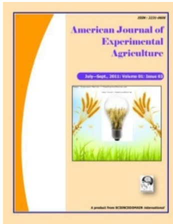

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Determinants of Farmers' Decision on Soil Fertility Management Options for Maize Production in Southern Ethiopia

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Authors' contributions

This work was carried out in collaboration between all authors. Author EG designed the study, performed the statistical analysis and wrote the first draft. Author AB verified the study design, checked the analyses of the study and wrote the final manuscript. Authors BK and EE looked after the study protocol and managed the literature searches. All authors read and approved the final manuscript.

Research Article

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ABSTRACT

In Ethiopia, food insecurity has always been a burning problem. The gap between demand for and supply of food can be minimized through protecting and managing soil fertility and thereby increasing productivity of crops. This study was conducted in major maize growing areas of southern Ethiopia. The objectives of the study were to assess soil fertility management options available to smallholder farmers and identify the factors that affect their decision making to apply a given alternative in maize crop. The study was based on the cross sectional data obtained from a random sample of 385 smallholder farmers. A multinomial logit model was employed to identify socioeconomic, institutional and environmental factors determining farmers' decision regarding the choice of a particular soil fertility management option. The result indicated that size of farm, access to credit, availability of extension services and training pertaining to soil fertility management were important factors affecting the decision to use a particular soil fertility management practice.

Keywords: Maize; multinomial logit model; Southern Ethiopia; soil fertility management.

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1. INTRODUCTION

Land degradation and decline in soil fertility have become serious threats to agricultural productivity in Sub-Saharan Africa. The declining fertility of soils because of soil nutrient mining is regarded as a major cause of decreased crop yields and per capita food production in Africa; and decreasing soil fertility accompanied with increasing population pressure is one of the major causes of the gap between demand for and supply of food [1;2]. The use of mineral fertilizers has been considered as crucial to boost crop productivity specifically that of cereal crops. Soils in most of the Sub-Saharan Africa have inherently low fertility and do not receive adequate nutrient replenishment [3;4].

In southern Ethiopia, various attempts have been made for about four decades to restore the fertility of degraded arable lands since the early 1970s. The aim of these efforts was to improve the crop and livestock productivity and to increase the production of raw materials for domestic use and for export. Greater emphasis was given to the promotion the use of modern inputs such as improved seeds and mineral fertilizer. Facilitating the provision of fertilizer and promoting soil fertility replenishing technologies received continuous attention in all past extension programs. These efforts, however, have not helped much in increasing agricultural productivity and production in the Wolaita and Gofa area of southern Ethiopia as can be portrayed from ever worsening food insecurity and pervasive poverty [5]. The areas are highly food insecure due to a combination of factors including high population pressure, low soil fertility and frequent rainfall irregularities [6]. The level and extent of use of soil fertility management technologies remains low and the gains in productivity were far from expectations.

Maize is major staple and cash crop produced in Ethiopia in greater extent than any other crop [7]. In the package of production practices recommended for improvement of maize productivity, fertilizer is recommended as a key input. However, its application has been low due to a number of factors that influence the decision of smallholder farmers in choosing soil fertility management practices. Information on ways to reduce risk and uncertainties farmers face in choosing appropriate soil fertility management options remains scanty. This study was, therefore, undertaken to assess the soil fertility management decisions of smallholder farmers in southern Ethiopia and identify factors influencing the choice of alternative soil fertility management options.

2. METHODOLOGY

2.1 The Study Areas

This study was carried out in Wolaita and Gamo Gofa zones of Southern Nations, Nationalities and Peoples Region (SNNPR) of Ethiopia. Wolaita zone encompasses agro-ecologies of high, middle and low altitude land areas with proportion of 9; 56; and 35 percent, respectively, distributed across 12 districts. The total population of the zone was estimates at 1,527907, out of which 752,668 were males and 775240 were females [8]. The zone has asphalt and all weather roads which interconnect the entire 12 districts with exits to neighboring zones and regional capital or all central parts of the country. Wolaita Sodo, which is the capital of the zone, is situated at about 390 km from Addis Ababa on the line through Shashemene to Arbaminch. With rainfall dispersed throughout the year into two main rainy seasons and small showers in dry months, there is usually some crop growing in the fields or home gardens. It is an area of intensive agriculture; where farming system combines annual and perennial crops. The use of improved soil fertility management practices such as mineral fertilizer and compost has been in place in the zone for more than four decades since the time of Wolaita Agricultural Development Unit (WADU), a World Bank financed project, which introduced improved agricultural technologies in the area.

Gamo Gofa zone is situated bordering Wolaita and has wider agro-ecological and socio-cultural settings. The general elevation of the zone ranges from 600 to 3300 meters above sea level. According to the population census of Ethiopia [8], the total population of Gamo Gofa zone was 1,595,570 (794,845 males and 801,085 females). Arbaminch is the capital town of the zone, located at 505 km from Addis Ababa. This study was concentrated in Gofa area of Gamo Gofa zone located west of Arbaminch town behind the humid mountainous highland agro-ecology dissecting the mid and lowland agro-ecologies. This area was specifically selected from the zone for the study on the basis of its high extent of maize production and representativeness for maize producing areas. It is located some 140 km south from Wolaita Sodo. There are seven districts in this area having high, middle and low altitude land areas. The level of use of mineral fertilizer and other improved soil fertility management practices in this area is very low even though there has been continued effort by the government's agricultural extension program for more than a decade. Most farmers are still reluctant to the use of mineral fertilizer despite the fact that fertilizer use has been promoted by the government. Even though farmers recognize some yield advantage over the local practice, they believe it is not enough to cover the high cost of fertilizer due to low market price of maize output.

2.2 Sampling Procedure and Data Analysis

In order to select sample households, multistage sampling technique was followed. In the first stage, study districts were purposively selected based on the extent of maize production. Two districts were selected from both Wolaita and Gofa areas. In the second stage 2-3 villages where different soil fertility management practices have been promoted by extension agencies were selected from each district based on the discussion with district agricultural extension service officers. Finally sample farmers who have been participating in the soil fertility management efforts were randomly selected from each village to administer the survey.

The sample size for the study was determined based on the following formula given by Yamane [9].

$$n = \frac{Z^2 pq}{e^2} \quad (1)$$

where n = the sample size needed.
Z = the inverse of the standard cumulative distribution that corresponds to the level of confidence.
e = the desired level of precision.
p = the estimated proportion of an attribute that is present in the population and
q = 1-p.

With the assumption that there is large population but we do not know the variability in the proportion about the use of soil fertility management practices, p = 0.5 was considered.

Based on this, a total of 385 households were selected for the study assuming a 95 percent confidence level and ±5 percent precision. The households were selected from each village using random sampling method. The dataset contained detailed information on household's socioeconomic and demographic characteristics, farm characteristics, input utilization and institutional as well as policy related variables.

2.3 Conceptual Framework and Empirical Model

The conceptual framework for analysis of soil fertility management decisions is based on the approach to consumer theory developed by Lancaster [10]. It is assumed that the choice of soil fertility management option is an activity in which the alternative options, singly or in combination, are inputs in which the output is a collection of characteristics. The neoclassical economic theory assumes that each decision-maker is able to compare two alternatives *a* and *b* in the choice set using a preference-indifference operator $\geq$. If $a \geq b$, then the decision-maker prefers either *a* to *b*, or is indifferent. Utility rankings are therefore assumed to rank collection of alternatives indirectly through the characteristics that they possess. A given soil fertility management option embodies a number of characteristics that may influence choice decisions. In addition, given characteristics of alternative soil fertility management outcomes, other socioeconomic and demographic characteristics of the farm household may influence the choice of an option. Then the observed choice for an alternative soil fertility management option is likely to be the result of a complex set of interactions between comparable alternatives and farmers' socioeconomic and demographic characteristics.

Soil fertility management decisions involve choices between alternative management practices. A multinomial logit (MNL), therefore, can be used to analyze the decision behavior of smallholder farmers in using soil fertility management technologies. The dependent variable (in this case the choice of soil fertility management options) is a discrete variable with J+1 alternatives (j = 0, 1, 2... J). Multiple response choice models, such as MNL and multinomial probit (MNP), are more desirable compared to binomial logit and probit models in that they allow exploring factors conditioning specific management practices as well as combination of management practices. These models estimate the effect of explanatory variables on a dependent variable involving multiple choices. This study used a MNL model to analyze the soil fertility management decisions of smallholder farmers involving multiple unordered discrete dependent variables based on the specifications by Greene [11]. The MNL model is based on the random utility model. The utility to a user of an alternative is specified as a linear function of the household and the farm specific characteristics, the attributes of alternative institutional factors as well as a stochastic component. The probability of choosing an alternative is equal to the probability that the utility of that particular alternative is greater than or equal to the utilities of all other alternatives in the choice set.

The soil fertility management choices included in the model were Mineral Fertilizer only (MF), Farmyard Manure only (FYM), Compost only (COM), Crop rotation only (CRO), crop residue (CRE), integrated soil fertility management (ISFM) and no soil fertility management (NO). Thus, the dependent variable was defined as a discrete variable taking values 0, 1, 2, 3, 4, 5 and 6 representing the above choices. The MNL provides a set of probabilities for the J+1 choice set for a farmer with characteristics X_i as follows.

$$\text{Prob}\left(Y_i = j \middle| X_i\right) = \frac{e^{\beta_j X_j}}{1 + \sum_{k=1}^{J} e^{\beta_k X_i}} \text{ for j = 0, 1, 2... j, } \beta_0 = 0 \tag{2}$$

The MNL model assumes that the odds for pair of outcomes are determined without reference to the other outcomes that might be available. This is known as the independence of irrelevant alternatives (IIA) property. Hausman and McFadden [12] proposed a Hausman-type test of this hypothesis. Basically, this involves the following steps. First, estimating the full model with J outcomes included; these estimates are contained in $\hat{\beta}_F$. Secondly, estimating a restricted model by eliminating one or more outcome categories, these estimates are contained in $\widehat{\beta}_R$. Finally, assuming $\hat{\beta}_F^*$ as a subset of $\hat{\beta}_F$ after eliminating coefficients not estimated in the restricted model, the Hausman test of IIA is defined as:

$$\mathrm{H_{IIA}} = (\widehat{\beta}_R - \hat{\beta}_F^*)'\left[\widehat{\mathrm{var}}(\widehat{\beta_R}) - \widehat{\mathrm{var}}(\hat{\beta}_F^*)\right]^{-1}(\widehat{\beta_R} - \hat{\beta}_F^*) \tag{3}$$

where $\mathrm{H_{IIA}}$ is asymptotically distributed as chi-square with degrees of freedom equal to the rows in $\widehat{\beta}_R$ if IIA is true. Significant values of $\mathrm{H_{IIA}}$ indicate that IIA property has been violated. Hausman and McFadden noted that $\mathrm{H_{IIA}}$ can be negative and a negative $\mathrm{H_{IIA}}$ is evidence that IIA holds. The log-likelihood can be derived by defining, for each farmer, d_{ij}=1 if the soil fertility management alternative j is best preferred by the farmer i and 0 if not, for the J-1 possible outcomes. Then for each i, one and only one of the d_{ij}'s is 1.

The parameter estimates of the MNL model provide only the direction of the effect of the independent variables on the dependent variable, but estimates do not represent either the actual magnitude of change nor probabilities. Differentiating equation (2) with respect to the explanatory variables provides the marginal effects of explanatory variables on soil fertility management choice variable. Accordingly, the marginal effects of characteristics on the probabilities can be obtained by differentiating equation (2) as follows:

$$\delta = \frac{\partial P_j}{\partial X_i} = P_i\left[\beta_j - \sum_{k=0}^{j} P_K \beta_k\right] = P_j\left[\beta_j - \overline{\beta}\right] \tag{4}$$

where $\overline{\beta} = \sum P_j \beta_j$ is a probability weighted average of the β_j. The signs of the marginal effects could be different from the signs of coefficients due to $\overline{\beta}$.

2.4 Variable Specification

The decision to choose a particular soil fertility management option depends on agro-ecological, farmer and farm specific as well as institutional factors. These factors include the agro-ecological location of farm household, sex of household head, livestock holding of the household, farm size, number of farm plots, use of hybrid maize variety, extension visit, distance from farm to village development center, training received on the use of improved soil fertility management, off/non-farm income and access to credit.

The agro-ecological variable (AGROECO) takes values 1, 2 and 3 for high, middle and low altitude land areas, respectively. Sex of household head (SEX) is a dummy variable which takes the value 1 for women headed and 0 for men headed households. Total livestock holding of the household is measured as a continuous variable in terms of the tropical livestock unit (TLU). Farm size (FARMSIZE) refers to the total land available to the household as cultivated, fallowed, grazing, and tree land measured in hectares. The variable number of plots (NUMPLOTS) represents the total number of plots available to the household in separate locations.

The use of hybrid maize seed (HYV) is measured as a dummy variable taking the values 1 if the farmer has planted hybrid maize seed and 0 otherwise. Extension visit (EXTVISIT) refers to availability of extension service to the famer taking values 1 if the extension agent has visited farmer's field during the cropping season from the beginning to the end and 0 otherwise. The distance from farm to village development center (DISTDC) is measured as continuous variable in hours taken to walk from farmer's residence to the village development center. Training received on the use of improved soil fertility management (TRAINSFM) is measured as a dummy variable taking values 1 if the farmer has received such training and 0 otherwise. Off/non-farm income (OFFINCOME) is a continuous variable measured in birr representing total income earned from off-farm and non-farm sources. Access to credit (CREDIT) is measured as a dummy variable taking 1 if the farmer has received credit for maize production and 0 otherwise.

3. RESULTS AND DISCUSSION

3.1 Soil Fertility Management Decision Outcomes

The decisions to adopt a given soil management technology by an individual farmer are not made in isolation. They are made in the context of the whole farm and of the totality of the resources and assets available to the farmer [13]. These resources and assets include: (i) labor (family labor plus hired labor if sufficient cash is available), (ii) cash to buy fertilizer and other minerals, (iii) their entire landholding and the different fields comprising it, (iv) purchased assets such as implements, machinery, animal traction, (v) access to water (either on farm or off farm), and (vi) access to other off-farm resources (such as communal resources, forested lands and woodlots). Farmers focus on the trade-offs between the efforts they have to make to meet their production objectives and the payoffs they expect from these efforts. They consider the totality of their holding and its various current and potential uses vis-à-vis their production objectives and weigh these in terms of the outcomes they expect when combining their resources into different practices (including soil fertility management). Chinangwa [5] reported that the use of alternative soil fertility improvement technologies is affected by different factors.

Farmers in the study areas apply different soil fertility management practices to produce maize depending on their choice which is a function of several natural, socioeconomic and institutional factors. These soil fertility management options include the use of practices such as mineral fertilizer only, farmyard manure only, compost only, crop rotation, crop residue and integrated soil fertility management. However, about 12 percent of sample farmers applied no soil fertility management practice at all. It can be depicted from Table 1 that about 82 percent of the sample households used either mineral fertilizer or integrated soil fertility management for maize production.

Table 1. Soil fertility management practices used by farmers for maize production

Soil fertility management practice	Frequency	Percent
No soil fertility management (NO)	45	11.7
Mineral fertilizer only (MF)	157	40.8
Farmyard manure only (FYM)	13	3.4
Compost only (COM)	6	1.6
Crop rotation (CRO)	1	0.3
Crop residue (CRE)	4	1
Integrated soil fertility management (ISFM)	159	41.3
Total	385	100

3.2 Determinants of Farmers' Decision of Soil Fertility Management

The result pertaining to MNL model on soil fertility management decisions are presented in Table 2. The main factors affecting the choice and use of the alternatives include agro-ecology, sex of household head, farm size, number of farm plots owned, high-yielding varieties, extension visit, training and access to credit.

Table 2. Empirical results of soil fertility management decisions based on MNL model

Variable	MF	FYM	COM	CRO	CRE	ISFM
AGROECO	-1.356***	-0.995	-0.328	594.435	19.849	-2.807***
SEX	-24.267***	-24.036***	2.650	-4726.385	-7.755	-23.328***
TLU	0.048	-0.267	0.190	-810.609	-0.828	0.029
FARMSIZE	0.712**	0.253	-1.035	920.801	1.813**	0.481
NUMPLOTS	-0.1918	-0.158	-20.143***	-1509.155	.054	-0.222
HYV	1.3279***	-0.370	-.4184	1032.973	.265	1.131***
EXTVISIT	1.657***	-0.574	1.686	478.345	1.693	1.157
DISTDC	-0.690	-0.901	-1.166	522.779	0.924	-0.862
TRAINSFM	0.977**	1.637*	0.143	10875.23	-0.246	1.332***
OFFINCOME	0.0002	0.0004*	0.0004	0.713	-0.002	0.0002
CREDIT	1.625**	0.132	-43.627	5594.295	-43.070	1.376**
Constant	25.569	25.509	16.375	-13617.74	-54.777	28.629
Log likelihood	-348.83317					
Number of obs.	378					
LR chi^2 (66)	227.36					
Pseudo R^2	0.2458					

****, ** and * indicate the level of significance at 1, 5 and 10 percent, respectively.*

Mineral Fertilizer Use: Mineral fertilizer refers to fertilizers DAP and Urea fertilizers which are recommended for maize production in the study areas. Kumwenda et al. [14] argued that the use of mineral fertilizer outside of the large scale commercial sector is still very low in southern and eastern Africa. It was near seven kg of fertilizer per hectare that is the average for sub-Saharan Africa in contrast to the most parts of the world where mineral fertilizers play a major role in maintaining or increasing soil fertility. For example fertilizer use in Africa is less than 10 percent of that in Asia [1]. Farmers in SSA lag far behind other developing areas in fertilizer use [15] (Crawford *et al.*, 2006). The average intensity of fertilizer use throughout SSA (roughly 9 kilograms per hectare) is much lower than elsewhere (e.g., 86 kg/ha in Latin

America, 104 kg/ha in South Asia and 142 kg/ha in Southeast Asia averaged over the 2000-2001 and 2002-2003 years).

The world food and fertilizer price hypes from 2006 to 2008 highly affected fertilizer use in SSA, which accounted for only one percent of the global fertilizer use [16]. It was indicated that major fertilizers like DAP witnessed about 320 percent increase in price from 2006 to 2008 while urea had a 160 percent price increase compared to just 108 percent for maize. This makes it difficult for smallholder farmers to afford fertilizer which plays key roles to economies highly dependent on agricultural production for domestic food production and for export [17].

The results MNL model revealed that the use of mineral fertilizer was significantly influenced by agro-ecological zone, sex of the household head, family size, use of hybrid maize seed, training received on improved soil fertility management practices and access to credit. This was consistent with other studies conducted on the use of mineral fertilizer. For instance a study in Nepal on the adoption of fertilizer for maize production found out that the decision to use fertilizer is influenced by a number of important factors [18]. Family size, farm size, credit use, off-farm income and timely irrigation availability were found to be important determinants of decision making regarding fertilizer use.

Agro-ecological location of the household, rated from high altitude areas to low altitude areas in an ascending order, negatively and significantly influenced the use of mineral fertilizer at less than one percent significance level. This suggests that the farmers in the extreme low lands are unlikely to use mineral fertilizer due to the perception that their soils are fertile and low coverage of extension advice, and also due to uncertainty of rainfall which may affect the farmers' risk taking behavior to spend on fertilizer. On the contrary, the farmers in the mid- and high-altitude areas are more likely to apply mineral fertilizer for maize production as the soil fertility status was low in these areas.

The sex of the household head negatively influenced the use of mineral fertilizer at less than one percent level of significance. Thus, female-headed households are less likely to use mineral fertilizers, as compared to male-headed households. This could be due to the low risk bearing capacity of female-headed households, resulting from their meager resource positions and cash constraints they face to purchase mineral fertilizer.

Farm size had a positive and significant effect on the use of mineral fertilizer at 5 percent level of significance. This indicates that farmers with large farms are more likely to use mineral fertilizers for maize production than farmers with small farms. Farmers that had small farms would opt to choose low external input or did not use mineral fertilizer to produce the crop. One of the reasons for this could be that using mineral fertilizer requires farmers to have at least reasonable size of cultivated land (e.g. 0.25 ha) to be eligible by extension system to be beneficiary of mineral fertilizer and hybrid seed. Moreover, since the farm sizes in the study areas are getting smaller and smaller due to population growth, the probability of the application of mineral fertilizer for yield improvement could be threatened as diminutive and fragmented farm sizes can be one of the disincentives for mineral fertilizer use.

The use of hybrid maize seed had a positive and significant effect on the decision to use mineral fertilizer to produce maize. This implies that the use of mineral fertilizer is highly related to the use of improved maize seed, since the use of improved varieties requires the application of mineral fertilizer as part of the package of technologies for maize production.

The result suggests that the promotion of hybrid varieties by extension service, together with other yield improving technologies including mineral fertilizer as major component is regarded as a vehicle for increasing the use of mineral fertilizer.

Extension visit played a highly significant role in influencing the use of mineral fertilizer at less than one percent level of significance. Farmers who were visited by the extension worker during and before the cropping season in 2009/10 applied mineral fertilizer for maize production more than others. This reveals that increased number of extension workers is crucial for increased awareness and use of mineral fertilizer.

Training received on improved soil fertility management practices positively and significantly affected the farmers' decision to use mineral fertilizer at less than one percent significance level. The probability of mineral fertilizer use by the farmers who participated in soil fertility management trainings was higher than those who did not. Therefore, trainings play vital role in creating awareness about the technology and improving the skill level of the farmers in the application of mineral fertilizer. As a result, increased efforts to regularly organize farmers' trainings on the use of improved soil fertility management practices are likely to increase the probability and level of use of mineral fertilizer for maize production.

Access to credit had a positive and significant influence on the decision to use mineral fertilizer at 5 percent level of significance. This could be due to the reason that easy credit availability tackles capital constraints faced by smallholder farmers to acquire the purchased inputs, especially mineral fertilizer.

Farmyard Manure Use: Farmyard manure is regarded as a key input of farm production in the study areas. The MNL model result showed that sex of household head, training received on soil fertility management and the amount of off-farm income earned were important factors determining the use of farmyard manure.

The use of farmyard manure was highly influenced by the sex of the household head at less than one percent level of significance. The negative relationship between the probability of farmyard manure use and the sex of the household head suggests that female-headed households had lesser labor required to transport farmyard manure for maize production which is usually located in the outfield. This limited labor supply was a major production constraint of female-headed households. Furthermore, farmyard manure use is restricted to the availability of livestock. As a result, the low livestock holding of female-headed households inhibited their use of farmyard manure.

Training received on the use of improved soil fertility management practices had a positive and significant effect on the decision to use farmyard manure. Increased access to knowledge and skill required to better utilize farmyard manure is likely to improve the probability of use of using farmyard manure. Consequently, strengthening the farmers' training on soil fertility management is a factor responsible to reduce mismanagement and wastage of farmyard manure and utilize it as components of improved soil fertility management option.

The availability and magnitude of off/non-farm income had a positive and significant effect on the decision to use farmyard manure as a soil fertility management option. This could be because farmers who are engaged in off/non-farm employment have limited resources and could not afford buying mineral fertilizer. The next alternative for them is, therefore, to use farmyard manure. Additionally, since there is no market for farmyard manure and its alternative uses are limited, it is more likely to be used as a soil fertility amending input for crop production.

Compost Use: The use of compost as a soil fertility management option has been promoted by extension programs since long. However, its application has been restricted to few farmers and homestead horticultural crops. Efforts that encourage the application of compost for field crops like maize were threatened by its high material and labor demanding nature which resulted in farmers' reluctance to use it as an option for soil fertility management. As result, the use of compost was not influenced by most of the variables hypothesized. It was affected only by the number of farm plots the farm households possess. The negative and significant relationship between the number of farm plots and the use of compost can also be related to bulkiness and labor demanding nature of the resource. If there are many plots located in different places, transportation and application of compost would be difficult resulting in lower use of the option. Therefore, farmers with a large number of farm plots in different locations were less likely to use compost for maize production.

Crop Residue Use: Incorporating the leftovers of crops after harvesting time has been considered as one of the soil fertility amending practices that reduces the amounts of nutrients mined from farm fields. Although there are a number of competing uses of crop residues such livestock feed, fuel wood and construction material were found to be existing in the study areas, the farmers with large farms left maize stalk after harvest and incorporate it into soil while preparing the land for the next cropping. The decision to use crop residue as a soil fertility management option for maize production was positively influenced by farm size at 5 percent level of significance. As expected, farmers with larger farms incorporate more crop residues to enrich the soil for the next cropping.

Integrated Soil Fertility Management Use: The integrated soil fertility management refers to a set of soil fertility management practices that necessarily include the use of fertilizer, organic inputs, and improved germplasm combined with the knowledge on how to adapt these practices to local conditions, aiming at maximizing agronomic use efficiency of the applied nutrients and improving crop productivity [19]. Differences in access to resources for farm production and variability of soil fertility within and between farms are key determinants of crop productivity at household level [20]. In this study, the agroecological location of the farm households had statistically significant and negative effect on the farmers' decision to use integrated soil fertility management at less than one percent level of significance. The negative sign suggests that the farmers in low altitude are less likely to apply the integrated soil fertility management practice than those farmers in middle altitude and high altitude areas. The level of the application of integrated soil fertility management decreased as one goes form highland areas to lowland areas. Therefore, the probability of the application of integrated soil fertility management practice for maize production is less likely to be practical in lowland areas, where farmers face recurrent moisture stress problems. On the other hand, integrated soil fertility management practice could be more practical in highland areas, where there is relative rainfall stability and better awareness about improved soil fertility management practices.

The decision to use integrated soil fertility management practice was negatively and significantly affected by the sex of the household head. That is, the probability of the application of integrated soil fertility management for maize production was lower for female-headed households than male-headed households. This could be reasoned out by the resource limitation of female-headed households. Besides, female-headed households usually experience labor shortage problem as they head their households either because they are widowed or their husbands are absent. Consequently, they are less likely to apply integrated soil fertility management to produce maize.

Using hybrid maize seed had highly significant effect on the decision to use integrated soil fertility management at less than one percent level of significance. This is because the use of hybrid maize seed requires farmers to use better soil fertility management as the high yielding varieties are high input feeders. In addition, the farmers who decided to purchase hybrid maize varieties were better-off in terms of resource availability and knowledge that can enhance their decision-making capacity. Therefore, farmers who use hybrid maize varieties are more likely to apply integrated soil fertility management than those who use local varieties.

Training received by farmers on improved soil fertility management had a positive and significant effect on farmers' decision to use the integrated soil fertility management at less than one percent level of significance. This implies that trainings on the use of integrated soil fertility management can improve farmers' skill and knowledge of the technology and enhance the decision to use the practice. Thus, farmers' participation in soil fertility management trainings is a key factor to increase the probability of the application of integrated soil fertility management.

Access to credit was also an important institutional variable that significantly influenced the farmers' decision to use integrated soil fertility management practices at less than 5 percent level of significance. Farmers who have got access to sufficient credit are more likely to apply integrated soil fertility management than those who have no or limited access. This shows that improving farmers' access to credit improves their ability to purchase inputs required for integrated soil fertility management and increases the probability of use of integrated soil fertility management.

3.3 Effects of Changes in Determinant Factors

According to the MNL model results, the most important soil fertility management decision outcomes were mineral fertilizer, farm yard manure and integrated soil fertility management. The marginal effects of significant explanatory variables on the probability of each of these outcomes have been presented in Table 3. A change in agro-ecology from high to middle altitude area or from middle to low altitude areas reduces the probability of use of mineral fertilizer as a soil fertility management practice by about 31 percent. Moreover being woman household head reduces the probability of use of mineral fertilizer by about 24 percent. A one hectare increase in farm size would lead to 6.5 percent increase in the probability of use of mineral fertilizer. A change in the use of hybrid maize variety from being non-user to user increases the probability of use of mineral fertilizer by more than 8 percent.

A change in the variable extension visit from 0 to 1 would increase the probability of use of mineral fertilizer for maize production by 16.5 percent. A change in status of the farmer from being non-trained to trained farmer on the use of improved soil fertility management options would result in 7 percent increase in the probability of use of mineral fertilizer. A change of household from being non-user to user of credit service for maize production leads to more than 8 percent increase in the probability of farmers' use of mineral fertilizer.

With respect to the marginal effects of explanatory variables on the decision to use farmyard manure a change in the dummy variable sex from 0 to 1 would lead to a slight (0.3 percent) decrease in the probability of the use of farmyard manure as a soil fertility management option for maize production. A change in the training variable form 0 to 1 increases the probability of using farmyard manure.

A unit change in agro-ecological location of household from high to middle altitude area or from middle to low altitude area would reduce the probability of use of integrated soil fertility management by about 38 percent. Similarly, a change in sex of household head from male to female reduces the probability of use of integrated soil fertility management by 19 percent. A change in the status of the household head from non-user to user of hybrid maize results in one percent increase in the probability of use of integrated soil fertility management. Likewise, a change in the values of dummy variables training and access to credit from 0 to 1 would result about 10 and 4 percent increase in the probability of use of integrated soil fertility management practices, respectively.

Table 3. Marginal effects of explanatory variables on soil fertility management decision outcomes

Variable	Marginal effects		
	MF	FYM	ISFM
AGROECO	0.313	0.015	0.379
SEX	0.237	0.003	0.190
FARMSIZE	0.065	0.005	0.046
HYV	0.083	0.034	0.010
EXTVISIT	0.165	0.057	0.057
TRAINSFM	0.070	0.007	0.097
CREDIT	0.083	0.016	0.039

4. CONCLUSION

The study has identified different soil fertility management practices applied by farmers in the study areas including mineral fertilizer, farmyard manure, compost and integrated soil fertility management. Agro-ecological location of households had a significant influence on the use of mineral fertilizer and integrated soil fertility management. Accordingly, raising the awareness of farmers in the low altitude areas about the benefits of improved soil fertility management practices through field demonstrations needs to be emphasized. Efforts that improve output market performance are required to reduce lowland farmers' fear of risks in decision making. The probabilities of use of mineral fertilizer, farmyard manure and integrated soil fertility management were found to be less in the case of women-headed households. Efforts have to be made to improve women's access to credit and initiate women empowerment programs. Training played a significant role in farmers' decision to use mineral fertilizer, farmyard manure and integrated soil fertility management for maize production. Hence, improvement of the quality and coverage of focused training programs should be undertaken to improve soil fertility. Size of farm and number of farm plots were also important factors that influenced farmers' choice of soil fertility management technologies. This suggests the need for consolidation of farm plots to increase farm size and concentration of efforts that promote the use of improved soil fertility management practices on farmers who have few or single large plots.

COMPETING INTERESTS

The authors did not have any competing interests.

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