Determinants of Adoption of Sustainable Land Management (SLM) Practices among Smallholder Farmers' in Jeldu District, West Shewa Zone, Oromia Region, Ethiopia

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Abstract
Land degradation in form of soil erosion and fertility loss are ruthless problems in developing countries including Ethiopian Highlands, which have serious implications for food security and livelihoods of local farmers in particular and the nation in general. Low land productivity due to land degradation in form of soil erosion is one of the leading challenges to improving the performance of the smallholder farming system sector in Ethiopia. In this context, the adoption of Sustainable Land Management practices/ technologies is quite crucial to increase agricultural productivity, ensure food security and improve the livelihoods of smallholder farmers. Farmers recommend various SLM practices/technologies for sustainable implementation, but adoption of such agricultural land management practices/ technologies is still very low. There is no clear understanding of the problems encountered by farmers in the adoption of recommended SLM practices/ technologies. Therefore, the main purpose of this study was to assess the socio-economic, institutional, psychological and biophysical determinant factors that influence adoption of SLM practices/technologies among smallholder farmers in Jeldu district in West Shewa zone. Primary data were collected through household questionnaires surveys, focus group discussions, key informants interviews and personal observations while secondary data were collected from relevant local authority reports and records. A total of 224 households were interviewed. Both Descriptive statistics, binary logistic regression model were used to analyze the data. The computed independent T-test for the mean income difference was statistically highly significance between adopters and non-adopters, suggesting that adopters were in better-off position to improve their livelihood.. From the 18 explanatory variables entered into the model, 14 variables were found to be statistically significant at less than 5 to 10% probability levels. These are education level of the household head, farm size, perception of land degradation ,effectiveness of SLM practices, frequency of development agent contact and livestock ownership significantly positively affect adoption o land management practices while distance to market affects it negatively at less 10% probability levels. Planners and policy makers should formulate appropriate policies and programs considering the farmers' interest, capacity, and limitation in promoting improved soil conservation technology for greater acceptance and adoption by the farmer.
Keywords: Sustainable Land Management Practices, Adoption, Smallholder Farmers'.

INTRODUCTION

Background and Justification of the study

To feed the world's growing population which is projected to exceed 9.2 billion by 2050 (World Bank, 2009; FAO, 2013; Nkonya *et al*, 2011.), it will be necessary to boost the production of food. However, land degradation is extensively increasing, covering approximately 23% of the globe's terrestrial area, increasing at an annual rate of 5-10 million hectares, and affecting about 1.5 billion people globally (Gnacadja, 2012). Processes of land degradation occur in all climatic regions, with 'land' interpreted to include soils, vegetation, and water, and with the concept of 'degradation' implying adverse consequences for humanity and ecological systems (Conacher, 2009; Vlek *et al*., 2010; Braun *et al*., 2012; Pingali *et al*., 2014). Land consists of not only the soil but also the associated natural resources such as water, vegetation, landscape, and microclimate that are components of a larger ecosystem(Thompson *et al.,* 2009; Chasek *et al.,* 2011; Akhtar-Schuster *et al.,* 2011; Reed *et al.,* 2011).As the land is inter-connected with other natural resources such as the air, water, fauna and flora, managing land well, in addition to guaranteeing food supplies, poverty reduction and socio-economic protect environment and natural resources and to provide ecological functions and services in a sustainable manner(World Bank, 2003; Bridges and Oldeman, 1999; Berry *et al*., 2003; Jones *et al*., 2003; Stringer and Reed, 2007; Bai *et al*. 2008; Stoosnijder, 2007; Nachtergaele *et al*. 2010; Lal and Stewart, 2013; Zucca*et al.,* 2014).Land degradation often results from immediate causes such as biophysical causes and unsustainable resource management practices, or with underlying causes including population density, poverty, institutional set up, land tenure and access to agriculture extension, infrastructure, opportunities and constraints created by market access as well as policies and general government effectiveness (Nkonya*et al*., 2011; Lambin*et al*., 2001).

Ethiopia's economy has its foundation in the smallholder agriculture. Land degradation is a major cause of Ethiopia's low and declining agricultural productivity, continuing food insecurity, and abject rural poverty (Pender and Hazell, 2000; IFAD, 2001; Shiferaw and Bantilan, 2004; (FAO, 2012).The productivity of agricultural economy, which is the backbone of the country's economy, is being seriously eroded by unsustainable land management practices both in areas of food crops and in grazing lands **(**Leonard, 2003; Shiferaw and Holden 1998)**.** At present extent and speed of land degradation, particularly due to soil erosion is distinguished as a serious threat to the viability of the subsistence agriculture in the country (Lakew*et al*., 2000; Le *et al*., 2014)). Its severity is explained by a decline in productivity, formation of rills and gullies in both farming and grazing lands through time (Stringer and Reed, 2007; Bai *et al*., 2008; Nachtergaele*et al*., 2010; Lal and Stewart, 2013; Zucca*et al.,* 2014).Although the country endowed with enormous biophysical potential, it has been affected by the interlinked and reinforcing problems of land degradation and extreme poverty (Teshome*et al*., 2014). This is further aggravated by high population pressure, climatic variability, top-down planning systems, lack of appropriate and/or poor implementation of polices and strategies, limited use of sustainable land management practices, limited capacity of planners, land users as well as frequent organizational restructuring (Tesfaye et al. 2013; Kassie *et al*., 2009; Tiwari *et al*., 2008; Bewket, 2007; Shiferaw and Holden 1998). There is evidence that these problems are getting worse in many parts of the country, particularly in the highlands (areas >1500m above sea level). Furthermore, climate change anticipated to accelerate land degradation in Ethiopia (Pender and Gebremedhin, 2007).

Recognizing the threat of land degradation, the government of Ethiopia has made several Natural Resource Management (NRM) interventions through various programmes such as productive safety net programme (PSFP),Food for Work programme and MERET and MERET PLUS Programme since mid-1970s and 80s (Aklilu, 2006;Shiferaw and Holden, 1998). As a result a range of land conservation practices, which include stone terraces, stone bunds, area closures, and other soil and water conservation technologies and practices have been introduced into individual and communal lands at massive scales. In 2008, Ethiopia launched Sustainable Land Management Programme (SLMP) in 36 woreda defined as the process of enhancing agricultural yields with minimal environmental impact and without expanding the existing agricultural land base (Tesfaye et al. 2013; Kassie et al. 2009; Tiwari *et al*., 2008; Bewket, 2007**)**.The concept and definition of sustainability is broad and varies depending on the problems to be addressed. There is a need to give a clear working definition of sustainability in the context of our problem. WOCAT (2005), define Sustainable Land Management in more specific term as the use of both indigenous and introduced land management practices and technologies for agricultural and other purposes to meet human livelihood needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions. In this regard, SLM is not only the use of physical SWC measures, which is a common mistake made by almost all actors in the country, but also includes the use of appropriate soil fertility management practices, agricultural water and rain water management, forestry and agroforestry, forage and range land management, and application of these measures in a more integrated way to satisfy community needs while solving ecological problems (Bridges and Oldeman, 1999; Berry *et al*., 2003; Jones *et al*., 2003; Stringer and Reed, 2007; Bai *et al*., 2008; Stoosnijder, 2007; Lal & Stewart, 2013; Zucca*et al.,* 2014; Gete*et al*., 2006). SLM is a combination of technologies, policies and activities integrating socio-economic and environmental concerns in order to reach simultaneously environmentally friendly, economic viable and socially acceptable production goals (Smyth and Dumanski, 1993; Hurni, 2000).

The downward spiral of land degradation and poverty cannot be reversed in a sustained fashion unless farmers adopt profitable and sustainable land management practices or pursue livelihood strategies that are less demanding of the land resource than current agricultural strategies (Berry *et al*., 2003; Jones *et al*., 2003; Stringer and Reed, 2007; Bai *et al*. 2008; Stoosnijder, 2007; Nachtergaele*et al*., 2010; Lal and Stewart, 2013; Zucca*et al.,* 2014). Adoption of sustainable land management (SLM) practices plays a critical role in achieving food security, household income and poverty reduction through reducing soil erosionand improving soil fertility. However, studies reveals that farmers adoption of SLM practices/ technologies at lower rate and more often they dis-adopt them (Aklilu and de Graaff, 2007 (Thompson *et al.,* 2009; Chasek*et al.,* 2011; Akhtar-Schuster *et al.,* 2011; Reed *et al.,* 2011; ELD Initiative, 2013). In most places, implemented SWCStructure was either totally or partially destroyed by farmers (Tesfaye *et al*. 2013; Kassie *et al*. 2009 and Tiwari *et al*., 2008 and Bewket, 2007). For instance, of the total conservation measures implemented between 1976 and 1990, only 30% of soil bunds, 25% of stone bunds, 60% of hillside terraces, 22% of the planted trees, and 7% of the reserve areas survived (TGE, 1994; Nurhussen, 1995). A recent survey in the Amhara region also showed that only 30% of the implemented soil and water conservation structures of the past two and half decades of conservation, work has survived (EPLUA, 2005). The above two survey results, however, should be seen in time context. Better land and water management and increased use of soil conservation practices could help to reverse soil degradation and boost crop yields, but in many parts of the country, these practices are not yet widely adopted. The adoption and investment in sustainable land management is crucial in reversing and controlling land degradation, rehabilitating degraded lands and ensuring the optimal use of land resources for the benefit of present and future generations (Akhtar-Schuster *et al*., 2011).

Despite on-going land degradation and the urgent need for action to prevent and reverse land degradation, the problem has yet to be appropriately addressed, especially in the developing countries, including in Eastern Africa. Identifying the determinants of SLM adoption is a step towards addressing them (Braun, *et al*., 2012). There is an urgent need for evidence-based economic evaluations, using more data and robust economic tools, to identify the determinants of adoption as well as economic returns from SLM (Tesfaye *et al*. 2013; Kassie *et al*. 2009; Tiwari *et al*.2008; Bewket, 2007). One size- fits-all approaches will not solve land management problems in the heterogeneous environment of the Ethiopian highlands (Brown *et al*., 2006; Fensholt and Proud, 2012; Beck *et al*., 2011).The growing consensus appears to be that many past soil conservation programs were disappointing for a number of reasons: they used a flawed "environmental narrative" to promote large-scale, top-down interventions; gave inadequate consideration to farmers' perspectives, constraints, and local conditions; provided limited options to farmers; and in some contexts promoted options of very limited profitability (Shiferaw and Holden, 1999; Keeley and Scoones, 2000; Dejene 2003; Rahmato, 2003; Bekele, 2004).Implementation of SLM should be seen within the specific local context.

Given this state of conditions, analysis of the issue of what specifically determines the decision taken by farmers to adopt SLM practices/technologies is very important and relevant to formulate policy options and support systems that could accelerate use of soil conservation technologies (Stoosnijder, 2007; Lal &Stewart, 2013; Zucca *et al.,* 2014). To ensure sustainable adoption and implementation of SLM practices and beneficial impacts on productivity and other outcomes, rigorous empirical research needed on where particular SLM interventions are likely to be successful(Brown *et al*., 2006; Fensholt and Proud, 2012; Beck *et al*., 2011). For a better understanding of the barriers faced by households when deciding to adopt SLM practices more detail context specific household-level studies focusing on the barriers of SLM practices adoption by farmers needed (Carthy, 2011; Tesfaye*et al*. 2013; Kassie et al. 2009; Tiwari et al.2008; Bewket 2007; Shiferaw and Holden 1998). An available evidence shows that studies on the determinants of adoption of SLM practices among smallholder farmers are few and far below adequacy. Therefore, this study conducted in view of bridging this gap. It intends to add to the stock of knowledge on the factors that determine farmers' decision to implement certain sustainable land management practices. The general objective of this study was to assess the determinant of adoption of SLM practices/technologies among smallholder farmers' in Jeldu district in West Shewa zone of Oromia regional state, Ethiopia. So, this study is significant in that the identification of context based determinant factors of adopting sustainable land management practices will inform decision makers to design context-specific socio-economic, biophysical ,institutional and demographic context based SLM technologies/ practices and avoids " one size fits to all" problem of the previous top down approaches. Such knowledge is important to guide policy makers and development agencies in crafting programs and policies that can better and more effectively address land degradation in Ethiopia.

2. Theoretical Framework of the Study

There are many perspectives involved in understanding farmers' views as to how and why they make decisions on whether or not to adopt the improved technology for soil conservation. There are many complexities and regional variations in biophysical and socio-cultural factors so that conclusions drawn based on the condition of one area cannot necessarily be replicated in another area (ICIMOD, 1995; Thompson and Warburton, 1985). Adoption of agricultural technologies is affected by various factors, usually categorized into; farm specific characteristics, technology specific attributes, and farmer's socioeconomic characteristics. Examples of such variables that have been found to influence technology adoption include: farm size, farmer's age, education, social networks (e.g. membership of association), dependency ratio, gender, access to agricultural advice and information, land tenure security, soil fertility, soil type, income, input availability, access to markets, risk aversion behavior, technology awareness, farming experience, adequacy of farm tools, technical and economic feasibility of using the technology, agro-ecological conditions, access to credit and presence of enabling policies(Feder et al., 1985; Boyd and Turton, 2000; Olwande*et al*., 2009). Some of these factors increase adoption; others reduce adoption; while others have mixed effects,

Adoption of conservation technology should not be regarded as an end in itself, but rather as a continuous decision-making process. Individuals pass through various learning and experimenting stages from awareness of the problem and its potential solutions and finally deciding whether to adopt or reject the given technology. Adoption of new technology normally passes through four different stages, which include awareness, interest, evaluation, and finally adoption (Rogers and Shoemaker 1971). At each stage, there are various constraints (social, economic, physical, or logistical) for different groups of farmers. In Ethiopia, the adoption of improved soil conservation technology has been very low at farm level and it is apparent that there is gaps between what technicians see as necessary and what the farmers are prepared to do in the field (Paudel and Thapa 2001). Adoption behavior is complex and often requires a blend of income, profit, and institutional support (Ervin and Ervin 1982; Feder and Umali, 1993)

Farmers' adoption of SLM Practices is determined by interactive effects of household socio economic characteristics, resource availability, physical characteristics of the land and institutional support provided by the public or NGO sector (Garcia 2001; Mbaga-Semgalawe and Folmer, 2000; Paudel and Thapa, 2004). It is important to understand the relationship between these factors and the process of adoption of new technology to improve farm production and sustainable land management. It is assumed that the farmers will compare the advantages and appropriateness of different soil conservation technologies, based on the available resources at their disposal and their opportunity for profit. Therefore, the conceptual framework of the adoption of SLM practices in this article is based on the principal of absolute and comparative advantage to farmers in combination with some influence of the personal, socio-economical, institutional, and biophysical factors. The empirical binary logistic regression model used in this study explains the factors that influence the decision of farmers to adopt or not adopt improved soil conservation technologies.

3. Methodology of the Study

3.1. Description of the Study Area

The study was conducted at Jeldu district, West Shewa zone, Central Ethiopia, which is delineated by Meta Robi, Dendi and Ejere*Woredas* in East, Gindeberet *Woreda* in West, Abuna Gindeberet *Woreda* in North and Eliphata *Woreda* in South. The area has a bi-modal rainfall pattern with two distinct rainy and cropping seasons. The main rainy season (*meher*), which is also the main cropping season, extends from June to September. The short rainy season, known as "*belg* rain", usually covers the period from February to April. The mean annual rainfall of the area ranges from1800 to 2200 mm. The maximum and minimum temperature of the area ranges from 17 to 22ºC. The farming system of the area is mainly rain-fed. The soil type is characteristic of clay and clay-loam type, but the riverbed has a loam and sandy-loam type of soil (Dereje, 2010). *Eucalyptus globules* are the main tree planted in the area. It has an area of 139, 389 hectares. Undulating slopes divided by V-shaped valleys of seasonal and/or relatively permanent streams characterize the topography of the study area. Steep slopes are found along the valley sides, where slopes greater than30% is very common. The district is characterized as a mixed crop livestock production system. Land preparation mainly done by ox-drawn plough. The main crops grown in the study areas include wheat (*Triticumaestivum*), teff (*Eragrostistef*), broad bean (*Viciafaba*), barley (*Hordeum vulgare*) and potato (*Solanum tuberosum*).Soil erosion in the area is mainly attributed to the steep slopes, population pressure, deforestation, poor farming methods and vulnerable soils. However, the major factor fuelling soil erosion on the steep slopes is that farmers are increasingly destroying contour bunds on terraces to pave way for more farmland. As a result, soil erosion has been accelerated which in periods of heavy rainfall results in silting and flooding of the valley-bottom fields and landslides are becoming very common.

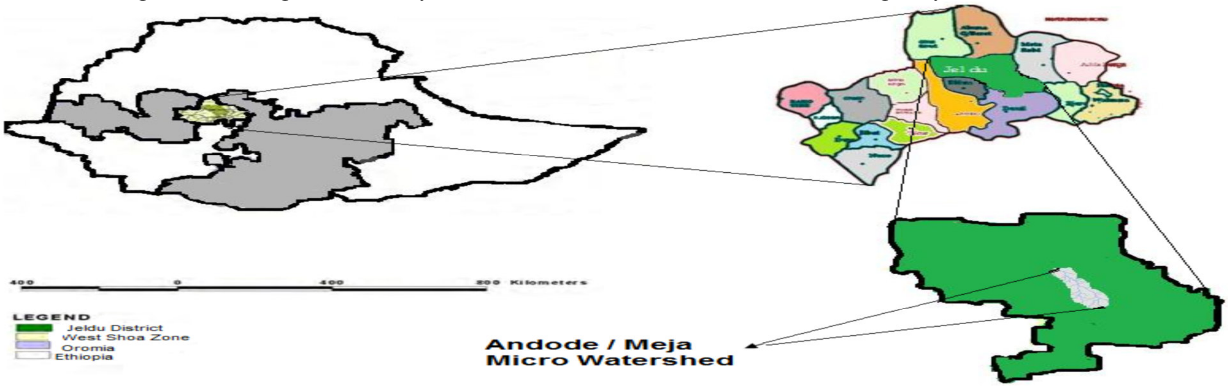

Figure1: Map of the Study Area

3.2. Data Collection Techniques and Instruments Adopted

Data for the study was collected from both primary and secondary sources. Primary data collected by employing household questionnaire survey, focus group discussion, field observation, and key informant interview to bring the study to realization. Information about personal characteristics of the household head, the knowledge of SLM practices/ technologies, the resource endowment of farmers, farm management practices, cropping patterns, crop yield, role of different institutions to improve farming, and adoption of improved and indigenous soil conservation technologies, such as the construction of check dams, terrace improvement, terrace bunds, hedge management, retention walls, waterways, and mulching, were collected through individual interviews by using a semi- structured questionnaire. Pilot-tests of questions were made by distributing questionnaire to five farmers in each site to assess whether the instruments were appropriate and suited to the study at hand. Necessary adjustments were made based on the comments obtained from pre-test responses from farmers to ensure reliability and validity. Data collectors were trained with respect to the survey techniques and confidentiality issues. Additional qualitative information, such as changes in soil conservation practices and cropping patterns over time, adoption of indigenous and improved soil conservation technologies, role of local level institutions in the promotion of SLM technologies/practices were collected through six focus group discussions, 12 key informant interviews, and through observation of the watershed. Focus group discussions were conducted with 8 to 10 farmers in each group. Audiocassettes were used to record the focus group discussions and key informant interviews. A secondary data source includes journal articles, research reports and other publications, including internet sources of information.

3.3. Sampling Design of the Study

In this study, a multi-stage sampling procedure employed. First, Jeldu district was purposively selected because; the district is one of severely affected areas by land degradation (Brihanu, 2011).The district is highly vulnerable to land degradation in particular soil compaction, deforestation and environmental degradation. Second, four *kebele (Edensa Galan, Seriti, KoluGalal and Chillanko)* were randomly selected from the existing 38 *kebeles (lowest administrative unit in Ethiopia)*. Thirdly, the sample respondent households were selected by simple random technique. The sample size of the study determined by using Gujarati sample size determination formula (Gujarati, 2004). Accordingly, 224 sample households from the selected *kebeles* drew using simple random sampling technique for the household questionnaire survey. The random selection of households based on the list of household heads found in each kebeles and proportional to the size population.

3.4. Methods of Data Analysis

3.4.1 Descriptive Analysis *Techniques*

Data were analyzed through generation of descriptive statistics and estimation of double-hurdle models. Descriptive static techniques such as percentages, means, standard deviations and frequency counts, tables were generated for general information, t-tests were applied to compare the mean differences between adopters and non adopters, chi-square tests were applied to analyze categorical data, correlation and cross tabulation method were used to identify inter-dependence among various factors influencing the adoption of soil conservation technology. T-test was run to see if there is statistically significant difference in continuous variables of farm characteristics of household who have adopted introduced soil and water conservation practices and those have not done so. The chi- square was used to see if there is systematic association between decision on the use of introduced soil and water conservation practices and with some of the independent variables, for categorical data.

3.4.2. Binary Logistic Regression

Binary logistic regression model was developed to assess the personal, social, economic, institutional, and bio-physical cal factors influencing the adoption of ISCT in this study (Agresti, 1996). The Binary Logit Model was applied in this study to assists in estimating the probability of decision on the use of introduced soil and water conservation practices that can take one or more of practices or do not practiced the technologies. In the study area farmers practice improved and traditional physical soil and water conservation structures. There are also non-adopters of these improved soil and water conservation measures. A logistic regression mode was developed to explore the personal/social, economic, institutional, and geographical factors influencing the adoption of SLM in this study. A regression model, and its binary outcomes, helps the researcher to explore how each explanatory variable affects the probability of the occurrence of events (Long andFreese, 2006). This model helps to explore the degree and direction of the relationship between dependent and independent variables in the adoption of improved soil conservation technology at the household level. The logistic regression model is an appropriate statistical tool to determine the influence of independent variable son dependent variables when the dependent variable has only two groups. In the logistic model, the coefficients are compared with the probability of an event occurring or not occurring and bounded between 0 and 1 (Sheikh, 2003). The dependent variable becomes the natural logarithm of the odds when a positive choice is made. The odds ratio and predicted probability of the independent variables indicate the influence of these variables on the likelihood of adoption of improved technology if other variables remain the same. Hence, if the estimated values of these variables are positive and significant, it implies that the farmers with higher values for these variables are more likely to adopt improved soil conservation technology

$$P_i = \frac{1}{1+e^{-Z_i}} \qquad (1)$$

Where P (i) is a probability of adopting a given practice for ith farmer and Z (i) is a function of m explanatory variables (Xi), and is expressed as:

$$Z_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + --- + \beta_m X_m \qquad (2)$$

Where,

B_0Is the intercept and βiare the slope parameters in the model.The slope tells how the Log-odds in favor of adopting soil conservation practices change as independent variables change by a unit. Since the conditional distribution of the outcome variable follows a binomial distribution with a probability given by the conditional mean P_i, interpretation of the coefficient will be understandable if the logistic model can be rewritten in terms of the odds and log of the odds (Hosmer and Lemeshew, 1989.)Since the conditional distribution of the outcome variable follows a binomial distribution with a probability given by the conditional mean P_i, interpretation of the coefficient will be understandable if the logistic model can be rewritten in terms of the odds and log of the odds. The odds to be used can be defined as the ratio of the probability that a farmer uses or adopts the practice P_i to the probability that he or she will not P*i-1*

But,

$$1 - P_i = \frac{1}{1 + e^{-Z_i}} \qquad (3)$$

Therefore,

$$\frac{P_i}{1 - P_i} = \frac{1 + e^{Z(i)}}{1 + e^{-Z_i}} = e^{Z_i} \qquad (4)$$

And

$$\frac{P_i}{1 - P_i} = \frac{1 + e^{Z(i)}}{1 + e^{-Z_i}} = e^{\beta_0} + \sum_{i=1}^{M} \beta_i X_i \qquad (5)$$

Taking the natural logarithm of the odds ratio of equation (5) will result in what is known as the logit model as indicated below:

$$L_n\left[\frac{P_i}{1 - P_i}\right] = L_n\left[e^{\beta_0 + \sum_{i=1}^{M} \beta_0 X_i}\right] = Z_i \qquad (6)$$

If the disturbance term Ui is taken in to account the log it model becomes:

$$Z_i = \beta_0 + \sum \beta_0 X_i + U_i \qquad (7)$$

Hence, the above econometric model was used in this study and was treated against potential variables assumed to affect the farmer decision of soil conservation practices. The parameters of the model were estimated using the iterative maximum likelihood estimation procedure. The later yields unbiased and asymptotically efficient and consistent parameter estimates. Therefore, the above econometric model was used in this part of the study to identify determinant variables that influence adoption practices of land management in the study area.

Definition of Variables and Working Hypothesis

1. **Dependent Variable**: The dependent variable for the adoption model indicates whether a household has adopted SLM practices (‘‘adopt’’ versus ‘‘not-adopt’’). Therefore, in this study adopters are households who adopted at least one of these practices while non-adopters are those who did not adopt any of these land management practices.SLM technologies/practices include adoption of improved terraces, hedge plantation, construction of check dams and terrace bunds, whereas indigenous technologies include mulching, slope terraces, retention walls, plantation of shrubs and trees at the edge of farm terraces, diversion drains, and waterways. Improved and indigenous SLM practices were identified based upon field observation and discussion with farmers. In this study, a farmer who has adopted at least one improved soil conservation technology, either as recommended by extension workers or with some modification, was defined as adopter. A value of ‘‘1’’ was assigned to all households who adopted at least one improved SLM practices (the ‘adopters’’) and ‘‘0’’ was assigned to households using only indigenous SLM practices (the ‘‘no adopters’’).Whether or not to adopt any SLM practices is determined by personal, social, economic, institutional, and geographical factors. These variables we retreated as explanatory variables in this study.
2. **Selection of Explanatory Variables and Expected Impact on Adoption:** Adoption of SLM practices/technologies in the study area is a complicated process similar to the other research in agriculture technology adoption (Doss 2006; McDonald and Brown 2000) that may be influenced by a

set of interrelated personal, social, economical, institutional, and biophysical factors (Table 1).

Table1: Definition of all the explanatory variables used in the model

Variable		Description
Adoption		A value of ''1'' was assigned to all households who adopted at least one improved SLM practices (the ''adopters'') and ''0'' was assigned to households using only indigenous SLM practices (the ''no adopters'').
Demographic factors	AGE	Age of the household head in years
	HHSIZE	Number of people in the household
	EDUCTION	Literacy of the household head; 1if literate and 0 otherwise
	SEX	Gender of the household head; 1if male and 0 otherwise
	Family-labour	Potentially available family labour force
Institutional factors	TENURE	Whether a farmer perceives a risk of loss of land in the future; 1 if he/she perceives 0 otherwise
	MEMBSHIP	Membership in local organizations; 1if a farmer is a member and 0 otherwise
	TRAINING	Whether training about SLM practice received by the farmer; 1 if a farmer got training and 0 otherwise
	CREDIT ACCESS	Whether a farmer needed credit and was able to get it; 1 if he/she accessed 0 otherwise
	EXTENSION VISITS	Number of extension visits received
Physical Factors	FMSIZE	The size of the farm, in hectares
	DISTANCE	Average distance of a plot from homestead, in minutes
	SLOPE	Slope of the plot; 1 if steep and 0 otherwise
Economic Factors	OFFINCOM	Whether a farmer engaged in off-farm employment, 1 if a farmer has off-farm employment and 0 otherwise
	TOTAL INCOME	Estimated average income earned annually
	LIVESTOCK	Number of livestock's in TLU
Attitudinal Factors	PERCEPTDEGRADATION	whether a farmer perceives land degradation as a problem; 1 if farmer had perceived land degradation as a problem and 0 otherwise
	PERCEPTSLM	whether a farmer anticipates introduced structures effective in retaining soil from erosion; 1 if a farmer anticipates soil retention due to structures and 0 otherwise

RESULT AND DISCUSSION

4.1 Descriptive Statistics

In order to investigate the presence of group means difference with respect to the hypothesized socio-economic, biophysical and institutional factors uni-variate tests were used. Student's t-test and Chi-square test were used, respectively to identify potential continuous and dummy variables differentiating adopters from non- adopters. Adopters and non-adopters significantly different in three of the nine hypothesized continuous socio-economic variables (Table 2).The survey results showed that landholding size of total sample households ranges from 0.125 to 4.00 ha with a mean of 1.29 and standard deviation of 0.79 ha. The average landholding size of adopters and non-adopters were 1.54 and 1.27 ha with a standard deviation of 0.99 and 1.05, respectively. There was a slight difference in the mean size of landholding between the two groups. However, the result of t-test showed that the mean landholding size difference between the two groups was significant. Land is one of the most important production factors for agricultural production. In rural households, in the study area land and labor account for the largest share of agricultural inputs. Hence, the quality and quantity of land available for farm households largely determine the amount of production.

Table2. Continuous variables differentiating adopters from non-adopters of SLM practice/ technologies among 224 sample households

Variables	Adopters		Non-adopters		*t-value*
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	
Household Size (in number)	6.4	1.7	6.7	1.8	0.232
Age of household head (in years)	51.5	14.4	49.05	13.76	-0.36
Education status of household head (in years)	3.1	1.06	3	0.99	3.46**
Land holding size (in hectares)	1.54	0.99	1.27	1.05	2.251**
Farming Experience (in years)	27	13.42	24	11.87	0.232
Distance of plots from residence (in Kms)	0.57	0.221	0.68	0.46	0.96
Off-farm income (in ETB)	452.5	123.67	376.42	99.56	0.87
Livestock holdings (in TLU)	3.45	1.02	3.04	1.20	2.86**
Extension contact(in number)	1.02	0.76	0.98	0.78	1.98*
Size of labour force	3.02	1.66	2.96	1.54	3.65**

***indicates Significant at 10%and 5% probability level respectively*

Livestock is an important component of the farming system in the study area. A vast majority of the sample households included in this survey own animals of different kind. Cattle, donkeys, horse sheep, goats and chicken are common domestic animals. Small ruminants and chickens were sold and serve the purpose of immediate cash needs at times of cash shortage. The size of livestock owned indicates the wealth status of the household. The average size of livestock in TLU was found to be 3.45, 3.79 and 3.04 for total sample households, SLM adopters and non-adopters with a standard deviation of 1.02, and 1.2, respectively. About 33% of total sample household heads has more than five TLU sizes of livestock. The t-test revealed that there is significant difference in the number of oxen owned by farmers who have adopted SLM practices and those who have not.

The number of labour force available in the family is assumed to influence decision of farmers to adopt SLM practices. Families with large household members will be able to supply the extra-labour that could be required for adoption and continuous implementation SLM activities. In addition, the result of t-test revealed that there was significant difference in the mean size of labour force between adopters and non-adopters. The average available labour was calculated to be 2.95person per day for total sample households, 3.02person per day for users and 2.96person per days for non-users, with a standard deviation of 1.68, 1.66, and 1.54, respectively.

In the study area, the most important sources of information cited were through communication with relatives and neighbors, community leaders, and the government's mainstream agricultural extension program. Farmers' pointed out the governments' extension service as the most important one. In addition, they further revealed that information about input supply and use, land management practices; improved cultural practices and soil conservation practices are among the aspects covered by the extension services. Access to extension service is very important element of institutional support needed by farmers to enhance the use of agricultural technologies in general and soil conservation technologies in particular. Three Development Agents (DA's) were assigned in each sample *kebeles*. It was expected that sample farmers in the study area have an access to extension services through the DAs, attending field days and training. However, about 22% of users, 43% of non-adopters have reported that they did not get extension services (visits) in the year 2015/016. Development agents had visited about 56% of sample households from one to three times per month. The average monthly frequency of extension services/visits/ was found to be 0.97 and 0.70 for users and non-users with a standard deviation of 0.80 and 0.83, respectively. The mean monthly extension visit difference of the two groups was found to be statistically significance.

4.2. Descriptive Statistics of Categorical Variables

Generally, adopters and non-adopters not only vary in terms of quantitative variables but also in terms of qualitative variables. It was, therefore, quite essential to use a method of testing the differences between adopters and non-adopters.

Table 3: Dummy variables differentiating SLM adopters from non-adopters of SLM practices among 224 sample households

Variable	Score	Adopter	Non-adopter	Total	X^2
Sex	0	37	47	84	8.65***
	1	64	76	140	
	0	17	32	49	6.25***
Perception	1	102	73	175	
Degree of slope of the plot	0	34	52	85	1.34
	1	77	62	139	
Access to credit service	0	87	22	109	7.05***
	1	88	27	115	
Land certification	0	33	37	70	9.63***
	1	98	56	154	
Prior public conservation campaign	0	56	62	118	
	1	72	34	106	1.02

******: significant at <1 probability level.***

From the total 224 sample household heads, 84 (37.5%) were men's and 140(62.5%) were men's respectively (Table 3). The majority of adopters of the SLM Practices (63.36%) were male-headed households while only 36.63 % were female-headed households. Chi-square test results show that there is a statistically significant difference between adopters and non-adopters in terms of sex of the household heads at 10% probability level.

Overwhelming majority of farmers disclosed that their land productivity is declining with each passing year due to soil erosion. Farmer's perception about the existence of land degradation problem on their farm plots, causes of the problems as well as its consequences might make farmers to adopt and continuously implement SLM measures. The majority of the sample household heads (78.12%) have perceived the problem of soil erosion on their farm plots. From this, only 58.28 % of households adopted SLM practices/ technologies at least in one of their plots. This can imply that perceiving the problem of land degradation problem is cannot always be a guarantee for adoption of SLM practices/ technologies. The difference between the two groups with respect to perceiving the existence of land degradation on farm plots was statistically significant.

In the study area, it was found that only 51.34 % of the respondents have reported obtaining credit at least once since the last five years. Whereas, 48.66 % of respondents have not obtained credit from formal sources. When the data analyzed by disaggregating into adopters of SLM practices and that of non-adopters, it was assured that 79.81% of those who were adopted and continuously practiced SLM practices have obtained credit, but only 20.18% has got credit from those non-adopters. The Chi-square analysis disclosed that there is a significant association between access to credit service and adoption of SLM practices and it is significant at 10% level of significance. This could prove that farmers who have access to credit have a higher probability of adopting and retaining SLM practices/technologies than those with no access.

4.3.Smallholder Farmers' Status of Adoption of SLM Practices/Technologies

Long-term productivity and sustainability of the land resource requires sound land conservation measures in the farming systems that enhance maintenance and/or improvement of soil and land quality in general. This is an important consideration as it influences agricultural productivity and local livelihoods. In many instances, environmental degradation has stimulated a variety of responses and adaptation mechanisms by local communities. This study made an enquiry on whether farmers had undertaken any deliberate efforts to protect their land holdings from soil degradation. Majority of respondents (63.75 %) indicated to have used one or more SLM Practices in their farms as a means of adjusting and adapting to land degradation processes. Graph2 presents the various SLM practices as mentioned by the interviewed farmers.

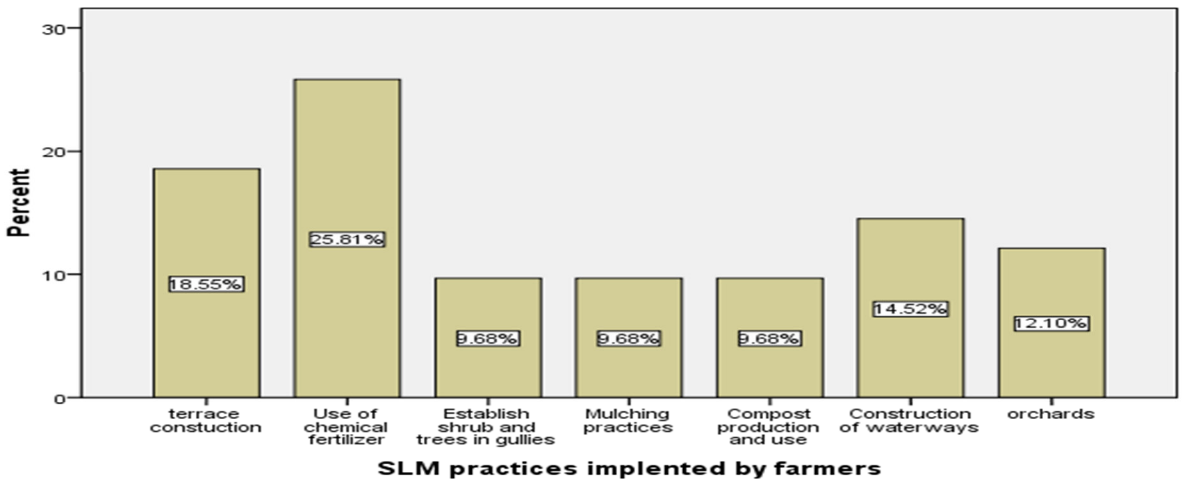

Figure 2: SLM practices implemented by farmers in the study area.

4.4. Farmers perceived Constraints of adoption of SLM Practices

In previous discussions, it was indicated that land degradation in the study area has been the major problem farmers faced with. In addition, the initiatives taken to tackle the problem and efforts have been end up with mixed results of both success and failure. In terms of problems with the conservation activity, about 56.24% of the respondents complained that they face problems in putting up conservation structures. Only 23% of the respondents do not encounter any problem. The most important problem mentioned by the respondents was conservation practices compete for labor that could have allocated for other activities. Local people will not convert their terraces into more permanent terraces because they perceive that the SLM Practices would be too labour intensive to maintain (it would involve digging residues into the soil twice annually rather than pulling soil down slope to bury them). With significant rates of out-migration, labour can hardly be said to be a constraining variable to land improvement— thus returns to labor, as outlined above, must be regarded as more significant. Land shortage was also another main reason that people cited for being unable to implement erosion prevention methods (27%) as trees and terraces both absorb land and trees further shade crops. Among institutional factors, low credit availability and access (62%) and lack of community participation before farmers applying introduced SLM practices (78%) were mentioned by the majority. In addition, the presence of different drawback associated with introduced SLM practices such as narrowing land, inconvenient for ploughing and damage of structures by rain or livestock were the other restraining factor explained by the majority.

4.5. Multicollinearity Test

Prior to running the logistic regression analysis, the existence of Multicollinearity among the explanatory variables were checked using variance inflation factor (VIF). The VIF values for all the explanatory variables were found to be very small (much less than 10) indicating that absence of Multicollinearity between the explanatory variables. For this reason, all of the explanatory variables were included in the final analysis.

4.6. Econometric Analysis of Determinants of Adoption of SLM Practices

Logistic regression model was used to address the second objective of the study. That is to identify the factors that affect adoption of the introduced land management practices in the study area. The likelihood ratio test statistic exceeds the chi-square critical value with 12degrees of freedom. The result is significant at less than 1% probability level indicating that the hypothesis that all the coefficients except the intercept are equal to zero is not acceptable. Likewise, the log likelihood value was significant at 1% level of significance. Another measure of goodness of fit used in logistic regression analysis is the Count-R^2, which indicates the number of sample observations correctly predicted by the model. TheCount-R^2 is based on the principle that if the estimated probability of the event is less than0.5, the event will not occur and if it is greater than 0.5 the event will occur. In other words, the i^{th} observation is grouped as non-adopters if the computed probability is greater than or equal to 0.5, and as adopter otherwise. The discussion about the significant variables is given below.

Table4: Analysis of Determinants Using Binary Logistic Regression Model result for perception of the effects of land degradation risks

Variable	βSE		ZSigOdd Ratio		
__AGE	2.142**		0.562	0.862	0.0671
0.025					
HHSIZE	0.235	1.320	1.230	0.215	0.0670
EDUCATION	0.072*	1.892	2.290	0.021	0.201
SEX	0.040**	3.536	0.968	0.091	0.056
FAMILY-LABOUR	0.235*	0.360	0.386	0.026	0.024
TENURE	0.042**	1.765	0.564	0.086	0.210
MEMBERSHIP	0.246	1.156	1.961	0.534	0.056
TRAINING	0.836*	2.034	0.862	0.020	0.092
EXTENSION VISIT	0.865*	0.458	1.926	0.031	0.032
FRMSIZE	2.280	0.985	0.862	0.915	0.042
LIVESTOCK	0.965*	2.045	1.926	0.020	0.031
TOTAL INCOME	1.626	1.963	0.034	0.234	0.023
OFFINCOME	-0.025*	2.094	2.026	0.0251	0.031
DISATANCE	-0.965**	1.096	0.648	0.096	0.802
CREDIT ACESS	1.028*	2.064	1.025	0.020	0.035
SLOPE	2.860**	2.021	1.806	0.091	0.020
PERCEPDEGRADATION	0.689*	1.091	0.962	0.031	0.380
PERCEPTSLM	1.096**	2.026	0.863	0.062	0.031
Constant					

Model Chi-square 102.280
Log likelihood function 92.165
Nagelkerke (R^2) 0.75
Number of observation 226

*****, * Significant at 0.1 and 0.05 probability levels, respectively***

Age of the Household Head: This result suggests that older farmers are less likely to adopt SLM practices. This could be explained by the fact that older farmers have a short planning horizon compared with younger colleagues. This is in line with the findings of Anley et al. (2007) and Shiferaw& Holden (1998).

Off- Farm Activities: Adoption of SLM practices also found to be negatively influenced by off-farm activities. This is because farmers who are involved in off-farm activities may encounter time and labour constraints for investing in bunds. This is in line with other findings (Tenge et al., 2004; Amsalu & deGraaff, 2007).

Number of livestock owned: The number of TLUs is positively related to the decision of compost/manure investment. This is because animal manure is one of the major inputs for compost/manure production. As hypothesized, this variable affected adoption of SLM practices s positively and significantly at 5% probability level. The marginal effect for this variable shows that keeping all factors constant an increase in livestock ownership by one TLU increases the probability of SLM Practices adoption by 0.031.

Extension contact: As hypothesized, frequency of extension contact is found to have a significant positive effect on the adoption of SLM Practices s at 10% probability level. This may be explained by the fact that the message/contents that farmer gain from extension agents help them to initiate to use the newly introduced land management practices on their farm to protect their land from erosion and improve its fertility. Therefore, contact between a farmer and development agent and information gained accelerate the attitude of farmers towards SLM practices positively, and the decision of farmers to invest on SLM Practice on his/her land (Tesfaye 2006). Many other case studies too revealed that low adoption of rainwater harvesting technology were due to lack of extension services (Nasr, 1999; Kihara, 2002; Mitiku and Sorsa, 2002; Ngigi, 2003). The marginal effect value for farm size shows that keeping all factors constant an increase in extension contact by one e increases the probability of SLM Practice adoption by 0.032.

Farmers' perception on effectiveness of introduced land management practices: This variable is hypothesized to influence land management practices adoption either positively or negatively. The model results show that this variable has a significant positive impact on land management practices. The variable is significant at less than 5% probability level. As hypothesized, farmers' perception of effectiveness of SLM measures influence households' decision to invest on introduced land management practices positively.

Perception of severity of land degradation: This variable indicates the severity of soil erosion as perceived by the farm households. The variable positively influenced the adoption of SLM practices/ technologies at less than

1 percent level of significance. The reason for this is that farm households' awareness of the erosion hazard is attached to their perception of the negative consequences of soil erosion and benefits of soil and water conservation. This could be explained by the fact that those farmers who have perceived soil erosion as a serious problem were willing to participate in conservation strategies of land management. Those farmers, who have better perception of soil erosion, will develop good initiations towards management scheme and become less dependent on external assistance for undertaking land management activities.

Educational level of sampled household head: As hypothesized, education of the HH head was found to be positive and having a significant influence on the adoption of improved soil conservation technology. This implies that longer schooling of the HH head increased their ability to access information, and strengthened his/her analytical capabilities with new technology. Furthermore, a longer education leads to a better understanding of the new technology when reviewing the different extension materials, which enhanced adoption of improved technology. Many authors report that education has a positive impact in the adoption of improved soil conservation technology (Lapar and Ehui2004; Mbaga-Semgalawe and Folmer2000;). The findings of this study on the effect of education were close to that of other studies conducted previously. Adoption of a given technology is a behavioral change process, which is the result of a decision to apply that particular innovation. Farmers need enough information about the technology to make the right decision. Education enhances the capacity of individuals to obtain, process, and utilize information disseminated by different sources. This implies that literate farmers are in a better position to get information and use it in such a way that it contributes in their adoption of SLM Practices. As hypothesized, educational level of household heads was found to be a significant at less than five percent probability level. This may be explained by the fact that those farmers who were more educated are likely to use introduced land management than the non-educated farmers in the study area. This is because, educated farmers were more opt in understanding the problem of land degradation and could easily decide to take part in conservation strategies of land management practices . This is attributable to the fact that education reflects acquired knowledge of environmental amenities and educated farmers tend to spend more time and money on land management practices. The marginal effect value for education shows that keeping all factors constant an increase in education by one year increases the probability of adoption of SLM Practices by 0.201.

Land tenure: Farmer's feeling about the land belongs to him/she will have a positive effect on his/her decision to adopt land management practices. The lack of title to land is one important factor affecting adoption of SLM Practices because lack of tenure security means that people are reluctant to invest in new land management practices on a land which they do not formally own. Therefore, farmers' perception that the farmland he/she owns will remain his/her owns at least during his/her lifetime affects the decision on land management practices. For farmers' to be able to carry out long or medium term investment, they require security of tenure. This does not necessarily mean that they have to have individually documented proof of title rather need the feeling of ownership to make sure that the land will be theirs to work in the foreseeable future, and not unpredictably taken away and reallocate to somebody else. This variable is found to significantly and positively affect the independent variable, SLM Practice. This is because to adopt and invest on land management practices, first there should have a sense of ownership so that farmer can take care of his land.

Slope of the farm plots (SLOP): This variable positively influenced the adoption of SLM practices/ technologies at less than 1 percent level of significance. The significant positive terms in adoption of conservation practices indicate that farmers are inclined to invest in conservation practices where their farm plots are located on higher slopes. This goes with the perception that those plots can only be productive if protected by conservation structures. On the other hand, Berhanu and Swinton (2003) have stated that an increase in the slope of the plots may create a disincentive to invest in soil conservation practices as the slope of the plot increase the distance between two consecutive terraces will decrease because the structures of SLM measures occupy more area of land and will create inconvenience for farm operation.

Conclusion and Policy Implication

The findings of this study have important policy implications for promoting sustainable land management practices and technologies in the study area. Descriptive data analysis showed that only 63.75 % of the HH adopted SLM practices. Farmers reported that the improved terraces are effective in reducing soil erosion, though they were not common due to high labor cost and inconveniency for ploughing with oxen. A range of socio-economic, institutional, personal and biophysical factors determines adoption of SLM practices in the study area. The result of the binary logistic regression model showed that SLM practices is significantly influenced by education, tenure security, livestock ownership, perception of severity of land degradation, perception of effectiveness of SLM measures, off-farm activities, credit services access, age of households, slop of the plot ant etc. Planners and policy makers should formulate appropriate policies and programs considering the farmers' interest, capacity, and limitation in promoting improved soil conservation technology for greater acceptance and adoption by the farmers. Any future land management efforts should give a due attention to genuinely involve farmers in entire process of any land management interventions from technology generation to final monitoring and evaluation. Generally, this study recommends that decision-making about land management and land degradation should encompasses factors that may be biophysical (agro-ecological conditions, location), economic (access to credit and markets, non-farm incomes, availability of technologies), social (organizational structure, labor availability, land tenure), historical (environmental history and that of land tenure) and cultural (traditional knowledge, environmental awareness, and gender.

Acknowledgement
I am extremely grateful to Ambo University for funding this research project. Also I wish to thank all farmers who provided their valuable time and shared their experiences on SLM practices.

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