Miheretu and Yimer *Ecological Processes* (2017) 6:19
DOI 10.1186/s13717-017-0085-5

Ecological Processes

RESEARCH Open Access

Determinants of farmers' adoption of land management practices in Gelana sub-watershed of Northern highlands of Ethiopia

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Abstract

Introduction: Soil erosion is the major environmental problem in Ethiopia. In response to this problem, the country has been in continuous struggle to adopt land management practices. Therefore, the objective of this study was to investigate the determinants of farmers' adoption of land management practice in the Gelana sub-watershed, Northern highlands of Ethiopia.

Methods: The data was collected from 176 randomly selected farming households using a survey questionnaire and was analyzed using multinomial logit model (MNL).

Results: The results showed that education, family size, slope of the plot, tenure security, training, access to farm credit and extension service positively and significantly affect adoption of land management practices while age has a negative and significant influence on adoption.

Conclusions: The findings suggest that improving farmers' education status and increase the availability of credit to reduce poverty and increase income would enhance the adoption of land management practices.

Keywords: Land management, Adoption, Multinomial logit model, Ethiopia

Introduction

Agricultural land is a scarce resource in the highlands of Ethiopia. It constitutes the fundamental base of rural livelihoods. However, its sustainable use is highly affected (among other factors) by bio-physical and institutional aspects of land (Teshome et al. 2016). The living conditions of the rural poor in Ethiopian highlands have been worsening because of low agricultural productivity caused by increasing deterioration of the quality and quantity of agricultural land resources (Anley et al. 2007). There are diverse factors behind the low agricultural productivity in Ethiopia. Among others, recurrent drought, erratic rainfall, pests, land tenure insecurity, population pressure, soil erosion, overgrazing, deforestation, lack of efficient rural organizations and weak institutional support are often cited (Beshah 2003). Among these, although drought and shortage of rainfall are considered as the major causes for low agricultural productivity and food shortage, soil degradation (excessive nutrient exhaustion and removal of top soil by water erosion) is by far the largest contributor (Sahlemedhin 2000). Degradation resulting from soil erosion and nutrient depletion is one of the most challenging environmental problems in the highland agricultural systems of Ethiopia.

The Ethiopian highlands have been experiencing soil fertility decline and severe soil erosion due to encroachment of intensive farming system on steep and fragile lands (Amsalu and de Graaff 2007). A national level soil erosion assessment in the 1980s showed that about half of the highland's land area (about 27 million hectares) is significantly eroded; 14 million hectares are seriously eroded and over 2 million hectares of farm lands, have extremely eroded, could not able to sustain economic crop production in the future (FAO 1986). According to

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Hurni (1993), average soil loss rates on croplands have been estimated to be 42 tone ha^{-1} $year^{-1}$ but may also reach up to 300 tone ha^{-1} $year^{-1}$ in individual fields. Such losses might lead to irreversible changes in soil productivity that directly affects the food security situation in Ethiopia whereby farmers could not tolerate further deterioration of soil productivity (Sonneveld and Keyzer 2003) and might also reduce the future productivity of agricultural land (Shiferaw and Holden 1999). In response to this problem, Ethiopia has been in continuous struggle to establish sustainable agricultural practices so as to increase agricultural production, reduce poverty and ensure sustainable use of the natural resources since 1970s by rehabilitating degraded lands (Gebremichael 1999; Bewket 2007). However, in some places significant increase in agricultural productivity could not be attained because the agricultural land resource bases are continued to be degraded. Hence, promoting sustainable land management (SLM) is critically important for agricultural growth in Ethiopia. To this end, new land conservation technologies were introduced in some degrading and food deficit areas of the highlands, mainly through food-for-work incentives since the early 1980s (Shiferaw and Holden 1998). However, the natural resource conservation interventions were primarily technology oriented in which beneficiaries had less stake in decision making. Despite concerted efforts by the government and NGOs, the adoption rate of improved technology remains low (Bewket 2007; Shiferaw and Holden 2001; Kassie et al. 2009; Adimassu and Kessler 2012). This problem can be explained by the fact that investments in land management practices are found to be influenced by complex sets of demographic, socioeconomic, institutional, and biophysical factors (Zeleke et al. 2006; Amsalu and De Graaff 2007; Adimassu et al. 2012; Guteta and Abegaz 2015a, b). As a result, the current land management effort of the study area seems less successful. Therefore, designing land management practices based on demographic, socioeconomic, institutional, and biophysical factors could be useful in adjusting present land management practices or in the development of appropriate land management options for a given area. This is particularly important in the study area where varied demographic factors, land management practices and soil fertility prevailed.

Furthermore, unlike many past studies that only considered land management practices as binary variable (Pender et al. 2004; Benin 2006; Tiwari et al. 2008; Belay and Bewket 2013; Guteta and Abegaz 2015a) for adoption decisions, the present study considers the land management adoption decision as multivariate variables because using multivariate models considers the effect of useful interdependent demographic, economic, institutional, or biophysical variable and simultaneous adoption decisions (Bekele and Drake 2003). Therefore, the objective of this study was to identify factors that affect the adoption of farmers land management practice in the Gelana sub watershed, Northern highlands of Ethiopia.

Methods

Study area

The Gelana sub-watershed is situated in Wollo area, Amhara region of Ethiopia. Geographically, it lies between 11° 34'44" and 11° 45'4"N, and 39° 34'11" and 39° 45'2"E (Fig. 1). It is located at a distance about 491 km north of Addis Ababa. It covers 24,972 ha of land. Its elevation ranges from 1365 to 3328 meters above mean sea level. The present complex topography has been formed by large-scale tectonic and volcanic activity and covered by Cenozoic volcanic rocks (Mohr 1971) and subsequent fluvial erosion. It is composed of rugged topography and relatively low-lying plain. The slope gradient of the study area varies from flat to very steep slopes. The sub-watershed drains to the Awash River.

The study area falls into three agro-climatic zones: hot (Kolla), temperate (Woina Dega) and cool (Dega) climatic zone (MOA 1998). The mean annual temperature of 22 years (1992–2014) was 20.9 °C (National meteorological service agency 2015: Temperature and rainfall data of Mersa, unpubished document). The mean monthly temperatures ranging from 18.2 °C in December to 24.3 °C in June (Fig. 2).

The watershed is characterized by bimodal pattern of rainfall with a mean annual rainfall of 1024 mm with a peak rainfall in August (Fig. 2). About 59% of the rainfall occurs between June and September.

The major soil types in the study area are Leptosols, Cambisols, Vertisols, and Regosols (Amhara design and supervision works enterprise 2011: East Amhara development corridor integrated land use planning project soil survey thematic report, unpublished document). Gelana sub-watershed is one of the populated areas in the district with estimated population size of 64,965 in 2007 (CSA 2008) and an average population density of 260 persons per km^2.

Agriculture has been practiced in the watershed for a very long time and it is the main economic activity and source of livelihood. The farming system is mixed crop-livestock production on a subsistence level. The major crops of the area are cereal crops including sorghum (*Sorghum bicolour*), *teff* (*Eragrostis tef*), maize (*Zea mays*), barley (*Hordeum vulgare*), and wheat (*Triticum vulgare*). Other major crops are pulses such as Chickpea (*Cicer arietinum*), Field Pea (Pisum sativum), and Faba Bean (*Vicia faba*).

The farmers also cultivate fruits and vegetables. The most commonly cultivated fruits are orange, banana, papaya, mango, lemon, avocado and *Tirengo* (*Citron medica*). Livestock is closely integrated in the farming system and is used mainly for ploughing, threshing and transport. Livestock is also important sources of food

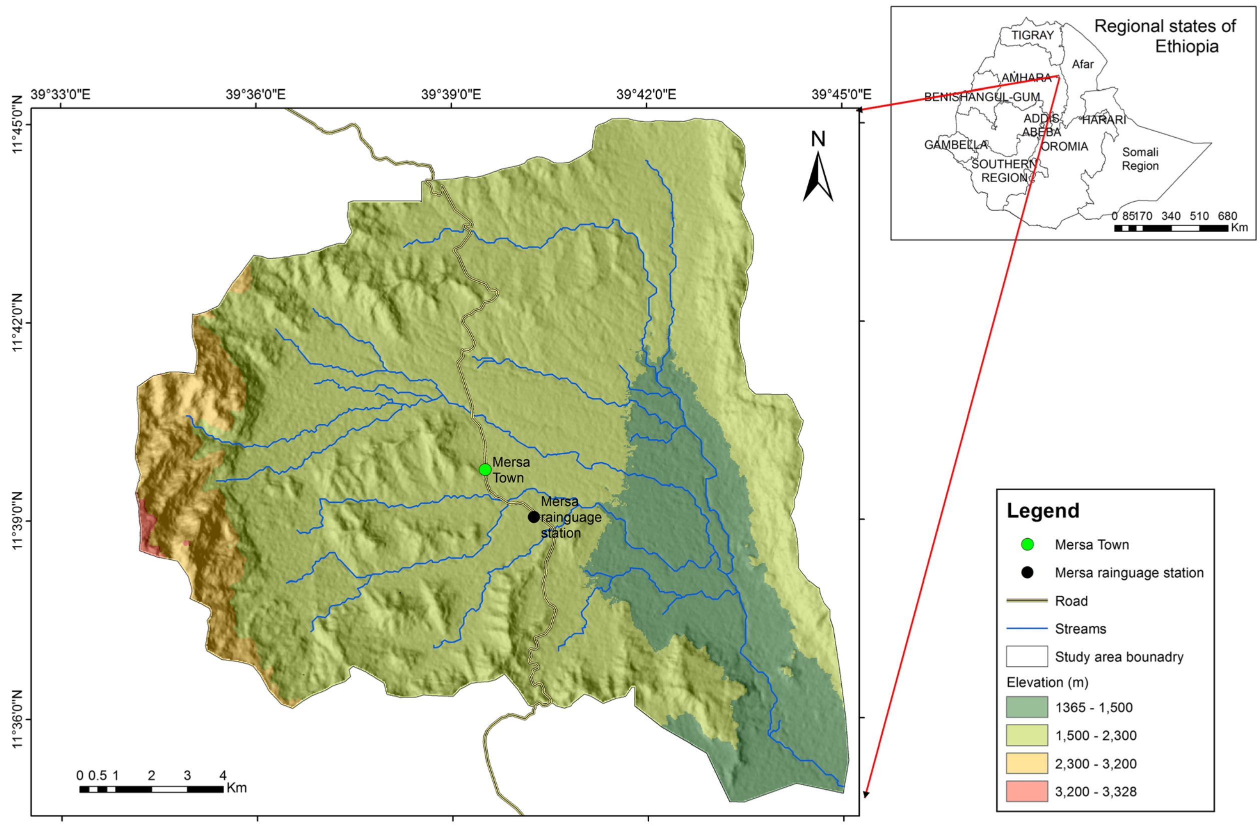

Fig. 1 Location of Gelana sub-watershed, Northern highlands of Ethiopia

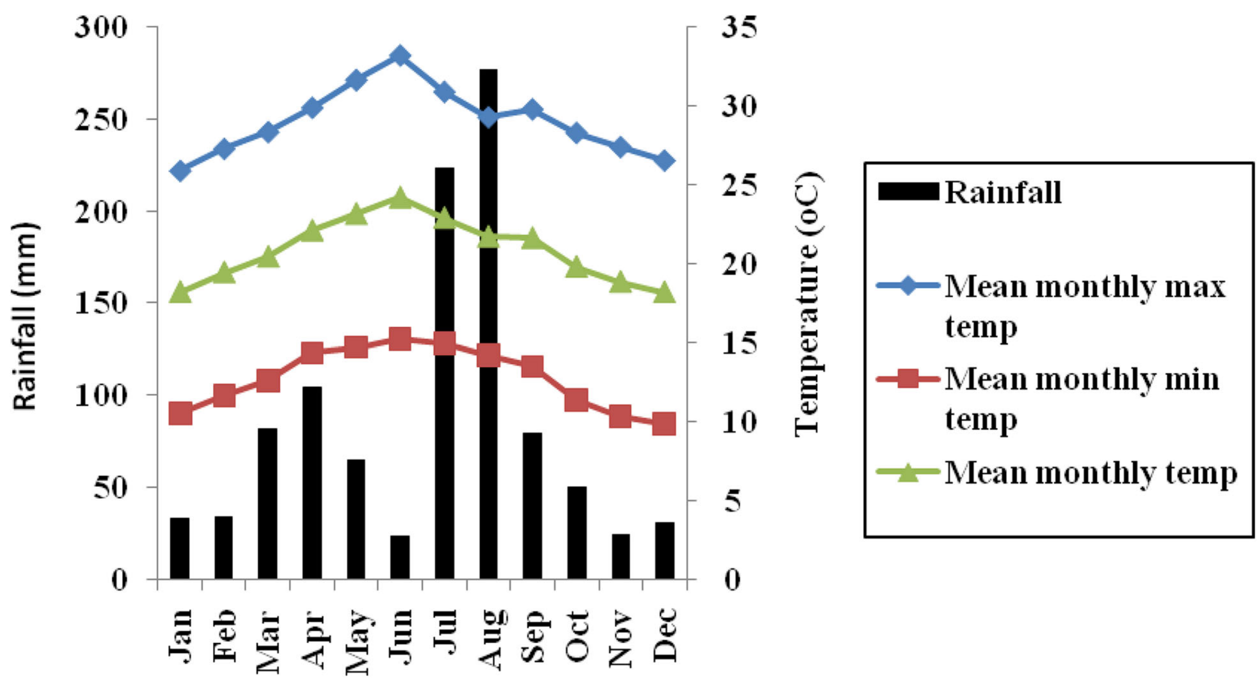

Fig. 2 Mean monthly maximum and minimum temperature and mean monthly rainfall records of 1992-2014, Mersa meteorological station (2100 masl; 11.67° N and 39.65° E), North Wollo, Ethiopia

and household income. There are limited areas of traditional irrigation in small plots as part of the overall mixed crop-livestock farming system.

Methods

Data requirements, sources and methods of collection

The relevant data to this study were collected from both primary and secondary sources. Required data on demographic, socioeconomic, institutional, and biophysical factors of households were collected in the period between January and March 2015. The main data collection methods employed survey questionnaire, key informant interview, focus group discussions, and field observations. The primary data obtained from the field survey were supplemented with data obtained from secondary sources in order to substantiate the study.

Household-level and plot-level data were collected through open and close-ended questions survey questionnaire. The researcher made a prior contact with the Kebele administrators of the study area where the researcher planned to conduct a pilot test. After the researcher secured grant, the researcher had arranged schedule to meet sample respondents. An explanation of the purpose of the study and request for their consent to participate on the pilot-test was done. Based on the feedback from pilot administrations, the instruments and the items were finalized. Bachelor degree holder enumerators administered the questionnaires to household heads. A brief orientation was given to them concerning the content of the questionnaire and how to extract more and reliable answers.

In addition to questionnaires, focus group discussion was also conducted to substantiate the responses acquired using questionnaires. The group discussions conducted with farmers in the study area includes young, adult, elderly farmers of both sex and others who have accumulated knowledge about land management practices. Three focus group discussions; each group comprised of ten persons, were carried out in the Gelana sub watershed. Moreover, in-depth interviews were held with 14 key informants and with 3 Development Agents (DAs) so as to capture their experiences of the land management practices of the study area.

Survey population and sampling technique

Based on the information obtained from agriculture and rural development office of Habru Wereda, North Wollo Zone of the Amhara regional state, Ethiopia, the Gelana sub watershed was purposively selected, because this area, among other areas of North Wollo Zone, had different land management practices which were undertaken by governmental and nongovernmental organization and its accessibility. In this sub watershed, three kebeles were selected by considering upper, middle and lower stream of the study sub watershed. The households of the sub watershed, therefore, considered as the survey population in this study. Moreover, the units of analysis from which information collected were heads of households. After identifying the sample kebeles in the sub watershed, we tried to estimate the sample size according to Kothari (2004) and the sample size was estimated to be 360 households. This sample size is a bit large to manage in terms of cost and time. Then, we followed sample size determination for multinomial logistic regression modeling, i.e., sample size guidelines for multinomial logistic regression indicate a minimum of 10 cases per independent variable (Hosmer and Lemeshow, 2000). Since 17 variables were considered to model factors affecting the adoption of land management practices, 176 samples (17 variables × 10 respondents) + 6) were selected. The plus six respondents were considered to meet this threshold requirement in case that dropout may appear (Guteta and Abegaz 2015a). The 176 household heads, which are 30.9% of the study population, were selected using random sampling technique based on the sampling frames and the principle of proportional allocation for each kebele (Table 1).

Methods of data analysis

Qualitative data obtained from key informant interviews and focus group discussions were compiled, organized, summarized, and interpreted. The analysis of household survey data was done by descriptive statistics and multinomial logit model using STATA 12 and SPSS 16.

Model specification

In this study, farmers are likely to have several land management practices from which they can choose. Bekele and Drake (2003) stated that it is more appropriate to treat adoption of soil and water conservation measures as a multiple choice decision, since attempting bivariate modeling excludes useful economic information contained in the interdependent and simultaneous adoption decisions (Dorfman 1996). It is important to treat adoption of land management practices as multiple-choice decisions made simultaneously. Therefore, the multinomial logit model was used to determine factors that influence the decision to adopt land management practices.

The household's decision of whether or not to adopt land management practices was considered under the general framework of utility or profit maximization. We adopt a linear random utility model as specified by Greene (2000). This linear random utility model is commonly used as a framework in determining of farmers' choice for land management practices (Greene 2000) and specified as:

$$Y_{ij} = \beta_j' X_{ij} + \varepsilon_{ij} \qquad (1)$$

where Y_{ij} is the utility of household i derived from land management practice choice j, X_{ij} is a vector of factors

Table 1 The study kebeles in the Gelana sub watershed of Northern highlands of Ethiopia

Name of the kebele	Position in the sub-watershed	Total No. of households	Sample size
Jarota	Upper stream	1680	52
Wutie	Middle stream	2744	85
Habru Ligo	Lower stream	1271	39
Total		5695	176

that affect the decision to use a particular land management practice choice j, and β'_j is a set of parameters that reflect the impact of changes in X_{ij} on Y_{ij}. The disturbance terms ε_{ij} are assumed to be independently and identically distributed. If farmers choose land management practice *j*, then Y_{ij} is the maximum among all possible utilities. This means that

$$Y_{ij} > Y_{ik},\ k \neq j \tag{2}$$

where Y_{ik} is the utility to the *i*th farmer from land management practice k. Eq. (2) means that when each land management practice is thought of as a possible adoption decision, farmers will be expected to choose the land management that maximizes their utility given available alternatives (Dorfman 1996). The choice of *j* depends on X_{ij}, which includes aspects specific to the household and plot, among other factors. Following Greene (2000), if Y_i is a random variable that indicates the choice made, then the multinomial logit (MNL) form of the multiple choices problem is given by:

$$\Pr ob(\mathrm{Y}_i = \mathrm{j}) = \frac{e^{\beta'_j X^i_j}}{\sum_{j=1}^{j} e^{\beta'_j X^i_j}} \quad ,j=0,\ 1,\ 2,\ ....,\mathrm{j} \tag{3}$$

Estimating Eq. (3) provides a set of probabilities for $j + 1$ land management practice choices for a decision maker with characteristics denoted by X_{ij}. The equation can be normalized by assuming that $\beta_0 = 0$. Therefore, the probabilities can be estimated as:

$$\Pr ob(\mathrm{Y}_i = \mathrm{j}) = \frac{e^{\beta'_j X^i_j}}{1 + \sum_{j=1}^{j} e^{\beta'_j X^i_j}} \text{ and :} \tag{4}$$

$$\Pr ob(\mathrm{Y_i} = 0) = \frac{1}{1 + \sum_{j=1}^{j} e^{\beta'_j X^i_j}} \tag{5}$$

Normalizing on any other probabilities yields the following log-odds ratio:

$$\ln\left[\frac{Pij}{Pik}\right] = X'_i\left(\beta_j - \beta_k\right) \tag{6}$$

The dependent variable is the log of one alternative relative to the base/reference alternative. The MNL model coefficients are difficult to interpret. So, the marginal effects of the explanatory variables on the choice of alternative land management practices are usually derived as (Greene 2000):

$$mi = \frac{\partial P_i}{\partial x_j} = P_j\left[\beta_j - \sum_{k=0}^{j} \mathbf{P_k}\beta_k\right] = P_j\left[\beta_j - \beta\right] \tag{7}$$

The marginal probabilities measure the expected change in the probability of a particular choice being selected with respect to a unit change in an independent variable (Greene 2000).

Definition of variables

In this study, adoption is defined as the use of land management practices on farmers' plots. If a farmer who has no land management practices in their plot of land considered as non adopters. Therefore,

The dependent variable ($\mathrm{Y_i}$) in this study was the adoption or use of the land management practices by farmers on their plots of land.

The dependent variable for multinomial Logit model was described as follow:

$Y_i = 0$ if a farmer has no land management practices(LMP) (j =0);

$Y_i = 1$ if a farmer adopted stone bund ($j = 1$);

$Y_i = 2$ if a farmer adopted chemical fertilizer ($j = 2$). The chemical fertilizer referred to the application of diamonium phosphate (DAP) and/or Urea; which are commonly applied to farmland in the study area.

Previous studies indicated that factors that affect adoption decision of farm household related to demographic, socioeconomic, institutional, and plot characteristics (Shiferaw and Holden 1998; Alemu 1999; Gebremedhin and Swinton 2003; Bekele and Drake 2003; Yirga 2007). A range of independent variables that influence the adoption decisions of land management practices (LMP) by a farmer was identified based on review of related literature. Accordingly, the descriptions of independent variables were indicated in Table 2.

Before running the model, all the hypothesized explanatory variables were checked for the issue of multicollinearity. There are different methods suggested to detect the existence of multicollinearity problem between the model explanatory variables. Among these methods, correlation

Table 2 Description of independent variables

Variable name	Description	Expected sign
Age of the household head	Number of years	+/−
Education of household head	Number of years in school	+
Household size	Number of household members	+
Off-farm activity	“1” for “yes” and “0” otherwise	+/−
Distance from plot to home	Kilometers	-
Training in LMP	“1” if households get training on land management practices and “0” otherwise.	+
Credit access	“1” for “yes” and “0” for those who do not have credit access	+
Livestock ownership of the household head	in tropical livestock units (TLUs)	+/−
Farm size	total farm holding of the household in hectares	+
Land tenure security	“1” for if a household head feel “secured” and “0” otherwise	
Distance from plot to nearest market	Kilometers	−
Farming experience of the household head	Number of years	+/-
Slope of the plot as perceived by the household head	“1” = Very flat, “2” = almost flat, “3” = undulated, “4” steep, “5” = very steep	+
Plot land quality as perceived by the household head	“ 1” = very poor, “2” = poor, “3” = neither nor, “4” = good,”5” very good	?
Access to extension services	“1” = yes, 0 = otherwise	+
Availability of economic incentives for LMP	“1” = yes, 0 = otherwise	+
perception of the household head about soil erosion problem	“1” if the household head perceives soil erosion problem in his farm, “0” otherwise	+

matrices and variance inflating factor (VIF) technique is commonly used. Based on these two methods, we detected multicollineraity problem for nine variables and those variables were excluded from the analysis.

Results and discussion

Characteristics of the households

The average age of the farmers was 43.61 years with a minimum of 25 years and a maximum of 62 years. The survey results indicate that out of the 176 sample household respondents, the majorities (84.09%) were males and the remaining (15.91%) were females (mainly divorcees, widows, and unmarried women). Women-headed farmers were constrained by family labour because those women were responsible for both farming and household activities. In rural Ethiopia, males have better access to resources, information and other socioeconomic opportunities, and bear fewer burdens of household chores than females (Guteta and Abegaz 2015b). The family size of the farm household ranges from 1 to 8 with a mean family size of 4. About 41% of the sample farm households had never got formal education while almost 43% of the household heads had elementary formal education (up to six years of schooling). On average the household head had about 3 years of education.

Land is the most important natural asset to the rural households. The farmers obtained their farm lands through land redistribution which was undertaken by the peasant association representatives in 1997 in the study area and through inheritance and land allotment from families. Farm households in the Gelana sub watersheds are characterized by a high level of subsistence production and small and fragmented landholdings. Considerable difference in holding size was observed among the farm household in the study area. The average total land holding of sample households found to be 0.63 ha in the study area. The household survey (77.8% of respondents) indicated that the size of the agricultural land was decreasing over time due to population pressure. As a result, about 92.6% of the respondents said that the current land holding size is inadequate to support their family. In line with this finding, Legass (2010) reported that the shortage of farming plots was one of the severe constraints of the community to produce enough agricultural yields and sustain the basic needs of their family throughout the year in the Gerado area, south wollo, Ethiopia. Coupled with land degradation, drought proneness, and traditional farming practices and the shortage of arable lands hampered the food security of the majority of households.

With regard to security of land ownership right, about 60% of the respondents indicated that they felt secure to use their farmland by the current land tenure security of the country. It was also learned from group discussion held with farmers, most of them felt secured under the existing land tenure system. The farmers feeling of security of land might have occurred due to two main reasons. The first is that the farmers received the current land certification card. In relation to land certification, the majority of farmers (92%) asserted that the current land certification give a guarantee to invest on land management practices in their plots of land. The second justification may be in relation to the 1997 land redistribution which was undertaken in the study area by EPRDF. The majority of farmers in the study area owned their land for more than 18 years. This longer period of possession of their land could give the farmers to feel secure.

Livestock production is one of the major farming activities and livelihoods in the study area, and in this study farmers owned a wide range of livestock types that included cattle, sheep, goats, horse, mule, donkey and camel. The farmers rear livestock for various purposes, including draught power, milk, meat, transport, cash income, and manure. Livestock lie at the core of household risk management strategies in the study area since livestock selling was used to buy crops during food shortage months. The average size of livestock holding measured in terms of tropical livestock unit (TLU) was 2.62 in the study area. However, during the group discussion and in-depth interview, farmers reported that there was shortage of feed for their livestock, especially during the dry season because of the decreased productivity of available grazing lands and decrease of the grazing lands due to conversion of grazing land into cultivation land.

Farmers' perception of soil erosion and the need for land management practices

The knowledge and perception of farmers regarding soil erosion is important when we consider sustainable land management practices. About 76% of the respondents perceived soil erosion as a problem on their plot of land (Table 3).

Farmers were asked to indicate the rate of erosion over the last ten years. About 51% of the survey households indicated that the rate of soil erosion was decreasing while about 49% of the respondents stated that it was decreasing over the last ten years. The major reason for the decreasing trend of soil erosion might be attributed to farmers' investment in land management practices like the construction of check dam, stone bund, and area closure.

Farmers have their own indicators for judging the presence of soil erosion on their plots of land. Amongst the farmers who perceived soil erosion problem, the surveyed households reported the indicators in terms of gully appearance on cultivated land (9.59%); decrease in soil productivity (50%); decrease in soil depth (38.89%); decline in yield from plots (49.1%) and decrease in capacity of soils to grow a variety of crops it formerly grows (36.11%). The survey households also indicate the causes of soil erosion. Accordingly, the main causes of soil erosion were steepness of the land (82.95%), heavy rain (52.27%), overgrazing (43.75%), deforestation (75%), improper plough (25.57%), and soil too erodible type (19.32%).

Land management practices

The management of land degradation is vital to reduce poverty and maintain ecosystem health. Besides, land management improves the productivity of agriculture and income of farming communities (Legass 2010). As confirmed during group discussion and key informant interview, the farmers were well aware of the problem of soil erosion and soil fertility loss which was largely influenced by their land management practices. As a result, farmers in the study area used different land management practices in their plot of land in minimizing soil loss, enhancing soil fertility and improving the productivity of impoverished lands to attain food security. These practices include Dib/Weber, traditional ditches (*Boyi*), Traditional waterways (*Gorf Mekided*), Mixed Cropping, crop rotation, manure, chemical fertilizer, tree planting, check dam, and stone bund. Key informants and focus group discussions revealed that the use of manure was very limited around the homesteads and was negligible as a small number of household apply manure on their plot of land because farmers used animal dung as a source of fuel due to shortage of firewood. The farmers interviewed acknowledged the practice of crop rotation as the most important soil fertility management practices in the study area. The major crop rotation practiced by the farmers in the study area was from cereals to legumes on seasonal basis. Similarly, Teshome et al. (2013) reported that crop rotations are an integral part of Ethiopian farming systems.

Moreover, the household survey revealed that 35.80 and 23.30% of the farmers used stone bund and Chemical fertilizers respectively to control soil erosion and to enhance fertility status of the farm land so as to improve the agricultural productivity of the study area.

Table 3 Farmers' perception on prevalence and trend of soil erosion in the Gelana sub wateshed of Northern highlands of Ethiopia

		Frequency	% of respondents
Is there soil erosion problem on your plots of land?	Yes	134	76.14
	No	42	23.86
How do you rate soil erosion over the last ten years in the study area?	Increasing	86	48.86
	Decreasing	90	51.14

Determinants of adoption of farmers' land management practices

The factors influencing the adoption of land management practices were examined using the multinomial logit (MNL) model. The estimated MNL model coefficients, standard error, marginal effect and their significance levels were presented in Table 4. The log likelihood estimation of -29.26 and the chi-squared value of 319.10 showed that the likelihood ratio statistics are highly significant ($P < 0.001$) suggesting the model is good-fit and has a strong explanatory power. The pseudo R^2 was 0.8450 indicating the explanatory variable explained about 84.5% of the variation in choice of land management practices. This means that the empirical MNL is highly significant in explaining the choice of land management practices by farmers.

Results of the MNL analysis revealed that adoption of stone bund and chemical fertilizer was influenced by several variables. The variables found to have a significant influence include age, education, family size, slope of the plot, tenure security, training, access to farm credit, and extension service.

The age of the farm household was negatively and significantly influenced adoption of stone bund and chemical fertilizer; implying that younger farmers had a higher probability of adopting the land management practices than the older farmers, probably due to younger farmers might have longer planning horizon and more flexible in deciding to adopt new ideas and technologies. This finding corroborate with the finding of previous studies (Shiferaw and Holden 1998; Teklewold and Köhlin 2011;) but in contrast with the findings of Amsalu and De Graaff (2007) and Beshir et al. (2012). For instance, Teklewold and Köhlin (2011) reported that older household heads probably have shorter planning horizons and are physically weaker, more resistant to change, and hence less interested in adopting soil conservation practices, which have long-term effects. Education positively and significantly affects the adoption of stone bund and chemical fertilizer in the study area (Table 4). This result is in line with the findings of other empirical studies (Asfaw & Admassie 2004; Yirga 2007; Tiwari et al. 2008).

The computed marginal effect for education showed that one year t increase in schooling would result in a 16.5 and 25.6% increase in the probability of adopting stone bund and chemical fertilizer, respectively. Education is generally believed to enhance the reasoning capability of an individual and enables him to have better awareness of new technologies and hence may be more likely to adopt new technologies. According to Asrat et al. (2004) who reported that educated farmers tend to be better at recognizing the risks associated with soil erosion and hence tend to spend more time and money on soil conservation.

Families are an important source of labor for farm operations and construction of land management practices. The household size was positively and significantly affects the adoption of soil bund and chemical fertilizer (Table 4). This suggests that households that are endowed with family labor tend to use labor intensive land management practices. This is in line with the findings of Gebremedhin and Swinton (2003) who stated that the presence of more working-age household members favored adoption of labor-demanding stone terraces. Kassie et al. (2009) also reported that the probability of adopting conservation tillage increased with the number of household members because conservation tillage adoption was labor intensive.

Slope of the plot was positively and significantly influencing the adoption of stone bund. This suggests that farmers are more likely to use stone bund on steep slopes that are susceptible to more rapid surface runoff. This is in line with the finding of previous studies (Gebremedhin and Swinton 2003; Asrat et al. 2004; Amsalu and De

Table 4 Marginal effects from Multinomial logit land management practices model

Variable	Stone bund			Chemical fertilizer		
	Coefficient	Standard error	Marginal effect	Coefficient	Standard error	Marginal effect
Age	-0.4559372	0.2257546	-0.0480113[b]	−0.4037107	.2358476	-0.0577354[a]
Education	1.67886	0.8023329	0.1653551[b]	1.702512	.8062886	0.2563915[b]
Family size	5.955979	2.540778	0.6342278[b]	5.140588	2.486968	0.7272045[b]
Slope	12.01226	5.195372	1.398967[b]	8.104238	4.994441	1.007615
tenure	9.056054	3.980339	0.3856156[b]	9.054743	3.875805	0.5820099[b]
training	11.76948	5.303237	0.2844511[b]	13.39839	5.614912	0.6888264[b]
Farm credit	7.353151	4.980221	-0.0428227	13.79203	5.264193	0.980661[c]
Extension service	8.615629	4.020413	0.2988511[b]	9.54752	4.066243	0.6747259[b]

Base category = No land management practices
Log likelihood = −29.262667 Number of observation = 176
LR chi2(16) = 319.10; Prob > chi^2 = 0.0000; Pseudo R^2 = 0.8450
[a], [b], [c] = significant at 10%, 5% and 1% probability level respectively

Graaff 2007;Kassie et al. 2009; Wossen et al. 2015) who reported that slope of the plot has been found positively and significantly affect adoption decision on land management practices. Amsalu and De Graaff (2007) reported that farmers invest on plots where they expect more benefits from conservation and conservation efforts should target areas where expected benefits are higher, like on the steep slopes, in order to encourage adoption. Moreover, slope significantly increased the probability of using stone bund by 1.4 units (Table 4). This result implies that farmers are more likely to invest conservation measures where their farm plots are located in steep slopes.

Land tenure security has been shown to be an important factor affecting farmers' conservation decisions. The general agreement is that land users must have secure property ownership rights of the lands they cultivate if they are to invest in conservation work in anticipation of long-term benefits (Bewket 2007). Results in Table 4 indicated that land tenure security positively and significantly influenced the adoption of stone bund and chemical fertilizer in the study area. This implies that land tenure security encourages and provides incentives for investments in land management practices. The result of the marginal effect indicates that tenure security significantly increases the likelihood of adoption of stone bund and chemical fertilizer by about 38.6 and 58.2% respectively, holding other variables constant. This finding confirms results of previous studies in Ethiopia that report the importance of tenure security in the adoption of land management practices (Gebremedhin and Swinton 2003; Teklewold and Köhlin 2011; Belay and Bewket 2013).

The positive and significant relationship between access to training and adoption of stone bund and chemical fertilizer suggests that farmers' training promote investment on land management practices. The results of marginal effect showed that access to training significantly increases the probability of adopting stone bund and chemical fertilizer by about 28 and 69%, respectively. This finding corroborate with the finding of Guteta and Abegaz (2015a). Ketema and Bauer (2012) reported that the farmers' knowledge gained through training enables them to be equipped with the technical knowhow required for constructing conservation structures and it makes them far-sighted to look for long-term benefits through sustainable production and land management practices rather than immediate benefits obtained at the expense of soil quality.

The availability of credit is important for the farmers' to purchase improved technologies and to solve financial constraints. The study showed a positive and significant relationship between farm credit and chemical fertilizer adoption. The marginal effect indicated that the farmer who has access to credit significantly increases the probability of using chemical fertilizer by 98%. This implies that the use of credit encouraged farmers to invest in land management practices. This is consistent with the finding of Yirga (2007) who reported that access to credit for the purchase of inorganic fertilizers found to have a significant positive impact on the likelihood of using inorganic fertilizers.

Agricultural extension services are the major sources of information for improved agricultural technologies. One means of which, farmers' access information about improved technologies is by contacting the extension agent (Beshir et al. 2012). Results also revealed that access to extension service positively and significantly affects the adoption of stone bund and chemical fertilizer. This finding suggests that providing agricultural extension services for the farmers will help to increase the adoption of land management practices to ensure sustainable agricultural production in the study area. The result of marginal effect also showed that access to extension contact (contact of the farmer with the development agents) increased the probability of the farmer to adopt stone bund and chemical fertilizer by 29.9 and 67.5%, respectively. This indicates that farmers who have access to contact with development agents would get the necessary information to acquire new skills and knowledge related to agricultural technologies and this also positively contributes to awareness and subsequent adoption of new technologies.

The result of this study is similar with the findings of previous studies on adoption (Bekele and Drake 2003; Ketema and Bauer 2012; Guteta and Abegaz 2015a).

Conclusions

This study used household survey data of smallholder farmers in the Gelana sub-watershed of northern highlands of Ethiopia to investigate the factors influencing farmers' decisions to adopt land management practices, with a particular focus on the adoption of stone bund and chemical fertilizer.

In the study area, a number of factors affect the adoption decision of farmers on land management practices. The result of the multinomial logit (MNL) model showed that land management practices were significantly influenced by age, education, family size, slope of the plot, tenure security, training, access to farm credit, and extension service.

The likelihood of adoption of stone bund and chemical fertilizer was observed to be higher with increase the level of education, increase in family size, tenure security, access to extension service and training. The age of the farmer was significant on probability of adoption of stone bund and chemical fertilizer. Younger farmers adopted more land management practices than older farmers.

Slope of the plot play a critical role for adoption of stone bund while the adoption of chemical fertilizer was likely to increase with availability of farm credit. However, farm credit and slope of the plot did not significantly influence the adoption of stone bund and chemical fertilizer, respectively. Therefore, policies aiming at promoting sustainable land management practices need to emphasize the crucial role of continuous investment by providing information on better conservation strategies to enable farmers to increase agricultural production. The findings also suggest that improve farmers' education status and increase the availability of credit to reduce poverty and increase income would enhance the adoption of land management practices.

Acknowledgements
The authors would like to thank to the International Foundation for Science (IFS) for providing financial support to the first author under grant number D/5639-1 and Addis Ababa University for the small financial support for this study. We also would like to thank the farmers, agricultural development agents, and local administrators of the study area for their assistance during the field work.

Authors' contributions
BA has made substantial contributions in the design, data collection, data entry, data analysis and interpretation of results. He also drafted the manuscript. AA has also contributed in sampling design and revision of the draft manuscript. Both authors have read and approved the final manuscript.

Competing interests
The authors declare that they have no competing interests.

Publisher's Note
Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

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Received: 16 September 2016 Accepted: 20 April 2017
Published online: 01 June 2017

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