultural intensification. Furthermore, this result underscores adoption of SLMPs is not scale neutral. Problems of pest are also important in technology adoption decisions, particularly inorganic fertilizer alone and inorganic fertilizer along with SWC or compost. This study supports the hypothesis that farm households who have plots with pest problems are less likely to adopt SLMPs than those with no problems of pest. In the same vein, we found water logging problem and the likelihood of adoption of SWC alone or its combination with manure are inversely and significantly related.

Results reveal that access to credit increases the probability of adoption of fertilizer alone or its combinations with SWC. Access to credit for externally purchased inputs, including inorganic fertilizer reduces liquidity constraints of resource-poor farm households. This is likely because resource-poor farm households have neither the capacity to purchase external inputs nor the ability to bear risks. This suggests that farm households who have access to credit are more likely to adopt both inorganic fertilizer (that require cash outlay), and its combination with SWC practices. Similarly, findings suggest that there is a positive significant correlation between adoption of both manure in isolation and only inorganic fertilizer and the extent of livestock holdings. This implies animal waste can be used as input for preparation of manure. Ownership of large livestock holding may provide security to farm households by relaxing the financial problems. In fact, households with more livestock holding are less likely to adopt the SWC alone. These appear due to the fact that households with grater livestock holding may prefer shifting cultivation instead of investment in SWC practice; plots that are under shifting cultivation can be also used for animal grazing. At the same time, farm households may adopt inorganic fertilizer using income from sale of animals for crop production. This finding agrees

with that of Shiferaw and Holden (1998) and Amsalu and De Graaff (2007) who investigated that ownership of more livestock decrease the chance to adopt stone bunds.

We find that total cultivated land holdings correlated significantly and negatively with the adoption of manure only and the SWC along with inorganic fertilizer or all SLMPs considered. This suggests that farm households are more likely to sustainably intensify production in their small lands to realize food security than relatively with large cultivable land. This result contradicts with Manda *et al.* (2016) who noted that households that have larger land holding are more likely adopting sustainable agricultural practices than their counterparts. This result also adds to the evidence of the negative effects of cultivated land size on adoption of technologies (Gebremedhin and Swinton, 2003; Teklewold *et al.*, 2013b). We also identified that farm households who are involved in a sale of dung cake are less likely to apply manure singly or manure plus SWC practices. Nonetheless, the sale of dung cake increases the likelihood of using inorganic fertilizer suggesting that they may invest the income they generated from the sale of dung cake for the purchase of farm inputs including inorganic fertilizer that realize the benefits in short-run.

In addition, the result shows participation in the non-farm income activities reduces the propensity to adoption of manure. This is in line with several previous studies which indicated that better access to non-farm activities discourage farm households to invest in conservation measures (Shiferaw and Holden, 1998; Gebremedhin and Swinton, 2003; Pender and Gebremedhin, 2007; Manda *et al.*, 2016). The association between non-farm income and farm households' adoption of technologies can be inversely related because involvement in non-farm activities diverts labors away from agricultural activities and thereby deter investment in land management practices.

Distance to market centers has an inverse relation with the adoption of a combination of SWC and Manure. This may reflect the marketability of output which reinforces the desire to invest in this practice. On the other hand, distance to markets center positively associated with the use of manure. This implies the marketability of dung cake deters the desire to improve soil fertility. As expected, the distance of the plot from homestead has a negative and significant influence on the adoption of manure alone or manure along with SWC practice. However, plot distance to homestead shows positive and significant association with a combination of SWC and inorganic

fertilizer. This may reflect that distant plot is less likely received manure or its combination along with other SLMPs; this is possibly due to the time lost by traveling to and from a plot.

We identify that the type of crops grown (chosen) in a given plot during the production year is significantly associated with the adoption of some technologies. For example, adoption of inorganic fertilizer or its combination with manure is less likely for legume crops. This finding is corroborated with Teklewold *et al.* (2017) who reported use of inorganic fertilizer is less likely on legume crops. We also find adoption SLMPs and crop rotation are simultaneously practiced. The chance of adoption of both SWC alone and a combination of SWC and inorganic fertilizer is higher on plots with steep slopes compared with gentle farm plots. Similarly, the likelihood of adoption of a combination of SWC and inorganic fertilizer or all the three practices is greater on plots with high soil erosion hazards. Moreover, the probability of adoption of SWC alone is greater on plots with high and medium erosion hazards. However, the chance of adoption of a combination of SWC and manure and SWC alone and inorganic fertilizer in isolation is lower on plots with medium soils as compared to deep soils. Likewise, the result shows the probability of adoption of a package of SWC and inorganic fertilizer is lower on plots with shallow soils. The results perhaps reflect plots with deep soils are more likely treated by SLMPs. The result indicates that farm households in middle highlands (Weinadega) are less likely adopting manure alone or manure along with SWC. However, farm households are more likely adopting inorganic fertilizer alone and combined with SWC or manure than households in upper highlands (Dega).

5.5.3. Impacts of SLMPs Adoption on household income

The unconditional average effect is presented in Appendix Table 5.3. For comparison purposes, the unconditional and conditional average effects of adoption of different combinations of SLMPs are estimated under the assumptions of exogenous and endogenous adoption of SLMPs, respectively. With the assumption of exogenous adoption decisions of SLMPs, the results of unconditional average effects indicate that adopters had a positive and significant higher crop net income than their counterparts. However, a simple comparison of these results would produce misleading inferences, since such comparisons overlook the disparity in the crop net income which might be caused by observable and unobservable characteristics of the farm households

(such as their management skills and motivation). This issue is addressed in this study by estimating a multinomial endogenous switching regression model.²¹

Table 3: The impact of adoption of SLMPs using multinomial ESR model (Ethiopian Birr/ha)

| s.no. | SLMPs | Adopter of SLMPs | | |
|-------|--|---|--|------------------------------------|
| | | Actual crop net income if farm households did adopt (A) | Counterfactual crop net income if farm households didn't adopt (B) | Impact (treatment) effects (A-B) C |
| 1 | Soil and water conservation alone | 17904.97 (419.12) | 16983.83 (363.84) | 921.13 8** (555.02) |
| 2 | Manure alone | 19672.36 (889.24) | 15923.74 (582.61) | 3748.62*** (1063.11) |
| 3 | Inorganic fertilizer alone | 17594.26 (501.31) | 13782.3 (456.42) | 3811.955*** (677.95) |
| 4 | Soil and water conservation and manure | 17853. 63 (671.91) | 16101.73 (505.83) | 1751.91** (841.03) |
| 5 | Soil and water conservation and inorganic fertilizer | 19281.68 (492.26) | 15250.39 (450.93) | 4031.29*** (667.58) |
| 6 | Manure and inorganic fertilizer | 18354.03 (1249.14) | 13928.3 (790.29) | 4425.73*** (1478.14) |
| 7 | Soil and water conservation, manure and inorganic fertilizer | 21254.26 (2284.24) | 13456.87 (742.31) | 7797.39*** (2401.81) |

Note: The total sample: 1,305 plots. Standard errors are in parenthesis. **Significant at the 5%*** significant at the 1% level.

The study estimates the impact of SLMPs adoption (in single or as a combination) on crop income per hectare. To this effect, we compute average crop net income (a proxy for productivity) under actual and counterfactual conditions. Table 3 presents the true average adoption effects of crop net income under actual and counterfactual conditions. In this table, we

²¹ Appendix Table 5.4 presents the parameter estimates of crop net income, since we are mainly interested in the effects of the adoption of SLMPs on household income it is not discussed.

compare expected crop income per hectare under the actual case that the farm household adopted a particular combination of SLMPs (columns A), and the counterfactual case that they did not adopt (columns B), see Table 3. This is done by applying Equations 7a-7j). The last column (C) presents the impact of each land management practice on crop net income, that is the adoption effect (ATT), calculated as the difference between columns (A) and (B).

Results show that the adoption of either single practice or a portfolio of them significantly increases farm household crop net income compared with non-adoption. Using the counterfactual scenario, we identify a set of SLMPs that can offer the highest payoff. The results of counterfactual analysis showed that the impact of individual SLMPs: SWC, manure and inorganic fertilizer on crop net income are positive and significant, when implemented in isolation. In particular, adoption of inorganic fertilizers in isolation delivers greater crop net income than adopting other practices in isolation.

The result further confirmed that the impact of adopting integrated soil fertility management practices (manure and inorganic fertilizer in combination) on crop net income is highly significant, it is about the Ethiopian Birr (ETB)²² 4425.73/ha, that is second to the largest income. Interestingly, regardless of higher incomes (but SLMPs portfolio), it is only statistically different from SWC in isolation (t-statistic= 3.97). The net income of adopting a combination of soil and water conservation practices with manure is 1751.91EB/ha. The findings indicate that the impact of SWC on crop net incomes is statistically significant when implemented in isolation or combined with other SLMPs. However, farming households that implemented SWC alone realized significantly less income than other combination of SLMPs.

The adoption of combined SWC and inorganic fertilizer has a positive and statistically significant impact on crop income (ETB 4031.29/ha). Regardless of a payoff income this practice is only statistically different from SWC alone, or along with manure (t- statistic = 5.82 and t- statistic = 3.13, respectively) and when the three SLMPs practiced as part of the same adoption portfolio (t- statistic= -1.99). Nevertheless, it is not statistically different from manure or fertilizer only. When inorganic fertilizer is implemented individually, it offers payoff income, which is greater and highly significantly different from SWC or combined manure and SWC (t-

²² 1 USD = 21.3345 ETB

statistic = 5.68 and 2.99, respectively). On the other hand, inorganic fertilizer delivers a lower payoff (when compared with all the three SLMPs), and only significantly different from a comprehensive SLMPs (t- statistic= -2.33). In the remaining cases (practices) it has no significant average crop net income difference.

Table 4: Average treatment effect for untreated (non-adopter)

| s.no. | SLMPs | Non-adopter of SLMPs | | |
|-------|--|---|--|--------------------------------|
| | | Actual crop net income if farm households did adopt (A) | Counterfactual crop net income if farm households didn't adopt (B) | Impact (treatment) effects (C) |
| 1 | Soil and water conservation alone | 17801.14 (341.95) | 16305.84 (278.48) | 1495.3*** (441.0) |
| 2 | Manure alone | 20478.55 (693.69) | 16305.84 (278.48) | 4172.71*** (747.5) |
| 3 | Inorganic fertilizer alone | 18421.44 (405.55) | 16305.84 (278.48) | 2115.6*** (491.95) |
| 4 | Soil and water conservation and manure | 18909.08 (519.06) | 16305.84 (278.48) | 2603.24*** (589.05) |
| 5 | Soil and water conservation and inorganic fertilizer | 18781.45 (347.63) | 16305.84 (278.48) | 2475.6*** (445.42) |
| 6 | Manure and inorganic fertilizer | 20722.82 (540.56) | 16305.84 (278.48) | 4416.98 (608.08) |
| 7 | Soil and water conservation, manure and inorganic fertilizer | 35378.08 (1592.49) | 16305.84 (278.48) | 19072.24*** (1616.66) |

Note: The total sample: 1,305 plots. Standard errors are in parenthesis. *** significant at the 1% level.

However, the highest crop net income (7797.39ETB/ha) is obtained from the adoption of soil and water conservation practices jointly with manure and inorganic fertilizer (a comprehensive portfolio of SLMPs), which is also higher than the impact of each practice individually or in

combinations. This underscores the importance of complementarity adoption of SLMPs. This finding is contrary to Di Falco and Veronesi (2013) who indicated that implementing climate change adaptation strategies that are more comprehensive may not always deliver a higher net crop revenue when compared with less comprehensive strategies. Teklewold *et al.* (2017) found a similar result where the adoption of a comprehensive climate smart practice provided more net maize income than adopting independently or in combination.

Farm households that adopted all SLMPs had earned significantly greater crop net incomes than households that practiced a piecemeal or parts of the SLMPs, but it is only not statistically different from combined manure and inorganic fertilizer (t-statistic=1.07). In all the other scenarios, the impact of implementing the three practices in combination is statistically different from the impact of adopting a piecemeal or parts of SLMPs.

In all counterfactual scenarios, farm households who actually adopted SLMPs would have earned a lower income if they had not adopted (column B of Table 3). In the same way, under the counterfactual cases if the non-adopters had adopted SLMPs, they would have earned higher crop income (see Table 4 column A of non-adopter's row). What is more is that the highest payoff (about ETB 19072.24/ha) is realized from simultaneous adoption of all SLMPs–SWC, manure and inorganic fertilizer (Table 4 column C).

5.6. Conclusions and implications

We applied the two-stage approach suggested by Bourguignon *et al.* (2007). We used a multinomial logit selection model to assess factors influencing adoption of SLMPs in the first stage. In the second stage, we applied a multinomial endogenous switching regression approach to estimate the true effects of adoption of SLMPs on crop net income. The multinomial logit results indicated that the probability of adoption of multiple SLMPs is significantly affected by: observable household characteristics, enabling conditions (access to market and information), risk factors resource factors and plot specific attributes.

The analysis of the determinants of adoption of SLMPs highlights the need for suitable entry strategies in promoting the practices. The sign of some of the variables pinpoints several possible policy cases to enhance multiple SLMPs adoption. For instance, we found farm households are more likely to adopt SLMPs on their own than on shared/rented cultivated plots. This scenario

calls for policy measures that guarantee a long-term tenure security. The study also reveals social capital plays a vital role in the adoption of SLMPs. This again implies establishing and strengthening local institutions/organizations are indispensable to speed up and sustain adoption of SLMPs. The study also highlights the importance of targeted extension services in delivering technical support and the role of other information sources (e.g. a local radio programs on SLMPs) in the dissemination and adoption of SLMPs suggesting the need to further strengthening these institutions. These institutions play a significant role in providing timely information.

The results of counterfactual analysis clearly indicated that the effect of individual SLMP: SWC, manure and inorganic fertilizer on crop net income are positive and significant, when implemented in isolation. Out of these practices, adoption of inorganic fertilizer in isolation provides greater crop net income than adopting other practices individually SWC alone delivers significantly lower income than other SLMPs. Moreover, in all counterfactual scenarios, the results of the analysis revealed that had the non-adopters adopted SLMPs, they would have earned higher crop income. We also found farm households that adopted all the three SLMPs at a time earned significantly greater crop net income (7797.39ETB/ha) than households that practiced a piecemeal or parts of the SLMPs signifying complementarity adoption is a profitable option. The paper generally confirms the adoption of SLMPs either in single or a portfolio of them significantly increases farm household crop net income as compared with non-adoption ones. This underscores the prospective role of adoption of land management practice in lowering income poverty.

In conclusion, the result of this study is relay on cross-sectional multiple plot-level data. If the study had been used a better data structure like panel data with a time dimension, the result would have provided more robust evidence on both the role of adoption and its economic implications. Therefore, further enquiry using panel data may be needed to examine the relationship between the adoption of SLMPs and crop income, so as to control for unobserved specific heterogeneity.

CHAPTER SIX

6. SYNTHESIS

6.1. Introduction

In Ethiopia, smallholder agriculture is the mainstay of rural economies and likely to remain so into the foreseeable future, and smallholders make up the majority of the country's rural poor and often occupy marginal and vulnerable land. However, past development effort to increase agricultural productivity of small farm households contribute to soil erosion and unsuccessful in reserving soil erosion. However, despite persisting for several decades, the problem did not receive policy attention until after the 1970s. Since then, large-scale conservation projects have been initiated and carried out by the government with the support of donor organizations, though the SLMPs introduced have not been adequately adopted by most farm households and land degradation remains unabated (Amsalu, 2006; Wolka, 2014). To understand the reasons for low adoption rate this study was designed.

This thesis contributes to the understanding of how adoption of agricultural technologies (i.e. SLMPs) affects smallholder farm households' crop net income. Moreover, the thesis contributes to the literature by indicating the link between people's participation in WMPs and investments in SLMPs. This thesis generally contributes to the vast literature on agricultural technology adoption by providing innovative ways of estimating impacts of SLMPs and shows the link between people's participation in WMPs and adoption decisions of SLMPs as well as provides useful policy insights that can contribute to the promotion of these technologies/practices.

In chapter two, we show the relationships between extent of people's participation in WMPs and socioeconomic and institutional variables. In Chapter three, we apply multivariate probit (MVP) to model joint estimation of multiple technology adoption thereby testing the complementarities and substitutabilities among the multiple technologies. In addition to this the question of whether these technologies are beneficial when they are adopted in isolation (individually) or as a combination (package) is yet to be answered in Ethiopia. In chapter four, we therefore assess the effect of adopting SLMPs either as a single practice or as a package (combination), in which we find that adopting a package of practices/technologies resulted in higher crop net income. The synthesis of these three core chapters is summarized in section 6.2. In the rest of this chapter we

will discuss the main findings of the thesis and provide policy implications and avenues for future research in the subsequent sections.

6.2. Main findings

Some literature documented that farm households participation in WMPs activities is very low in Ethiopia (Bewket and Sterk, 2002; Amsalu, 2006). However, scientific evidence on identifying and specifying specific connection between extent of people's WMPs and socioeconomic and institutional factors was lacking. Research objective described in chapter three was therefore: to examine determinants and extent of people's participation in WMPs we applied Tobit model. Results in chapter three consistent with (Amsalu, 2006; Wolka, 2014) show people's participation in WMPs is relatively low - only a few people have succeeded higher level participation in watershed programs. The Tobit analysis (chapter three) indicated that levels of people's participation in WMPs are influenced by age of household head, family size, participation in non-farm works, farm households' contact with extension agents, size of land holding, membership in multipurpose cooperatives, distance to roads and household perceptions about the impacts of WMPs (i.e. social, environmental and economic).

Moreover, the results in chapter four and five confirmed that people's participation in WMPs significantly enhances the likelihood of adoption of SWC practices, but discourage use of manure and inorganic fertilizer. What is more, the results in chapter four and five indicate the role of WMPs in promoting adoption decisions of SWC practices and signifying the programs focus was still building physical structure with little emphasis on fertility enhancing technologies.

In most adoption and impact studies, agricultural technologies are often modelled separately using single equation models (Manda *et al.*, 2016; Teklewold *et al.*, 2017). In in this thesis, we depart from this standard approach and model adoption of SLMPs and their associated impacts on household income using simultaneous and multinomial equation models. Using these approaches, we examine the determinants and impact of SLMPs on the farm household income in Bassonaworana district, central highlands of Ethiopia. The results on the determinants of adoption from the two core chapters (chapters 3-4) were pretty much consistent with many adoption studies (Kassie *et al.*, 2013; Teklewold *et al.*, 2013a; Kassie *et al.*, 2015a). Regarding

the impact of SLMPs on the farm household income proxied by crop income; adoption of SLMPs increased crop net income (chapter four),

In the recent times the role of sustainable land management is appreciated more than ever in Ethiopia. Different of SLMPs has been promoted as an approach to surely influence the management of land and water resource. Unfortunately, farm households are constrained to integrate these practices in to farming system and adoption of these practices is limited (Teklewold *et al.*, 2013a; Girma, 2015). In this regard, prior empirical studies have focused on the adoption of single practices/technologies in different plots ignoring the combined use of SLMPs in a plot (Kassie *et al.*, 2013; Teklewold *et al.*, 2013a). This dissertation in chapter four, therefore, considered multivariate nature of adoption decisions of SLMPs. Accordingly, the objective of the second study (described in chapter four): investigate factors influencing adoption of multiple SLMPs using comprehensive household and plot-level data collected from 354 households and 1305 plots, respectively.

In chapter four some attention was paid to the possibility of using a multivariate probit (MVP) model to estimate simultaneous and interdependent adoption decisions of SLMPs. This model would consider the interdependence among the different practices such as SWC practices, manure and inorganic fertilizer and jointly models the interrelated use of these practices. The potential correlation among the unobserved disturbances in the decision equations, and the use of the different practices was measured. Failure to capture such interdependence will lead to biased and overestimate the influence of various factors on adoption decisions (Maddala, 1983; Dorfman, 1996).

The evidence presented in chapter four similar to (Kassie *et al.*, 2012, 2013; Teklewold *et al.*, 2013a; Girma, 2015) and most strongly supports the claim adoptions of SLMPS are correlated. The results in chapter four show that the correlation coefficient between SWC and manure is positive and statistically significant. Similarly, the correlation coefficient between SWC and inorganic fertilizer is positive and significant. These significant correlations between SLMPs confirm that the propensity of using a practice is governed by the use of the others, indicating interdependence in the adoption of SLMPs (either substitutability or complementary between the practices). The results in this thesis on the determinants of multiple SLMPs were largely consistent with other studies in Ethiopia and elsewhere in Africa (Kassie *et al.*, 2013; Teklewold

et al., 2013a; Kassie *et al.*, 2015a). In sum, the empirical results show that adoption of SLMPs are influenced (negative or positive) by a number of interwoven factors: household characteristics, risk factors, resource-related factors and policy environment.

A multinomial endogenous switching regression model was employed to estimate the crop value of SLMPs use by controlling the problem of selection bias and endogeneity. Farm households endogenously self-select themselves into adopter/non-adopter, subsequently unobservable characteristics (for instance, expectation of yield gain from adoption, managerial skills, and/or motivation) may influence both adoption and the outcomes of interest (crop net income)(Asfaw *et al.*, 2012). This is corrected using a selectivity correction estimation method (Bourguignon *et al.*, 2007). In chapters five, we ask the question of whether adoption of SLMPs has an impact on farm household income (crop net income). Estimation of the treatment effects presented in chapter five confirmed that crop net income is significantly higher for plots treated with SLMPs than non-treated plots. Moreover, in all counterfactual scenarios, the results of analysis revealed that had the non-adopters adopted SLMPs, they would have earned higher crop net income. The result in chapter five indicates farm households that adopted all the three SLMPs at a time earned significantly greater crop net income (7797.39ETB/ha) than households that practiced a piecemeal or parts of the SLMPs.

This thesis also made a methodological contribution to the literature on the impacts of agricultural technologies (see chapter five). Specially, one of the challenges in impact evaluation was failure to control unobservable variables including the problem of selection bias and endogeneity. We accounted for this by controlling the problem of selection bias and endogeneity. The results in chapter five not only show that SLMPs is an important practices in increasing crop net income , but also underscores the importance of modelling the impacts in simultaneous equation framework. We also learned that adoption would have equally benefited non-adopters, had they choose to adopt SLMPs.

5.3. Main conclusions and Policy implications

The present study identified different sustainable land management practices implemented by the farm-households to deal with land degradation. The study revealed some important aspects of SLMPs: determinants of multiple uses of the practices and their impacts on household income (crop income). We also scrutinized the extent of people's participation in WMPs campaign and

its link with socioeconomic and institutional variables. Based on the above discussion, the following conclusions can be made.

Arising from the results and discussion above, important policy recommendations can be drawn. First, extent of people's participation in watershed management programs is relatively low. Therefore, willing participation of the local farm households is a necessary and this could be achieved by educating the households and by demonstrating meaningful results in order to raise their motivation and commitment (Amsalu, 2006). Moreover, the results in chapter three indicate that extension services need to target not only people's mobilization and construction of conservation structures but to ensure sustainability of watershed targeting maintenance and protection is also equally important.

Second, literature on SLMPs in Ethiopia shows that there is low adoption rate by smallholder farm households (Kassie *et al.*, 2009a; Merrey and Gebreselassie, 2011; Teklewold *et al.*, 2013a; Wolka, 2014; Girma, 2015). The challenge therefore is the promotion and realization of widespread and continued use of SLMPs. Arising from this thesis is major concerns that need policy attention include security of land tenure, efficient market (for agricultural inputs and outputs) and credit services, and enforcement of policies related to land management. In addition to this people's participation in WMPs increase only the propensity of adoption of SWC practice, suggesting that there is a need for balanced focus both on SWC conservation and fertility enhancing practices to ensure sustainability of natural resource use.

Besides, result in chapter four reveals that farm households adopt a bundle of technologies/practices that are either interdependent or complementary to each other's rather than adopting single once. Therefore, the designing of policies and implementation strategies need to recognize the adoption of one of SLMPs could have spillover effects on the other practices. Therefore, the different SLMP would need specific intervention (entry point) and promotion strategies.

Third, based on the results of impact study (chapter five) we may draw three main conclusions. First, implementations of SLMPs either in combination or standalone significantly increase crop net income. Second, a more comprehensive approach (a joint adoption of all SLMPs considered) is the best income yielding portfolio. Third, it is important that adoption of SLMPs continues to

be encouraged, especially among the smallholder farm households as it has been shown to be beneficial to not only adopters, but to potential adopters also. This suggests investment in SLMPs is payoff venture, thus designing appropriate policies and strategies that promote adoption SLMPs is recommended. Nonetheless, considering the potential danger of relying highly on short term yield enhancing inorganic fertilizer to deal with the soil degradation problem would be useful.

5.4. Prospect for future research

The results of this dissertation are relay on cross-sectional multiple plot-level data. If the study had been used a better data structure like panel data with a time dimension, the result would have provided more robust evidence on both the role of adoption and its economic implications. Therefore, future enquiry using panel data may be needed to examine the relationship between the adoption of SLMPs and crop net income, so as to control for unobserved specific heterogeneity. The study also would have used experimental data to analyze the effect SLMPs on natural resource bases, but this thesis did not analyze this. Further, in mixed farming system livestock productivity is important like crop production, nonetheless the impact evaluation has only dealt on the value of crop production. Future research could address these issues and provide wider insights on the impact of SLMPs in crop-livestock mixed farming system.

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APPENDICES

Appendix Table 1: Household interview schedule

Sustainable land management practices and their impact on household income

SECTION-A: HOUSEHOLD INFORMATION

A01. Kebele _____

A02. Village _____

A03. Name of household: _____

A04. Marital status of household: 1. Married 2. Single 3. Divorced 4. Widowed 5. Not together for some reason

| SECTION-B. HOUSEHOLD(HH) ROSTER | | | | | | | |
|---------------------------------|---------------------------------|---|---------------------------------|--|--|-----------------|-----------|
| Code | B01. What is the person's name? | B02. What is the relationship to HH? 1. HH head 2. Spouse 3. Child 4. brother/ sister 5. parent 6. Unrelated (eg. Worker) 7=Other (specify | B03. Sex? 1=Male 2=Female | B04. How old is [NAME]? For infants less than 1 year write 00 | B05. What is the highest level of education completed by name? 1= Illiterate 2 = Read and write 3 = School (specify grade. 1, 2...,10) 4 = Graduate (specify the grade like 10+1, 10+2, 12+2+12+3... | B06 Occupation? | |
| | | | | | | Primary | Secondary |
| 1 | | | | | | | |
| 2 | | | | | | | |
| 3 | | | | | | | |
| 4 | | | | | | | |
| 5 | | | | | | | |
| 6 | | | | | | | |
| 7 | | | | | | | |

SECTION-C: HH LAND HOLDING AND DESCRIPTION OF FARM PLOTS:

Record all the plots registered by the HH and/or used from other sources for the last cropping season (meher, 2014/15)

C01. How many farm plots did you **manage** (own, rented, shared) in last cropping season? _____.

| | Description | Plot (1) | Plot (2) | Plot (3) | Plot (4) | Plot (5) | Plot (6) |
|------------|---|----------|----------|----------|----------|----------|----------|
| C02 | Area of the Plot (<i>ha</i>)/ <i>timad</i> | | | | | | |
| C03 | Ownership type: Own 2) Shared in 3) Shared out 4) rented in 5) rented out | | | | | | |
| C04 | Total years since the farmer managed the plot? | | | | | | |
| C05 | Slope: 1) Plain to gentle 2) moderate slope 3) Steep slope | | | | | | |
| C06 | Distance from home: code: 0 for homestead _____ minutes. | | | | | | |
| C07 | Plot distance from main road. _____ (in walking minutes) | | | | | | |
| C08 | Plot fertility: 1) poor 2) medium 3) high | | | | | | |
| C09 | Color of the soil: 1) red 2) black 3) Brown 4) gray | | | | | | |
| C10 | Soil depth: 1) shallow 2) medium 3) deep | | | | | | |
| C11 | Drainage of plot: 1. well drained 2. Poorly drained (water logging) | | | | | | |
| C12 | Access to irrigation 1) yes 2) no | | | | | | |
| C13 | Severity of soil erosion: 1) Low 2) moderate 3) high | | | | | | |
| C14 | Crops grown in the last Meher: 1) barely 2) Teff 3) wheat 4. Faba beans 5) lentil 6) Pea 7) tree 8) Others (specify | | | | | | |
| C15 | Incidence (attack) of pests and/or diseases during Meher: 1. Yes, 2. No | | | | | | |

| SECTION- D: TYPE OF PHYSICAL STRUCTURE IMPLEMENTED AND ITS MAINTENANCE: Record all SWC practice employed by HH on each plot | | | | | | | |
|--|---|-----------------|----------------|----------------|-----------------|-----------------|-----------------|
| | Description | Plot -01 | Plot-02 | Plot-03 | Plot-0 4 | Plot-0 5 | Plot- 06 |
| D01 | Does the plot covered with soil buds? 1) Yes 2) No If yes go to D02, if no go to D07 | | | | | | |
| D02 | Soil bunds were constructed since_____. (e.g. 1999) | | | | | | |
| C19 | How many meters of soil buds are constructed? (e.g. 1, 2, 3...) | | | | | | |
| D03 | Who constructed it? Code: 1. Community participation 2. Food/cash for work program 3. Family labor 4. Hired labor 7. Others, specify_____ | | | | | | |
| D04 | Did you maintain soil buds? 1) yes 2) No, if yes goes to C22, if no goes to D07 | | | | | | |
| D05 | Number of persons (full labor days) involved to maintain soil bunds in the last year? | | | | | | |
| D06 | How many meters of soil buds have been maintained last year? | | | | | | |
| D07 | Does the plot covered with stone bud? 1) Yes 2) No If yes go to D08, if no go to D11 | | | | | | |
| D08 | Stone bunds were constructed since_____. (e.g. 1999) | | | | | | |
| D09 | How many meters of stone buds are constructed? (e.g. 1, 2, 3...) | | | | | | |
| D10 | Who constructed stone bund? Code: 1. Community participation 2. Food/cash for work program 3. Family labor 4. Hired labor 7. Others, specify_____ | | | | | | |
| D11 | Did you maintain stone buds? 1) yes 2) No, if yes go to D12, if no go to D14 | | | | | | |
| D12 | Number of persons (labor) spent to maintain the structure in the last year? | | | | | | |
| D13 | How many meters of stone buds are maintained in last year | | | | | | |
| D14 | In the previous (former) year a plot was: (possible to give more than one answers). Code: 1) fallowed, 2) had manure 3) planted a legume crop (faya bean, beans and lentil) | | | | | | |
| D15 | How many years if the plot was planted legume crop (s)? Code: (1, 2, 3...) | | | | | | |

| Section-E: ORGANIC SOIL FERTILITY MANAGEMENT (SFM) PRACTICES: Record all the SFM practices implemented by HH on each of farm plots in last 12. | | | | | | | | |
|---|------------------------------|---|--------------------------|-----------------------------|--|--------------------------|---|-----------------|
| plot | Animal manure (AM) | | | Compost (C) | | | Legume crops rotations | Other (specify) |
| | E01. Amount (Quintal) | E02. Full day labor used for preparation & transport (1, 2...) | E03. Value (birr) | E04. Amount Quintal) | E05. Full day labor used for preparation and transport (1, 2, 3...) | E06. Value (birr) | E07. Planted legume crop in the former cropping season? 1)Yes 2) No | |
| 01 | | | | | | | | |
| 02 | | | | | | | | |
| 03 | | | | | | | | |
| 04 | | | | | | | | |
| 05 | | | | | | | | |
| 06 | | | | | | | | |
| 07 | | | | | | | | |

| SECTION-F1: HOUSEHOLD PERCEPTION OF SLMPS- Perception of SWC practice: Code: 1= Disagree (DA) 2=Don't know (DK) 3= Agree (AG) | | | | | | | |
|--|-----------------------------------|------------|----|----|-----------|----|----|
| | Items | Stone bund | | | Soil bund | | |
| | | AG | DK | DA | AG | DK | DA |
| F101 | increases production | | | | | | |
| F102 | reduces soil erosion | | | | | | |
| F103 | improves fertility | | | | | | |
| F104 | harbors pests and disease | | | | | | |
| F105 | takes some land out of production | | | | | | |
| F106 | make difficulty to turn oxen | | | | | | |
| F107 | requires frequent maintenances | | | | | | |
| F108 | labor intensive (construction) | | | | | | |
| F109 | maximizes soil moisture | | | | | | |
| F110 | provides benefits in short-term | | | | | | |

SECTION-F2: HOUSEHOLD PERCEPTION OF SLMPS: -PERCEPTION OF SFM PRACTICE: Code: 1= Disagree (DA) 2=Don't know (DK) 3= Agree (AG)

| | Items | Inorganic fertilizer | | | Animal manure | | | Compost | | | Crop rotation | | |
|-------------|-------------------------------------|----------------------|----|----|---------------|----|----|---------|----|----|---------------|----|----|
| | | AG | DK | DA | AG | DK | DA | AG | DK | DA | AG | DK | DA |
| F201 | increases crop yield | | | | | | | | | | | | |
| F202 | improves fertility | | | | | | | | | | | | |
| F203 | increase pests & disease incidence | | | | | | | | | | | | |
| F204 | maximizes soil moisture | | | | | | | | | | | | |
| F205 | requires intensive labor to prepare | | | | | | | | | | | | |
| F206 | simple to transport | | | | | | | | | | | | |
| F207 | provides benefits in short-term | | | | | | | | | | | | |
| F208 | simple to prepare (skill) | | | | | | | | | | | | |

SECTION-G: PRODUCTION INPUTS: Record the inputs used on each of your farm plots in last 12 months. First copy the plot numbers from section C above. Then ask the questions plot by plot.

| Plot | G01.Crop type (Meher) Crop code: 1) barely 2) tef 3) Faba bean 4) lentil 5. others | Seed | | | | Fertilizer | | | | Other inputs (Birr) e.g. (pesticides, machinery, fuel, renting etc. | | | Oxen rent (Birr) | | |
|------|---|---------|-------------------|------------|-----------|------------|-----------|----------|-----------|---|----------|---------------------|-----------------------|----------------|------------------|
| | | Local | | Improved | | Urea | | DAP | | G10. Pesticides | G11.Fuel | G12. Machinery rent | G13. land preparation | G14. plantin g | G15. Harvesti ng |
| | | G02. kg | G03. Price (Birr) | G04 . (kg) | G05. Birr | G06 .Kg | G07. Birr | G08 . Kg | G09. Birr | | | | | | |
| 01 | | | | | | | | | | | | | | | |
| 02 | | | | | | | | | | | | | | | |
| 03 | | | | | | | | | | | | | | | |
| 04 | | | | | | | | | | | | | | | |
| 05 | | | | | | | | | | | | | | | |
| 06 | | | | | | | | | | | | | | | |

SECTION-H: CROP PRODUCTION (PLOT LEVEL) INPUTS: Labor (in full labor days) and oxen use: First copy crop code from section G above. Then ask the questions plot by plot. Code: number of full labor days (1, 2, 3...)

| Plot code | me her: | Land preparation (include all round) | | | | | Planting | | | | | Weeding (include all round) | | | | | Harvesting (incl., mowing, threshing & basic processing for storage and sale) | | | | | | |
|-----------|---------|--------------------------------------|-------------------------|------------------------|------------------|--------------|------------------------|-----------------------|-------------------------|------------------------|-------------|-----------------------------|--------------------|-----------------------|-------------------------|------------------------|---|---------------------|-----------------------|-------------------------|------------------------|--------------|-----------------------|
| | | Family labor (Days) | | | Hired labor (HL) | | Family Labor (days) | | | Hired Labor | | H11. Oxen (Days) | Family labor(days) | | | Hired labor (HL) | | Family Labor (days) | | | HL | | H22. Oxen (day) |
| | | H01. Male Adult | H02. female Adult | H03. Child labor | H04. days | H05. Birr | H06. Oxen (Days) | H07. Male Adult | H08. female Adult | H09. Child labor | H10. ays | | H11. Birr | H12. Male Adult | H13. female Adult | H14. Child labor | H15. days | H16. birr | H17. Male Adult | H18. female Adult | H19. Child labor | H20. Days | |
| 1 | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | | | | | | | | | |

SECTION-I: CROP PRODUCTION-PLOT OUTPUT: First copy crop code from section G above. Then ask the questions plot by plot.

| Plot code | Meher crop code | I01. Total output produced | | I02. Total crop residues (Chinet in number) |
|-----------|-----------------|----------------------------|--------------------|---|
| | | Amount | Unit (Kg/ Quintal) | |
| 01 | | | | |
| 02 | | | | |
| 04 | | | | |
| 05 | | | | |
| 06 | | | | |
| | | | | |
| | | | | |

SECTION-J: LIVESTOCK

| J01. Do you rear livestock? 1. Yes 2. No If No, go to J02, If Yes, go to J03 | | J02. Why you are not involved in animal production (livestock rearing) 1= Shortage of land 2= Shortage of initial capital 3= Labor shortage 4= Feed shortage 5. Others (specify) _____ | | | | |
|---|--|---|---|---|--|---|
| J03. Source of animal feed (multiple response is possible): 1= grazing, 2=purchased concentrates, 3=crop residue, 4=purchased crop residue, 5= green feed from private land 6= green feed from common managed land (watershed) | | | | | | |
| Types of Livestock | J04. How many of the [livestock] do you own recently? | J05. If you were to sell one of the (livestock), how much would you receive from the sale? | J06. Livestock By-product type 1=milk 2=egg 3=milk products 4=honey 5=livestock 6=Rent | J07. Value of output per year (Birr) Specify_____ | J08. Value of output per year (Birr) Specify____ | J09. Value of output per year (Birr) Specify _____ |
| Ox | | | | | | |
| Cross breed diary | | | | | | |
| Local dairy | | | | | | |
| Calve | | | | | | |
| Heifer | | | | | | |
| Goat/Sheep | | | | | | |
| Horse | | | | | | |
| Donkey | | | | | | |
| Mule | | | | | | |
| Chicken | | | | | | |
| beehive | | | | | | |
| Others | | | | | | |

SECTION K: ACCESS TO MARKET AND INFORMATION

K01. How many walking minutes take from your home to market center? _____ minutes.

K02. Which transportation systems do you often use to go to market center? 1= walking 2= public transport 3= bicycle 4= horse 5= donkey/horse and cart

K03. How many walking minutes take from you home to all-weathered road? _____ minutes

K04. Do you get extension service on SLMPs? 1) yes 2) No

K05. Who provides the extension service on SLMPs? 1= MoA) 4= NGO, 3=other specify

K06. How often are you visited by development agents last year? _____ times

K07. Have you participated in SLM training for the past three years? 1) yes 2) No

K08. If yes to K07, for how often? _____ times.

K09. Did you participate in exposure visits related to SLMPs? 1) yes 2) No

K10. Do you own a radio/Tape? 1) yes 2) No

K11. If yes to K10, have you got information about SLM? 1) yes 2) No

K12. Do you own a cell phone? 1) Yes 2) No

K13. Traveling from your home to extension office takes _____ walking minutes.

K14. What are/is your major sources of information about SLM? Rank the best three source of information. 1= Friend/Neighbor, 2= Model farmer 3= MoA , 4= NGO
5=Radio 6= others specify

| K15. Rank | |
|------------------|--|
| 1 st | |
| 2 nd | |
| 3 rd | |

| SECTION L: PARTICIPATION IN FARMERS' ORGANIZATIONS/ASSOCIATION (FOs) AND SOCIAL NETWORKS: Please indicate type of organization in which you are a member. | | |
|--|--|------------------|
| | Farmers' organizations/association (FOs) | Code: 1=Yes 2=No |
| L01 | Participation in WMPs | |
| L02 | Water users group | |
| L03 | Multipurpose cooperative | |
| L04 | dairy cooperative | |
| L05 | Local finance group (Eg. Equb) | |
| L06 | Save money microfinance/bank | |
| L07 | Religious group or spiritual group (Mahiber) | |
| L08 | Mutual support association (Edir) | |
| L09 | Political group (Cabinee/ Mlitia) | |
| L10 | WM committee | |
| L11 | Self-help labor <i>Debo/Jige</i> (labor group) | |
| L12 | Woman association | |
| L13 | Do you have relative in leadership position? | |
| L14 | How many of people you are rely on in case of difficulty _____ | |

| SECTION-M: CREDIT | | | | |
|---|--|-------------------------------|--|---|
| M01. Did you need credit for farming operation in the last 12 months? 1=Yes, 2=No If 1, go to M02, if 2, go to M07 | | | | |
| Credit | M02. Did you obtain credit in cash or in kind? 1=Yes, 2=No If 1, go to M03, if 2 to M06, go to M06 | M03. Amount in Birr | M04. For what purpose did you use? 1. Fertilizer 2. Seed 3. Food 4. Livestock (oxen, small remnants) 5. Other | M05. Source of credit? 1= Neighbor 2=Money lender 3= WOA 4=Micro finance ___ 5= Cooperative 6= Others(Specify) |
| | | | | |
| | | | | |
| M06. Why did you not take a loan? (if 1 for M02 but not obtain any credit) 1= Applied but failed to get, 2= No service provider 3= not applied 4=I have no assets for collateral, 5=Afraid of losing collateral, 6=Afraid that I cannot repay pack, 7=High interest rate 8-Other (specify) | | | | |
| M07. Why did you not need a loan? 1= I have sufficient funds of my own, 2= I don't need any credit. 3= High interest rate, 4= I have no assets for collateral | | | | |

| SECTION -N: OFF FARM AND NONFARM | | | | |
|--|---|---|--|--|
| N01. In the last 12 months did you or any other members of the household engaged in off farm income generating activities? 1=Yes 2=No If 1, go to N02 If 2, go to N08 | | | | |
| ID code of HH members | N02. Specify the type of work 1= Farm worker 3=Professional work 4=Skilled labor 5= Food for work 6= Others(specify) _____ | Total amount earned in last 12 months. If in kind, specify the form and value | | |
| | | N03. Amount in Birr | N04. In Kind form 1= Crop 2= Livestock 3=Others | N05. Value of the in kind earning |
| | | | | |
| | | | | |
| N06. In the last 12 months, have you or other members of your household have been involved in business activities? 1= Yes 2=No If 1, go to N07 | | | | |
| ID code of HH members | N07. Specify the type of business 1= Petty trade, 2= Local beverages sales, 3=Trading (grain) 4= Trading (livestock) 5= Fire wood collection & selling 6= Transport (pack animals) 7= Others (specify) ___ | N08. Total amount earned in last 12 months | | |
| | | | | |
| | | | | |

| SECTION -P: REMITTANCE AND OTHER INCOME | | |
|--|--|---------------------------------------|
| P01. Did the household receive any remittances (gifts, food aid/other aid and other transfer) from friends/relatives) in the last year? 1=Yes 2=No | | If 1, go to P03 If 2, go to |
| Total amount earned in last 12 months. If in kind, specify the form and value | | |
| P03. Amount (Birr) | P04. In Kind form :1= Crop 2= Livestock 3=Others | P05. Value of in kind earning |
| | | |
| | | |

| SECTION-Q: TREE CROPS AND DUNG CAKE INCOME | | | | | | |
|---|--|---------------------------------------|-----------------------------|---|---|---|
| Q01. Do you have eucalyptus trees? 1= Yes 2= No if yes go to Q02 , if no go to Q06 | Q02. If yes, its location: 1= farm land, 2= degraded land 3=homestead 4= around the farm | Q03. area covered by tree (ha) | Q04. Number of trees | Q05. Amount sold (last year) in birr | Q06. Did you sell dung cake? 1= Yes 2=No | Q07. , if yes to Q06 Revenue from dung cake |
| | | | | | | |

| SECTION-R: RAINFALL PATTERN IN THE PRECEDING THREE CROPPING SEASONS | | | | |
|--|---|------------------|------|------|
| No. | Items | Code: 1=Yes 2=No | | |
| | | 2013 | 2014 | 2015 |
| R01 | Rainfall came on time (variability). | | | |
| R02 | Rainfall stopped on time (variability). | | | |
| R03 | There was enough rain at the beginning (scarcity) | | | |
| R04 | There was enough rain during the growing season (scarcity). | | | |
| R05 | There was rained at harvest time (variability). | | | |

SECTION-S: FARMERS' PARTICIPATION IN WATERSHED MANAGEMENT PROGRAMS

S01. In the last five years, did you participate in any WMPs activities (planning meeting, implementation and maintenance) that have been undertaken in your in your *Kebele (Peasant association)*? 1= Yes, 2=No

S02. If yes to **S01**, how are you participating in the WMPs activities currently carried out in your in your *Kebele*?

1= It was based on farmer's willingness 2= It was forceful.

S03. Did you forced by external agency to implement the new SLM technologies in your field?

1. Yes 2. No

S04. Please indicate your level of participation in planning, implementation and maintenance of watershed development activities during the last five years. **Code:** Very high (VH), High (H) Moderate (M), Low (L) and very low/never (VL)

| | S05. Rate the following items (statements) | VH | H | M | L | VL |
|----|--|----|---|---|---|----|
| | Planning | | | | | |
| 1 | participate in planning meeting of WMP | | | | | |
| 2 | Involve in assessment of soil erosion and land degradation as a problem | | | | | |
| 3 | participate in selection land conservation measures) | | | | | |
| 4 | suggest idea during planning of check dam in the watershed | | | | | |
| 5 | suggest idea in the planning of agricultural crop cultivation in the watershed | | | | | |
| 6 | suggest information during planning of various forest trees planted in the watershed | | | | | |
| 7 | suggest idea during planning of land leveling works carried out in the different fields of the watershed area | | | | | |
| 8 | give information to include in the planning of various SWC measures | | | | | |
| 9 | motivate fellow farmers to participate in planning WMPs | | | | | |
| 10 | give suggestion about your primary needs such as fuel, fodder and food to be taken care of in the program planning | | | | | |
| | Implementation | | | | | |
| 1 | allow program implementing agency (PIA) to implement SWC program works in your field | | | | | |
| 2 | provide equipment during the construction of SWC structures | | | | | |
| 3 | provide labor during plantation work of forest plants | | | | | |
| 4 | Support during purchasing of construction materials for SWC structures | | | | | |
| 5 | contribute labor towards construction of SWC structures on communal land | | | | | |
| 6 | contribute money towards construction of SWC structures | | | | | |
| 7 | ask your fellow farmers for labor and money contribution towards construction of conservation structures | | | | | |
| 8 | participate in training program offered by the PIA regarding SWC program | | | | | |
| 9 | Involve in exposure visits of WMP | | | | | |
| 10 | Make supervision of the construction work each time during implementation stage of SWC program | | | | | |
| 11 | construct conservation measure on private land | | | | | |
| | Maintenance | | | | | |
| 1 | prevent entrance of animal in to protected area | | | | | |

| | S05. Rate the following items (statements) | VH | H | M | L | VL |
|---|---|----|---|---|---|----|
| 2 | take care of the forest plants during dry season by providing irrigation water | | | | | |
| 3 | inform the Development Agents (DAs) to repair the damaged SWC structures in communal land found in watershed | | | | | |
| 4 | Protect the SWC structures from natural calamities | | | | | |
| 5 | contribute own labor towards maintenance of SWC structure in your field | | | | | |
| 6 | contribute money towards maintenance of SWC structures in your field | | | | | |
| 7 | motivate your fellow farmers for labor (money) contribution towards repair and maintenance of SWCPs in the WS | | | | | |
| 8 | contribute labor/money towards the desilting of the SWC structures | | | | | |

| SECTION-T: EVIDANCE OF ENVIRONMENTAL, ECONOMIC AND SOCIAL CHANGE (perceived impact): Please give your agreement/disagreement to the following statements that describe WMPs implementation in your Kebele (peasant association). | | | | | | |
|---|---|----------------|-------|---------|----------|-------------------|
| | Items | Strongly agree | agree | Neutral | disagree | Strongly disagree |
| 1 | decreased in runoff (soil erosion) | | | | | |
| 2 | reduced downstream siltation | | | | | |
| 3 | improved soil fertility | | | | | |
| 4 | increased irrigated area | | | | | |
| 5 | raised water table (New/abandoned springs are originated) | | | | | |
| 6 | enhanced supplies of surface water | | | | | |
| 7 | increased diversity of plant and animal | | | | | |
| 8 | enhanced water retention capacity of soil | | | | | |
| 9 | endangered watershed areas are revived | | | | | |
| 10 | increased livestock feed | | | | | |
| 11 | created more employment opportunities | | | | | |
| 12 | increased crop yield | | | | | |
| 13 | promoted opportunities to harvest apiaries (bee keeping values) | | | | | |
| 14 | increased net income from livestock production | | | | | |
| 15 | Reduced illegal extraction of resources | | | | | |
| 16 | raised knowledge of management of natural resources (training) | | | | | |
| 17 | reduced conflict over common resources | | | | | |
| 19 | created agreed rule for equitable share of benefits from common resources | | | | | |

Chapter Three

Appendix table 3. 1: Summary of descriptions of variables used in Tobit models and expected sign

| Variables | Description | Mean | Std. Dev. | expected sign |
|--------------------------|---|-------|-----------|---------------|
| Gender | 1= if the sex of a household head is female | 0.11 | 0.32 | - |
| Education level | Education level of head of a household | 1.45 | 2.85 | + |
| Age | Age of the household head | 46.41 | 13.14 | - |
| Family size | Family size of a household | 4.5 | 1.74 | - |
| Marital status | 1= if not married | 0.21 | 0.41 | - |
| Access to market center | Farm households' residence distance to market center in walking minutes | 66.46 | 41.92 | - |
| Access to road | Farm households' distance to all-weather roads in walking minutes | 43.01 | 41.01 | + |
| Extension contact | Frequency of extension visit by extension agents (days/year) | 1.86 | 1.76 | + |
| Multipurpose cooperative | 1= if the member in multipurpose cooperative | 0.73 | 0.45 | + |
| Social impact | Perceived social impact of WMP, Index (1=best) | 0.72 | 0.14 | + |
| Economic impact | Perceived economic impact of WMPs Index (1=best) | 0.56 | 0.20 | + |
| Environmental impact | Perceived environmental impact of WMPs Index (1=best) | 0.70 | 0.12 | + |
| Joining WMPs unwillingly | 1=if a farm household was forced to participate in WMPs | 0.12 | 0.32 | - |
| Farm size | Cultivated landholding in a hectare | 1.22 | 0.49 | + |
| Non-farm income | 1= a farm household engaged in non-farm income | 0.10 | 0.30 | - |
| Livestock | Livestock holding in total livestock unit (TLU) | 5.46 | 3.16 | - |
| Agro-ecological zone | 1=mid- highlands, 0 =upper highlands | 0.45 | 0.50 | - |

Appendix table 3. 2: Conversion factor used to estimate tropical livestock unit (TLU)

| Age group | TLU Equivalent |
|-----------------|----------------|
| Calf | 0.40 |
| Heifer | 0.75 |
| Cow and Oxen | 1.00 |
| Donkey | 0.70 |
| Sheep and goat | 0.10 |
| Horse and Mules | 0.80 |
| Chicken | 0.013 |

Source: Freeman *et al.*, (1996)

Appendix table 3. 3: Parameter estimates of MLR models (robust std. Err)

| Variables | Participation components (factors) | | | | | | | | | | | |
|--------------------------|------------------------------------|----------|-------|----------|----------------|----------|-------|----------|-------------|----------|-------|----------|
| | Planning and decisions | | | | Implementation | | | | Maintenance | | | |
| | Coef. | Std. Err | T | P> t | Coef. | Std. Err | T | P> t | Coef. | Std. Err | T | P> t |
| Gender | -0.810 | 0.296 | -2.74 | 0.006*** | -0.226 | 0.320 | -0.71 | 0.479 | -0.803 | 0.359 | -2.24 | 0.026** |
| Age | 0.036 | 0.032 | 1.11 | 0.266 | -0.031 | 0.030 | -1.04 | 0.297 | -0.043 | 0.029 | -1.49 | 0.137 |
| Family size | -0.021 | 0.007 | -3.24 | 0.001*** | -0.017 | 0.006 | -2.66 | 0.008*** | -0.018 | 0.007 | -2.56 | 0.011** |
| Education level | 0.149 | 0.060 | 2.49 | 0.013** | 0.075 | 0.054 | 1.38 | 0.168 | 0.019 | 0.056 | 0.34 | 0.735 |
| Marital status | 0.187 | 0.273 | 0.68 | 0.495 | -0.089 | 0.269 | -0.33 | 0.742 | -0.117 | 0.294 | -0.4 | 0.69 |
| Access to market center | 0.005 | 0.003 | 1.63 | 0.105 | 0.005 | 0.003 | 1.55 | 0.121 | -0.006 | 0.003 | -1.93 | 0.055* |
| Access to roads | -0.001 | 0.003 | -0.45 | 0.656 | 0.001 | 0.003 | 0.34 | 0.738 | 0.010 | 0.003 | 3.17 | 0.002*** |
| Extension contacts | 0.127 | 0.046 | 2.74 | 0.006*** | 0.176 | 0.050 | 3.5 | 0.001*** | -0.048 | 0.045 | -1.08 | 0.283 |
| Multipurpose cooperative | 0.287 | 0.181 | 1.59 | 0.113 | 0.186 | 0.173 | 1.07 | 0.283 | 0.524 | 0.191 | 2.75 | 0.006*** |
| Social impact | -0.968 | 0.251 | -3.86 | 0.000*** | -1.117 | 0.246 | -4.53 | 0.000*** | -0.913 | 0.341 | -2.68 | 0.008*** |
| Economic impact | 0.373 | 0.203 | 1.84 | 0.067* | 0.396 | 0.209 | 1.9 | 0.059* | 0.251 | 0.208 | 1.21 | 0.228 |
| Environmental impact | -0.403 | 0.224 | -1.8 | 0.073* | -0.507 | 0.255 | -1.99 | 0.048** | -0.563 | 0.287 | -1.96 | 0.045** |
| Forced participation | 0.048 | 0.037 | 1.29 | 0.199 | -0.019 | 0.033 | -0.58 | 0.563 | -0.022 | 0.037 | -0.58 | 0.562 |
| Farm size | 1.255 | 0.730 | 1.72 | 0.086* | 1.188 | 0.583 | 2.04 | 0.042** | 0.711 | 0.669 | 1.06 | 0.288 |
| Non-farm income | -0.047 | 0.492 | -0.09 | 0.925 | 1.171 | 0.535 | 2.19 | 0.029** | 1.687 | 0.543 | 3.11 | 0.002*** |
| Livestock | 4.049 | 0.838 | 4.83 | 0.00*** | 3.178 | 0.837 | 3.8 | 0.000*** | 2.388 | 0.913 | 2.61 | 0.009*** |
| Agro-ecology | -0.282 | 0.190 | -1.48 | 0.139 | -0.023 | 0.184 | -0.13 | 0.9 | 0.117 | 0.193 | 0.61 | 0.544 |
| _cons | -4.509 | 0.654 | -6.89 | 0.00*** | -4.177 | 0.644 | -6.49 | 0.000*** | -2.605 | 0.688 | -3.79 | 0.000*** |

Chapter Five

Appendix Table 5. 1: Parameter Estimates: Test on the validity of the selection instruments

| Crop net income by farm households that did not adopt SLMPs | | | | |
|---|-----------|---------------------|-------|----------|
| Independent variables | Coef. | Robust Std. Err. | t | P> t |
| Education level of farm household | 97.57 | 174.98 | 0.56 | 0.578 |
| family size | -31.94 | 344.24 | -0.09 | 0.926 |
| Age of farm household | 78.44 | 43.56 | 1.8 | 0.073* |
| Gender of farm household | -5134.56 | 1939.13 | -2.65 | 0.009*** |
| multipurpose cooperative | -2477.62 | 1233.28 | -2.01 | 0.045 |
| saving group | 171.57 | 1175.07 | 0.15 | 0.884 |
| Plot size | -11125.45 | 3189.64 | -3.49 | 0.001** |
| farm size | 19.81 | 1509.58 | 0.01 | 0.99 |
| Live stock holding | 233.25 | 337.79 | 0.69 | 0.49 |
| Access to credit | 729.29 | 1549.52 | 0.47 | 0.638 |
| dung cake income | -3094.81 | 1075.58 | -2.88 | 0.004*** |
| Non-farm income | -1090.37 | 2065.73 | -0.53 | 0.598 |
| Ln access to road | 1286.24 | 559.97 | 2.3 | 0.022** |
| Mundlak's fixed effects | | | | |
| Mean plot distance | 3.01 | 28.25 | 0.11 | 0.915 |
| Mean medium slope | -856.56 | 1271.81 | -0.67 | 0.501 |
| Mean steep slope | -2181.21 | 1662.00 | -1.31 | 0.19 |
| Mean high plot erosion | 2082.89 | 2072.07 | 1.01 | 0.316 |
| Mean medium plot erosion | 867.43 | 1201.10 | 0.72 | 0.471 |
| Mean medium plot fertility | 609.74 | 1361.87 | 0.45 | 0.655 |
| Mean high plot fertility | -583.67 | 1629.20 | -0.36 | 0.72 |
| Mean shallow soil depth | 151.60 | 1835.46 | 0.08 | 0.934 |
| Mean medium soil depth | 1977.15 | 1180.94 | 1.67 | 0.095* |
| Mean water logging | -1612.95 | 1335.69 | -1.21 | 0.228 |
| Mean pest and disease problem | 440.53 | 1289.22 | 0.34 | 0.733 |
| Mean tenure insecurity | 256.64 | 1340.28 | 0.19 | 0.848 |
| Mean type of crop | 8255.19 | 950.80 | 8.68 | 0.000*** |
| Mean improved seeds | -381.64 | 3577.49 | -0.11 | 0.915 |
| Mean legume | -104.89 | 1183.98 | -0.09 | 0.929 |
| Instrumental variables | | | | |
| Ln distance from market center | -383.88 | 670.35 | -0.57 | 0.567 |
| Frequency of extension contact | -368.58 | 282.94 | -1.3 | 0.194 |
| Ln distance from extension office | 240.88 | 619.33 | 0.39 | 0.698 |
| Training on SLMPs | 194.26 | 1259.74 | 0.15 | 0.878 |
| Radio program on SLMPs | 1498.69 | 1025.55 | 1.46 | 0.145 |
| Field visit | 1648.85 | 1413.18 | 1.17 | 0.244 |
| Dairy cooperative | 474.56 | 1352.58 | 0.35 | 0.726 |
| Self-help group | -100.54 | 1088.75 | -0.09 | 0.926 |
| Kinship networking | 1277.93 | 1031.07 | 1.24 | 0.216 |
| Participation in WMPs | -1323.49 | 1239.66 | -1.07 | 0.287 |
| Other | | | | |
| Weinadega | -19.30548 | 1069.83 | -0.02 | 0.986 |
| _cons | 1583.547 | 4513.88 | 0.35 | 0.726 |
| Wald test on instrumental variables (F (39, 293) = 5.29) | | 0.000*** | | |
| Adjusted R ² | 0.197 | | | |
| Sample size | 333 | | | |

Appendix Table 5. 2: Definition and Descriptive statics of Explanatory Variables by Combination of Sustainable land management Practices

| Variable | Description | Non-adoption | SWC only | Manure only | Inorganic fertilizer | SWC and manure | SWC and inorganic fertilizer | Manure and inorganic fertilizer | SWC, manure and inorganic fertilizer | All mean | St. Dev |
|-----------------------------|---|--------------|----------|-------------|----------------------|----------------|------------------------------|---------------------------------|--------------------------------------|----------|---------|
| 2. Household factors | | | | | | | | | | | |
| Gender | 1= if female | 0.11 | 0.11* | 0.06 | 0.07 | .08 | 0.05** | 0.14 | 0.07 | 0.09 | |
| Education level | Year of education a household head | 1.5 | 1.15** | 1.42 | 1.85** | 1.13* | 1.58 | 1.82 | 0.73*** | 2.13 | 2.9 |
| family size | family size | | 4.47*** | 5** | 4.89 | 4.86 | 4.89 | 4.89 | 4.65 | 4.75 | 1.67 |
| Age | age of the household head | 46.7 | 46.7 | 47.9 | 47.4 | 47.9 | 45.2** | 47.6 | 47.67 | 47 | 12.69 |
| Multipurpose cooperative | 1= if member in multipurpose cooperative | 0.69 | .68** | 0.79* | 0.72 | 0.8** | 0.71 | 0.75 | 0.92*** | 0.73 | 0.44 |
| Dairy cooperative | 1= if member in dairy cooperative | 0.20 | 0.21** | 0.2** | 0.42*** | 0.22* | 0.31 | 0.39** | 0.35* | 0.27 | |
| self-help group | 1= if household member involves in any self-help association | 0.36 | 0.44 | 0.46 | 0.48 | 0.41 | 0.48 | 0.57** | 0.52** | 0.44 | |
| Participation in WMPs | 1= if member in WD group | 0.74 | 0.79** | 0.79** | 0.6*** | 0.76 | 0.78* | 0.57*** | 0.76 | 0.73 | |
| Saving | 1= if involved in saving in <i>Equip</i> and/or saving and credit association | 0.2 | 0.23 | 0.27 | 0.18 | 0.38*** | 0.21 | 0.29 | 0.44*** | 0.25 | |
| Kinship network | Number of relatives that farm household has relay on during difficulty | 1.6 | 1.6*** | 1.74 | 1.81 | 1.93*** | 1.8* | 1.89* | 1.9*** | 1.74 | 0.81 |
| 3. Plot attributes | | | | | | | | | | | |
| Gentle slope | 1= if gentle slope plot | 0.48 | 26*** | 0.47* | .49*** | 0.32** | 0.35** | 0.52** | 0.35 | 0.41 | |
| moderate slope | 1= if moderate slope plot | 0.24 | 0.31 | 0.34 | 0.35* | 0.37* | 0.28 | 0.34 | 0.32 | 0.31 | |
| Steep slope | 1= if steep slope plot | 0.28 | 0.41*** | 0.19*** | 0.16*** | 0.31 | 0.37** | 0.14*** | 0.33 | 0.29 | |
| Poor soil | 1= if poor soil | 0.13 | 0.12 | 0.06*** | 0.12 | 0.1 | 0.15 | 0.02*** | 0.20 | 0.12 | |
| Medium plot fertility | 1= if medium fertile soil plot | 0.61 | 0.62 | 0.6 | 0.61 | 0.63 | 0.62 | 0.59 | 0.61 | 0.61 | |
| High plot fertility | 1= if high fertile soil plot | 0.26 | 0.25 | 0.34** | 0.27 | 0.27 | 0.23 | 0.39** | 0.19** | 0.27 | |
| Low plot erosion | 1=if low plot erosion | 0.58 | 0.38*** | 0.63*** | 0.58** | 0.44** | 0.43** | 0.69*** | 0.43* | .51 | |
| medium plot erosion | 1=if medium plot erosion | 0.29 | 0.37 | 0.29 | 0.35 | 0.44*** | 0.32 | 0.23** | .29 | 0.33 | |
| high plot erosion | 1=if high plot erosion | 0.13 | 0.25** | 0.08*** | 0.07** | 0.13 | 0.25*** | 0.07*** | 0.27*** | 0.16 | |
| Shallow soil | 1= if shallow soil depth | 0.13 | 0.22** | 0.08*** | 0.15 | 0.04 | 0.08** | .017*** | 0.21 | 0.16 | |
| medium soil | 1= if medium soil depth | 0.53 | 0.55 | 0.52 | 0.53 | 0.56 | 0.5 | 0.55 | 0.56 | 0.54 | |
| Deep soil | 1= if medium soil depth | 0.34 | 0.23*** | 0.39** | 0.31 | 0.24** | 0.27 | 0.43** | 0.23* | 0.30 | |
| Improved seed | 1= if planted improved seeds | 0.01 | 0.02*** | 0.03 | 0.06 | 0.01*** | 0.09*** | .11** | 0.1** | 0.04 | |
| Legume | 1= If precursor crop was a legume | 0.36 | 0.42 | 0.47 | 0.44 | 0.46 | 0.56*** | 0.59** | 0.52* | 0.45 | |
| Crop type | 1= if the grown crop is legume | 0.31 | 0.31** | 0.42 | 0.56** | 0.42* | 0.33 | 0.45 | 0.34 | 0.36 | |

4. Risk factors

| Variable | Description | Non- adoption | SWC only | Manure only | Inorganic fertilizer | SWC and manure | SWC and inorganic fertilizer | Manure and inorganic fertilizer | SWC, manure and inorganic fertilizer | All mean | St. Dev |
|--------------------------------|---|------------------|-------------|----------------|-------------------------|-------------------|------------------------------------|--|---|-------------|------------|
| Plot Distance | Distance of plot from homesteads (walking minutes) | 23.1 | 23.5** | 13.3*** | 19.7 | 16.5*** | 25.1*** | 16.23* | 17.1* | 20.7 | 20.81 |
| Water logging | 1=if waterlogged plot | 0.18 | 0.09*** | 0.14 | 0.17* | 0.15*** | 0.13 | 0.2 | 0.1* | 0.14 | |
| Plot size | Plot size, ha | 0.27 | 0.27*** | 0.26** | .32** | 0.32** | 0.33*** | .339** | .384*** | 0.3 | 0.17 |
| Disease and pest problem | 1= if disease and pest incidence | 0.14 | 0.17*** | 0.11 | 0.07*** | 0.12 | 0.06*** | 0.41*** | 0.06*** | 0.11 | |
| Tenure security | 1= if shared/rented plot | 0.18 | 0.14 | 0.04*** | 0.4** | 0.14 | 0.04*** | 0.089 | 0.06** | 0.12 | |
| 5. Enabling conditions | | | | | | | | | | | |
| 5.1 markets services | | | | | | | | | | | |
| Access to road | Walking distance to a car road (minute) | 40.0 | 52.5*** | 55.5*** | 29.5*** | 66.1*** | 36.8*** | 25.19*** | 36.05** | 43.42 | 41.16 |
| Access to market | Walking distance to main market center (minute) | 63.4 | 65.4 | 76.7*** | 68.6 | 74.0** | 61.5** | 57.71* | 58.1** | 66.0 | 41.6 |
| 5.2 Access to information | | | | | | | | | | | |
| Frequency of extension contact | Frequency of extension contact on SLMPs (day/year) | 1.64 | 1.88 | 1.61*** | 2.22** | 2.22* | 2.32*** | 2.18 | 2.44*** | 1.98 | 1.79 |
| Radio program | 1= if radio information on SLMPs | 0.41 | 0.50 | 0.52 | 0.42** | 0.59*** | 0.54** | 0.42 | 0.56* | 0.48 | |
| Field visit | 1= if a field visit about SLMPs | 0.14 | 0.13*** | 0.18 | 0.16 | 0.19 | 0.24** | 0.23 | 0.32*** | 0.18 | |
| Extension office distance | Household residence distance to extension office | 48.2 | 55.5** | 62.4*** | 39*** | 67.9*** | 45.6 | 36.34*** | 38.47*** | 50 | |
| SMPs training | 1= if participate in SLMPs training in the last three years | 0.81 | 0.83*** | 0.65 | 0.83*** | 0.64** | 0.83*** | 0.86*** | 0.77** | 0.70 | |
| 6. Resource factors | | | | | | | | | | | |
| Farm size | Total cultivated farm size (ha) | 1.9 | 1.18 | 1.12*** | 1.32*** | 1.23 | 1.23 | 1.32** | 1.21 | 1.22 | 0.48 |
| Livestock | livestock owned by farm household (TLU) | 4.91 | 4.66*** | 6.0** | 6.22*** | 6.24*** | 5.41 | 6.03* | 5.74 | 5.46 | 2.95 |
| Dung cake income | 1= if sale dung cake | 0.18 | 0.15** | 0.20 | 0.38*** | 0.16** | 0.19 | 0.3* | 0.26 | 0.22 | |
| non-farm income | 1= if involved in non-farm activities | 0.1 | 0.12* | 0.03*** | 0.05** | 0.1 | 0.08 | 0.11 | 0.06 | 0.09 | |
| Credit | 1= if a household use credit | 0.15 | 0.18 | 0.09*** | 0.23** | 0.1*** | 0.26*** | 0.18 | 0.21 | 0.17 | |
| 7. Others factors | | | | | | | | | | | |
| mid highland | 1=mid highland (Weinadega) | 0.47 | 0.44 | 0.34 | 0.51 | 0.25*** | 0.66*** | 0.64*** | 0.57** | 0.47 | |
| upper highland | 1=upper highland (Dega) | 0.53 | 0.56 | 0.66*** | .49 | 0.75*** | 0.34*** | 0.32*** | 0.42** | 0.53 | |

Note: A test used to compare the means of explanatory variables between each combination of SLMPs (adopters) and non-adopters through the assumption of unequal variance. St. Dev is standard deviation. *, ** and ***, represents a significance level at 10%,5% and 1%, respectively.

Appendix Table 5. 3: Ordinary Least Squares Estimates of crop net income Equations on Pooled Sample (per hectare)

| Variables | Coef. | Std. Err. | t | P> t |
|--|----------|-----------|-------|----------|
| Soil and water conservation alone | 1502.99 | 683.62 | 2.2 | 0.028** |
| Manure alone | 2249.93 | 849.06 | 2.65 | 0.008*** |
| Inorganic fertilizer alone | 2811.26 | 722.17 | 3.89 | 0.000*** |
| Soil and water conservation and manure | 2891.89 | 837.64 | 3.45 | 0.001*** |
| Soil and water conservation and inorganic fertilizer | 3235.06 | 786.79 | 4.11 | 0.000*** |
| Manure and inorganic fertilizer | 5037.53 | 1149.90 | 4.38 | 0.000*** |
| Soil and water conservation, manure and inorganic fertilizer | 5552.34 | 1000.01 | 5.55 | 0.000*** |
| Education level of farm household | 158.26 | 80.76 | 1.96 | 0.05** |
| family size | 361.32 | 155.40 | 2.33 | 0.02** |
| Age of farm household | 4.15 | 18.27 | 0.23 | 0.82 |
| Gender of farm household | -1454.77 | 815.13 | -1.78 | 0.075* |
| multipurpose cooperative | -169.93 | 530.78 | -0.32 | 0.749 |
| saving group | 233.18 | 556.46 | 0.42 | 0.675 |
| Plot size | -3644.88 | 1418.66 | -2.57 | 0.01** |
| farm size | -551.76 | 550.03 | -1 | 0.316 |
| Live stock holding | 165.11 | 98.67 | 1.67 | 0.095* |
| Access to credit | 418.64 | 594.08 | 0.7 | 0.481 |
| dung cake income | -2808.47 | 606.49 | -4.63 | 0.000*** |
| Non-farm income | 552.36 | 793.18 | 0.7 | 0.486 |
| Ln access to road | 869.18 | 194.07 | 4.48 | 0.000*** |
| Mean plot distance | -4.88 | 10.82 | -0.45 | 0.652 |
| Mean medium slope | -19.47 | 587.83 | -0.03 | 0.974 |
| Mean steep slope | -716.81 | 752.61 | -0.95 | 0.341 |
| Mean high plot erosion | -686.53 | 854.72 | -0.8 | 0.422 |
| Mean medium plot erosion | -472.75 | 567.78 | -0.83 | 0.405 |
| Mean medium plot fertility | 706.20 | 739.23 | 0.96 | 0.34 |
| Mean high plot fertility | 1479.06 | 852.94 | 1.73 | 0.083 |
| Mean shallow soil depth | 290.24 | 783.91 | 0.37 | 0.711 |
| Mean medium soil depth | 1742.26 | 569.14 | 3.06 | 0.002*** |
| Mean water logging | -1492.79 | 684.91 | -2.18 | 0.029** |
| Mean pest and disease problem | -64.88 | 694.58 | -0.09 | 0.926 |
| Mean tenure security | -1390.06 | 725.71 | -1.92 | 0.056* |
| Mean type of crop | 9232.76 | 478.02 | 19.31 | 0.000*** |
| Mean improved seed | 233.00 | 1174.45 | 0.2 | 0.843 |
| Mean legume | -964.98 | 484.94 | -1.99 | 0.047** |
| Weinadega | 33.36 | 535.10 | 0.06 | 0.95 |
| _cons | -1971.46 | 1964.62 | -1 | 0.316 |
| F (36, 1268) | 15.94 | 0.000*** | | |
| Sample size | 1305 | | | |
| Adjusted R ² | 0.292 | | | |

Appendix Table 5. 4: Parameter estimates of crop net income by multinomial endogenous switching regression model

| Variables | Soil and water conservation | | Manure | | Inorganic fertilizer | | SWC and manure | | SWC and inorganic fertilizer | | Manure and inorganic fertilizer | | SWC, Manure and inorganic fertilizer | |
|--------------------------|-----------------------------|--------|--------|----------|----------------------|---------|----------------|---------|------------------------------|---------|---------------------------------|--------|--------------------------------------|---------|
| | Coef. | SE. | Coef. | SE | Coef. | SE | Coef. | SE | Coef. | SE | Coef. | SE | Coef. | SE |
| Education level | -52.5 | 790.3 | 690 | 10375.6 | -14.4 | 445.4 | -460.6 | 2578.1 | -97.3 | 0.66 | 224.2 | 1515.7 | 1819.9 | 3517.4 |
| Family size | -937.4 | 1310.6 | 1269.5 | 18100 | 369.1 | 1007.5 | -1126.5 | 4035.5 | 725.9 | 2688.7 | -265.9 | 2778.2 | 2400.0 | 5262.6 |
| AGE | 44.4 | 133.8 | -12.3 | 2117 | 70.2 | 139.1 | 85.1 | 407.9 | 26.4 | 1367.6 | 80.8 | 349.8 | -129.5 | 514.3 |
| Gender | 3101.7 | 5879.4 | -8345 | 111848.8 | -8836.1 | 6501.5 | 2645.6 | 18673.8 | 3055.8 | 18861.9 | -11523** | 5300.9 | 17291.0 | 18168.6 |
| Multipurpose cooperative | 3004.2 | 4405.3 | 3363.8 | 70745.8 | -369.7 | 3828.7 | -4483.6 | 20634.3 | -892.9 | 42118.2 | 6782 | 5302.1 | -11578.4 | 16316.5 |
| Saving group | -1598.4 | 5911.1 | -11213 | 153404.5 | -2879.2 | 5596.7 | 3465.3 | 16945.3 | -1675.4 | 12520.8 | -494.7 | 5777.6 | -54240*** | 15935.9 |
| Plot size | -14558 | 17748 | -4016 | 220562.9 | -1591.9 | 10290.9 | -10084.7 | 37398.5 | 313.2 | 54236.8 | 0 | 1781.9 | -38797.4* | 23566.8 |
| Farm size | 3516.5 | 4617.1 | -10019 | 86480.7 | 408.4 | 3938.4 | 2850.4 | 13804.9 | -888.1 | 41336.5 | -1271.1 | 6024.9 | -3986.7 | 17080.2 |
| Livestock | 156.1 | 1023.4 | 510.8 | 19681.3 | -299.4 | 643.5 | -375 | 1764.9 | -618.9 | 9603.4 | 351.01 | 1845.4 | -3419.7 | 4260.2 |
| Credit | -1934.6 | 4936.5 | 9520.6 | 114676.9 | 3654.6 | 3495.7 | -5959.4 | 25656.5 | 1561.3 | 59344 | -3208.8 | 5866.3 | 6690.4 | 16059.3 |
| Dung cake income | -6930.1 | 6909 | -451.3 | 60526 | 684.0 | 4044.0 | -4557.1 | 26990.1 | 5655.9 | 42891.9 | -2181 | 5131.5 | 18736.2 | 22665.0 |
| non-farm income | 4268.6 | 6045.9 | 16579 | 138264.6 | 3580.0 | 7857.7 | 38.7 | 23691.6 | -711.4 | 44139.4 | 0 | 3064.6 | 21346.5 | 16709.0 |
| Ln access to road | 850 | 1715 | 332.2 | 22524.4 | 201.0 | 1360.9 | 5111.4 | 7879.2 | -2008.7 | 17236.2 | -2037.2 | 3529.7 | -7030.3 | 9207.9 |
| Mean plot distance | -13.7 | 74.5 | 65.9 | 4050.9 | 68.6 | 103.5 | -184.3 | 274.9 | 10 | 361.8 | -218. | 290.8 | 542.4 | 429.3 |
| Mean medium slope | 1148.2 | 4445.1 | 3650.5 | 117225.5 | -2021.6 | 3665.5 | -841 | 12715.5 | 1407.3 | 21891.4 | -10567.1* | 6239.9 | 5461.6 | 16389.3 |
| Mean steep slope | -1389.6 | 5837.8 | 18301 | 195085.5 | -5002.2 | 6615.8 | -3787.7 | 16462.1 | 1696.6 | 17128.3 | -13033*** | 2369.6 | 21209.6 | 21670.5 |
| Mean high erosion | 3641.7 | 6832.3 | -15100 | 136688.8 | 4103.3 | 9618.8 | -6.1 | 26006.4 | -5341 | 57565.4 | 0 | 3627.8 | -31759.0 | 20973.5 |
| Mean medium erosion | 889.5 | 4220.5 | - | 142090.1 | 1902.2 | 4310.7 | -2937.2 | 14913.2 | -1565.4 | 83372.8 | 3548.3 | 6525.8 | -27547.6 | 19202.4 |
| Mean medium fertility | 1875.6 | 6259.6 | - | 120740.3 | 1123.8 | 5511.8 | 606.5 | 24810.2 | -2769.1 | 27946.5 | 1625.7 | 3715.6 | -10393.1 | 14569.7 |
| Mean high fertility | 4891.5 | 7033.4 | 1558.8 | 140455.4 | 3866.7 | 6030.4 | 2619 | 24660.1 | -954 | 12310.6 | 0 | 3923.8 | 6837.4 | 21529.8 |
| Mean shallow soil | -796.4 | 18336 | - | 142359.3 | 4566.6 | 4044.7 | 8417.6 | 14487.1 | -4396.8 | 17432 | 0 | | -16783.3 | 14948.7 |
| Mean medium soil | 3251.3 | 6101.4 | - | 52816.2 | 4187.6 | 3571.8 | 8117 | 14276.7 | 1648.9 | 12131.5 | 938.8 | 5868.0 | -8405.5 | 16729.5 |
| Mean water logging | -1934.1 | 7857.9 | 10329 | 115993.9 | -3082.5 | 4540.1 | -10750.1 | 27983.1 | 1546.1 | 32487.2 | -14885** | 5835.9 | 0.0 | 17031.2 |
| Mean pest problem | 1209.2 | 8629.9 | 7140 | 54862.5 | -7382 | 6499.9 | 9295.6 | 13084.4 | -6227.2 | 145258 | 0 | 3337.6 | 5939.6 | 15533.0 |
| Mean tenure security | 236.2 | 6719.7 | - | 210681.7 | 280 | 4188.7 | -4519.3 | 26827.3 | 2878.7 | 74784 | -9640.4* | 5528.2 | 6999.3 | 21546.6 |
| Mean type of crop | 9856*** | 3844.3 | 8494 | 55658 | 8945** | 3606.2 | 9395.6 | 10466 | 6495.1 | 52575.8 | 0 | 7652.1 | -12629.4 | 16660.6 |
| Mean improved seed | -3445.4 | 8474.4 | -322.4 | 252195.7 | 48 | 6058.2 | -15537.7 | 25687.7 | -3697.1 | 21699.7 | 0 | 3058.2 | -2405.5 | 17318.5 |
| Mean legume | -861.4 | 4595.3 | -10413 | 155532.2 | -5056 | 4331.7 | 2828 | 13010.7 | -1767.8 | 17388.8 | 0 | 5816.0 | -14782.5 | 13784.1 |
| Weinadega | 1262.2 | 6775.3 | 951.1 | 96073.3 | 4252.2 | 4152.6 | -1545.8 | 25609.4 | 8899.1 | 30931.8 | 0 | 5481.6 | 42308.9** | 18879.7 |
| _m1 | 1953.3 | 27832 | 29779 | 526211.2 | 22893 | 17803.0 | -22213 | 67285.6 | 41611.1 | 171799 | 0 | | 209179.1*** | 7680.7 |
| _m2 | 6176.1 | 9920.8 | - | 358139.2 | 24695 | 30682.5 | 54102.3 | 56947.9 | 2795.8 | 106916 | 0 | | 26777.51* | 16733.5 |
| _m3 | -5884.4 | 32609 | 2149.3 | 217196.3 | - | 39318.7 | 28871.5 | 70772 | -12900 | 126999 | 0 | | 10442.27 | 0.0 |
| _m4 | 736.2 | 34405 | 5538.5 | 377111.6 | 5733.7 | 8271.2 | 23990.4 | 131730 | 18563.9 | 239862 | 0 | 1635.5 | 10208.16 | 0.0 |

| Variables | Soil and water conservation | | Manure | | Inorganic fertilizer | | SWC and manure | | SWC and inorganic fertilizer | | Manure and inorganic fertilizer | | SWC, Manure and inorganic fertilizer | | |
|------------------------------|-----------------------------|-------|---------------------|----------|----------------------|---------|----------------------|----------|------------------------------|---------|---------------------------------|---------|--------------------------------------|-------------|---------|
| | Coef. | SE. | Coef. | SE | Coef. | SE | Coef. | SE | Coef. | SE | Coef. | SE | Coef. | SE | |
| _m5 | -8758 | 30963 | -14413 | 190497.5 | 13597.2 | 35669.0 | 3121.1 | 29609.8 | -19877 | 96845.1 | 0 | | -13625.5 | 10386.0 | |
| _m6 | -10293 | 37952 | - | 557152.2 | 7978.5 | 18933.9 | -29676.9 | 143538 | 4727.9 | 31357.9 | 0 | 1018.1 | 154234.9*** | 11660.2 | |
| _m7 | 18274.5 | 65932 | 3941.4 | 6261 | 440507 | 12965.2 | 24728 | -23870.3 | 183303 | 23952 | 127355 | 7937.8 | 6618.5 | 176908.8*** | 15940.6 |
| _m8 | 10046 | 42482 | 8726 | 295348.7 | 3493 | 36103 | 18554.2 | 79641.9 | 24431 | 241236 | 0 | | 10427 | 16785 | |
| _cons | -16877.5 | 30044 | 20850 | 383704.4 | 8891 | 15104 | -3815.9 | 83326.3 | 21352 | 86044 | 24723.9 | 26249.6 | 188071.4*** | 66358.6 | |
| Significance of mean of plot | F (15, 208) 4.64*** | | F (15,103) =5.34*** | | F (15, 181) =9.45*** | | F (15, 121) =3.35*** | | F (15, 139) 4.55*** | | F (14, 41) = 4.65*** | | F (15, 68) = 3.22*** | | |

Note: _mj (j=1...8) refers to the correction term. SE is bootstrapped standard errors. Sample size = 1305 plots. * Significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

