Determinants of Manure and Fertilizer Applications in Eastern Highlands of Ethiopia

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Abstract

Despite the fact that erosion undermines productivity in the Ethiopian highlands, adoption of fertility enhancing techniques remained very minimal. The objectives of this study is to examine factors affecting adoption of fertilize and manure use and their interrelationships using plot and household level data collected from 211 farm households. A two-stage probit model results revealed a negative reciprocal relationship between fertilizer use and manure applications, basically because of the difference in additional resource requirements for application of the two inputs. Whereas prices of chemical fertilizers are very high in the study area, manure is labor-intensive in its application. This implies that the ability to afford high fertilizer prices decreases the probability to apply manure; and endowment with adequate labor input decreases the probability to opt for fertilizer. The study also identified different impediments to adoption of fertilizer use and manure applications and important implications drawn from the results are discussed.

Keywords: chemical fertilizer, dual endogeneity, Ethiopia, manure, two-stage probit
JEL: Q12

1 Introduction

Land degradation has become a global environmental threat currently drawing widespread attention from the international community. It has an abysmal effect on agricultural productivity especially in developing countries where agriculture remains one of the largest sectors in the economy. In such agriculture-based low-income countries, reversing the deterioration of land productivity resulting from environmental degradation, and ensuring adequate food supplies to the fast growing population is a formidable challenge.

Ethiopia is among countries in Sub-Saharan Africa that are reported to suffer severe land degradation problem (STOORVOGEL and SMALING, 1990). The country with a population that doubled from about 39.8 million in 1984 to over 79 million in 2009 just within 25 years, is now the second most populous country in Africa with a current annual growth rate of 2.6 percent (CSA, 2008a). On the contrary, food gap has increased since the early 1980s, though per capita food availability has remained relatively stable over the years owing to the generous inflow of food aid; and the agricultural sector has registered a growth rate of only 1.7 percent since 1992 with more volatile production as compared to most developing countries (RASHID et al., 2007). That means the country's food production growth rate is far behind keeping pace with population growth rate ultimately leading to food shortages.

As a result, food insecurity and pervasive poverty epitomize the country as these ravage the lives of a significant portion of the population. According to FAO estimate, for instance, 44 percent of the population in Ethiopia is undernourished with 47 percent of the children suffering from malnutrition (FAO, 2009). Furthermore, the proportion of a population living below 1 US dollar a day (at PPP) is 39 percent (WHO, 2009). The causes for food insecurity and poverty may include demographic trends, recurrent drought, widespread land degradation, shrinking and fragmentation of landholdings, inappropriate policies, poor infrastructure, inefficient agricultural practices, and others. Land degradation problem mainly resulting from soil erosion and nutrient depletion, can be singled out as one of the most important environmental problems creating an unprecedented threat to food security goals of the country.

An estimate based on remote sensing tools indicated that about 26 percent of the land area in Ethiopia has been degrading over the years 1981-2003, directly affecting the livelihoods of about 29 percent of the population in the country (BAI et al., 2008). Available estimates of economic impact of soil erosion also show that it is among the factors contributing to the country's structural food insecurity problem. Soil erosion is estimated to reduce food production by at least 2 percent annually (FAO, 1993). The problem of accelerating land degradation is especially serious in the intensively cultivated highland parts of the country (GREPPERUD, 1996; BEWKET, 2007). The highland parts in Ethiopia have some of the most degraded lands in the world (HURNI, 1998).

It is, therefore, essential to look for agricultural practices that minimize degradation problem and at the same time increase agricultural productivity. Hence, improving soil fertility management among smallholder farmers is widely recognized as a critical aspect in addressing food security and poverty (TCHALE et al., 2004) through increasing agricultural productivity and at the same time curbing problems of nutrient depletion. In this regard, it is necessary for farmers to adopt inorganic fertilizers and organic manures, among others.

Despite the fact that erosion undermines productivity in the highlands, efforts to adopt these fertility maintenance techniques are very minimal. Impediments for adoption can be multi-faceted including factors related to the capacity to adopt in terms of different livelihood assets, the knowledge or awareness about these land management strategies, and farm-related features. It is, therefore, necessary to explore these factors affecting use of fertilizer and manure; it is also equally important to examine how uses of fertilizer and manure are interrelated as use of one affects use of the other.

In recent years, different studies have sought to identify factors affecting adoption of these fertility maintenance techniques in the country. However, these studies did not systematically address the relationship between use of fertilizer and manure application. That means there are no solid empirical analyses that take into account the reciprocal causation between manure and fertilizer applications. The present study uses data at household and plot levels collected from a total of 211 households in three districts of Eastern highlands of Ethiopia. The paper is organized as follows. The next section presents overview of manure and fertilizer use in the study areas and section 3 gives details of the methodological aspects and analytical frameworks of the study. Empirical results and their discussion are presented in section 4 followed by concluding remarks.

2 Overview of Manure and Fertilizer Inputs in the Study Areas

The study area, Eastern Highlands of Ethiopia, is found in Oromia regional state of Ethiopia. It consists of two zones, East Hararghe and West Hararghe zones. Farming systems in the East and West Hararghe zones of Ethiopia constitute complex production units involving a diversity of interdependent mixed cropping and livestock activities. The major annual crops grown in these zones include sorghum, maize, groundnuts, sweet potato, wheat, haricot beans, barley, and others. In addition, the major cash crops like t'chat[1] and coffee have a long-standing tradition in these zones. Production of t'chat makes the farming system in Hararghe highlands to be a cash crop-based mixed crop-livestock farming system, and not a mere grain-based mixed crop-livestock system, unlike the case in other parts of the country.

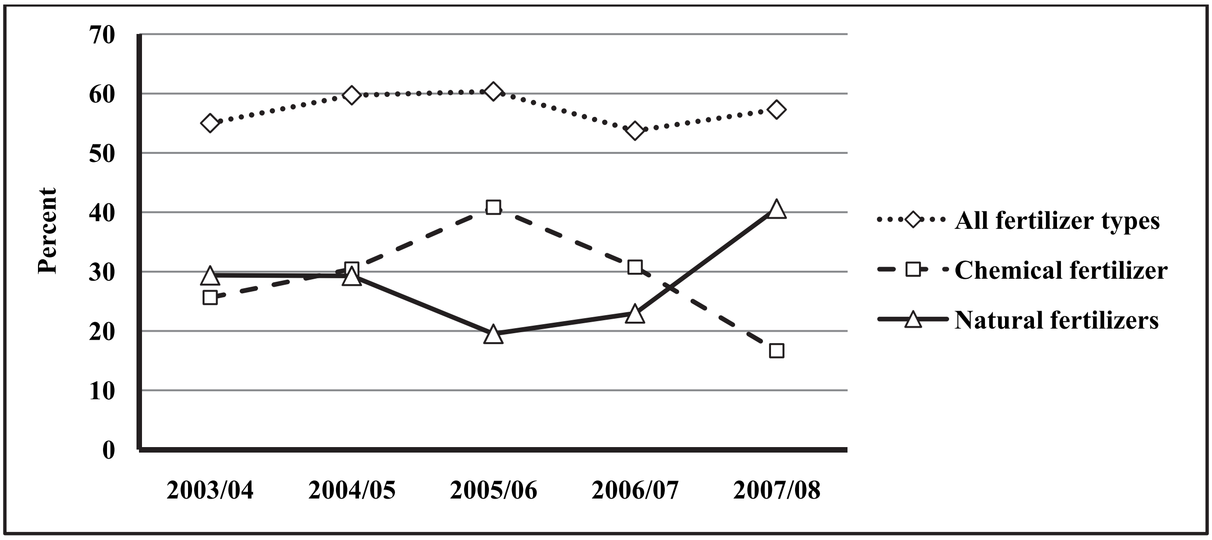
[1] T'chat (*Catha edulis*) is a mild narcotic perennial bush the leaves of which are chewed as stimulants. It is also the leading cash crop in East and West Hararghe (STORCK et al., 1997).

Increasing population density coupled with lack of alternative employment opportunities in rural areas has led to progressive land pressure and caused subsequent shrinking of individual land holdings, fragmentation of available holdings, and expansion into fragile and marginal areas. In 2008 cropping season, for instance, average land-holdings in East Hararge zone was about 0.59 hectares with about 85 percent of the households owning an average area of less than one hectare. In West Hararghe zone, the average holding was 0.9 hectare with about 66 percent owning an area of less than one hectare (CSA, 2008b). The indicated average holding in East Hararghe zone is fragmented into 3.15 parcels with an average size of only 0.19 ha. In West Hararghe zone, it is fragmented into 2.72 parcels with an average size of only 0.33 ha. The problem of fragmentation is very evident especially when compared to the average household size, during the same period, of 5.36 and 5.17 persons in East and West Hararghe zones, respectively. Furthermore, the severity of land degradation in the highland parts of these zones is becoming of grave concern.

Despite all these problems in these zones, the technological setup has not been transformed. Farming is still traditional with limited use of yield enhancing modern inputs like improved seeds, fertilizers, irrigation, and others. Use of chemical fertilizer, for instance, was only on 16.7 percent of cereal farms in East Hararghe zone while natural fertilizer was applied on 40.6 percent constituting a total fertilized cereal area of about 57 percent in 2008 (CSA, 2008c). Figures 1 and 2 depict how uses of chemical and natural fertilizers have changed over time in the two zones. For the period 2004 to 2008, the overall use of all fertilizer types shows a fluctuating trend in East Hararghe zone and a steadily increasing trend in West Hararghe zone. Interestingly, however, the use of chemical and natural fertilizers showed an opposite pattern in both zones. That means, when use of chemical fertilizer increases that of natural fertilizer decreases and vice-versa.

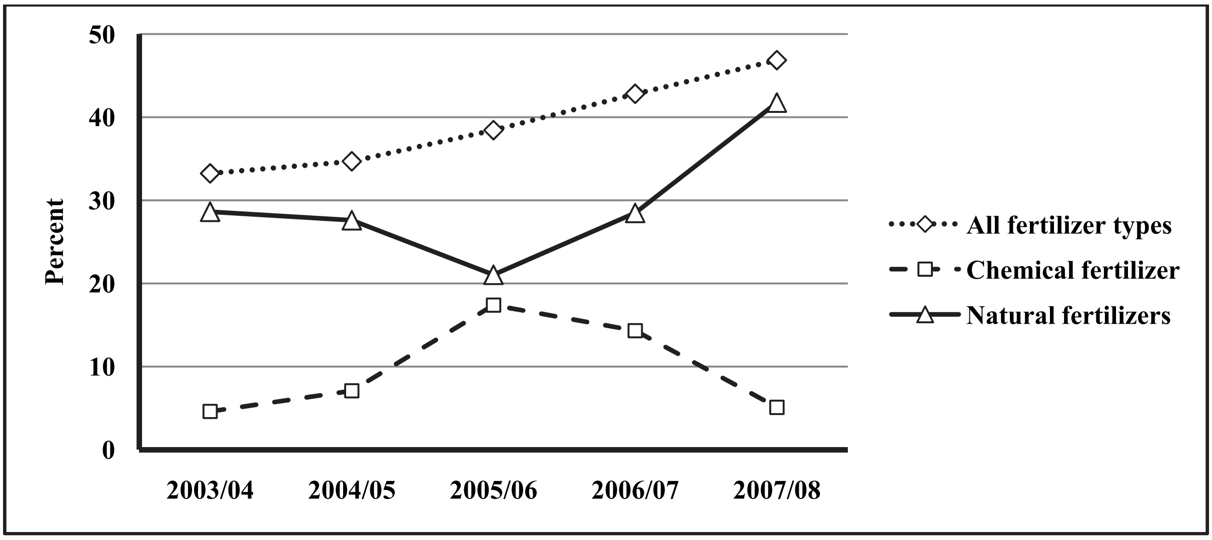
Use of manure and fertilizer are among a well-established nutrient and land management practices undertaken by smallholders in the study areas. Use of manure, locally called *dike*, is the oldest and most widely practiced means of nutrient replenishment in the study areas, and in Ethiopia in general. It involves collection of a mixture of farmyard manure, green manure, compost, and household wastes and transporting it to the farm. The use of chemical fertilizers (mainly in the forms of urea and DAP) for fertility maintenance/enhancing technique is of relatively recent origin in the study areas. It is now common though its application rate is by far less than the recommended rates owing to the costs or availability factors related to these fertilizers. However, there are also farmers who do not adopt one or both of these management practices because of various constraints.

Figure 1. Share of fertilized cereal crops in East Hararghe zone, 2003/04-2007/08



Source: computed from CSA reports (CSA, 2004c-2008c)

Figure 2. Share of fertilized cereal crops in West Hararghe zone, 2003/04-2007/08



Source: computed from CSA reports (CSA, 2004c-2008c)

3 Methodology

3.1 Data Sources and Measurements

Multi-stage sampling techniques were employed to select the final sample units. Initially three districts, two from East Hararghe zone and one from West Hararghe zone, were selected purposively based on severity of degradation problems. These districts were Meta and Goro-Gutu from East Hararghe zone, and Tulo from West Hararghe zone. In the second stage, a total of 9 *kebeles*[2] were randomly selected using highland *kebeles* in the selected districts as a sampling frame. In the third stage, the survey drew a total of about 211 farm households based on probability proportional to size sampling technique. Then household-level and plot-level data were collected.

Household-level data included variables like extension contact, credit access, farm training, membership to organizations, land holding, livestock holding, number of parcels, farm equipments owned, proportion of perennial crops, family size, dependency ratio, age, sex, education of the household head, involvement in non-/off-farm activities, and others. Plot level variables collected about all plots owned by the selected households, on the other hand, included use of different inputs, land management and conservation activities on the plot, size of the plot, slope of the plot, fertility level of the plot, ownership of the plot and others.

Since there are considerable differences in how farmers manage land depending on the characteristics of specific plots, analyses of land management practices are made at plot levels. Among the major land management strategies in the study area are use of inorganic (chemical) fertilizer and organic fertilizer (manure). The main purpose, here, is to assess how the uses of these two fertility maintenance techniques affect one another and how they are affected by other variables.

As to the measurement of these dependent variables, collecting data on the amount of manure applied on a given plot using a single-shot survey results in unreliable information; hence, it is measured as a dummy variable of using or not using. For fertilizer input, most of the respondents were found to be non-users, and use levels were very small for the users. Consequently, discrete type measurement (using or not using) is preferred to quantity levels of fertilizer use. Description and measurements of all the variables used in econometric analysis are presented in table 1 below.

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2 *Kebele* is the smallest administrative unit in Ethiopia.

Table 1. Description and summary statistics of explanatory variables

Variables		Description	Obs	Quantitative	
				Mean	S.D
Manure		1 if manure is applied, 0 otherwise	489	0.566	0.496
Fertilizer		1 if fertilizer is used, 0 otherwise	489	0.229	0.421
Parcel size		Parcel size (ha)	489	0.37	0.259
Slope:	Flat	1 for flat slope, 0 otherwise	489	0.313	0.464
	Gentle	1 for gentle slope, 0 otherwise	489	0.410	0.492
	Steep	1 for steep slope, 0 otherwise	489	0.239	0.427
	V. steep	1 for very steep slope, 0 otherwise	489	0.039	0.193
Fert. level:	Poor	1 for poor fertility, 0 otherwise	489	0.438	0.497
	Medium	1 for medium fertility, 0 otherwise	489	0.213	0.410
	Good	1 for good fertility, 0 otherwise	489	0.349	0.477
Farm distance		Home-farm distance in kilometer	489	2.06	2.033
Terracing		1 if stone terraces are available, 0 otherwise	489	0.534	0.499
Land holding		Total land holding (ha)	211	0.84	0.466
Livestock hold.		Livestock in Tropical Livestock Unit (TLU)	211	3.26	2.187
Farm equipment		Value of farm equipments (Br)	211	192.2	120.00
Fragm. (SI index)		Land fragmentation in Simpson Index (SI)*	211	0.48	0.226
Prop. of t'chat		Proportion of earnings from t'chat (Br)	489	0.25	0.247
Extension		1 if there is ext. contact, 0 otherwise	211	0.569	0.496
Credit		1 if credit is received, 0 otherwise	211	0.351	0.478
Membership to org.		1 if member of formal organizations, 0 otherwise	211	0.332	0.472
Trainings		1 if attended trainings within 5 years, 0 otherwise	211	0.251	0.435
Land ownership		1 if owned, 0 if rented-/shared-in	489	0.914	0.280
Age		Age of the household head (years)	211	40.8	9.96
Sex of the head		1 if a household is male-headed, 0 otherwise	211	0.877	0.329
Educ.:	no formal	1 if no formal education, 0 otherwise	211	0.360	0.481
	Primary	1 if primary level of education, 0 otherwise	211	0.450	0.499
	Secondary	1 if secondary level of education, 0 otherwise	211	0.190	0.393
Adult equiv.		Family size in adult equivalents	211	4.47	1.743
Female prop.		Proportion of female members in the family	211	0.46	0.127
Market dist.		Distance to the nearest market in kilometers	211	6.57	4.431
Off-/non-farm		1 if involved in off-/non-farm activities, 0 otherwise	211	0.332	0.472
Districts:	Metta	1 if Metta district, 0 otherwise	211	0.304	0.021
	Goro-Gutu	1 if Goro-Gutu district, 0 otherwise	211	0.355	0.480
	Tullo	1 if Tullo district, 0 otherwise	211	0.341	0.475

* Simpson Index (SI) is computed as $\boldsymbol{SI = 1 - \frac{\sum_1^n A_i^2}{(\sum_1^n A_i)^2}}$ where A_i is area of i[th] parcel and n is number of parcels; SI lies between zero and one; and a higher SI means a higher degree of fragmentation.
Source: field survey result

3.2 Analytical Framework

In order to select appropriate analytical model that takes into account the inter-relationships between the two inputs, it is necessary to start with one basic assumption about these inputs. The assumption, is the dependence of the decision to use chemical fertilizer on the decision to use manure and vice versa. This means that there is a reciprocal causation between the two variables in affecting one another, and are also being affected by other factors like farm characteristics, household characteristics, institutional factors, and others. The direction of relationship between the two inputs shows whether the relationship is of substitutability type or of complementary type.

In order to investigate such relationship where there is dual endogeneity, a two-stage probit (TSP) model can be applied. This is a model that controls for the reciprocal relationship (dual endogeneity) between the two factors. A handful of research articles are available on the application of the TSP models (HECKMAN, 1978; LYONS and YILMAZER, 2005; KIM and ROUSSEAU, 2005; WISSEN and GOLOB, 1990). This study also employs this model with the analytical set up described below.

Let the decision to use chemical fertilizer be Y_1, the decision to use manure be Y_2, and vectors of exogenous explanatory variables expected to affect the two be X_1 and X_2, respectively.[3] Then,

(1) $$Y_1^* = \gamma_1 Y_2^* + \beta_1 X_1 + \varepsilon_1$$

$$\text{where } Y_1 = \begin{cases} 1 & \text{if } Y_1^* > 0 \\ 0 & \text{if } Y_1^* \leq 0 \end{cases} \text{ and}$$

(2) $$Y_2^* = \gamma_2 Y_1^* + \beta_2 X_2 + \varepsilon_2$$

$$\text{where } Y_2 = \begin{cases} 1 & \text{if } Y_2^* > 0 \\ 0 & \text{if } Y_2^* \leq 0 \end{cases}$$

Y_1^* and Y_2^* are latent variables which are not observable, and Y_1 and Y_2 are observable counterparts as defined above. Y_1 is 1 if chemical fertilizer has been applied to i^{th} plot, and zero otherwise. Similarly, Y_2 is 1 if manure has been applied to the i^{th} plot, and zero otherwise.

The factors that determine use of chemical fertilizer (Y_1^*) include the endogenous regressor (Y_2^*) and a vector of exogenous variables (X_1). The factors that determine the use of manure (Y_2^*), on the other hand, include the endogenous regressor (Y_1^*) and a vector of exogenous variables (X_2). In order to ensure that each coefficient in the

[3] Subscripts representing observations are suppressed for simplification purpose.

system of equations is identified, it is necessary to include certain variables in the fertilizer equation and exclude from the manure equation and vice versa (cf, LYONS and YILMAZER, 2005). Included in X_1 but not in X_2, for instance, are market distance and involvement in off-farm activities as these factors directly affect the use of chemical fertilizer and may not directly affect manure application. On the other hand, variables like adult equivalent and share of female members in the family are included in X_2 and not in X_1, as these factors have something to do with the labor required for labor-intensive manure application and may not be with fertilizer use.

To estimate the models in equations (1) and (2), a two-stage approach is used to account for the endogenous regressors, Y_2^* and Y_1^*. The error terms, ε_1 and ε_2, are assumed to be distributed standard normally with mean zero and variances σ_1^2 and σ_2^2 both equal to one. In the first stage, binary probit model is used to estimate the following reduced-form equations:

(3) $$Y_1^* = \alpha_1 X + u_1$$

(4) $$Y_2^* = \alpha_2 X + u_2$$

Where X includes all of the exogenous variables in equations (1) and (2) above.

This first-stage regression is used to eliminate the likely correlation between the endogenous explanatory variables and the stochastic disturbance terms in each equation. The reduced-form estimates from equations (3) and (4) are used to obtain predicted values $\widehat{Y_1^*}$ and $\widehat{Y_2^*}$. Then, the predicted values are substituted into the right-hand side of equations (1) and (2) such that:

(5) $$Y_1^* = \gamma_1 \widehat{Y_2^*} + \beta_1 X_1 + \varepsilon_1$$

(6) $$Y_2^* = \gamma_2 \widehat{Y_1^*} + \beta_2 X_2 + \varepsilon_2$$

In the second and final stage, the probit method is again applied to estimate equations (5) and (6). The estimation is done by correcting for the possible non-independence of error terms across plots within a household, and hence robust standard errors are generated.

4 Empirical Results and Discussion

The results for the second stage regression of a two-stage probit model are presented in table 2 below. The estimated coefficients for predicted manure use in fertilizer application model (-0.151) and for predicted fertilizer use in manure application model (-0.149) are both negative and significant indicating a negative reciprocal influence on one another. This is justifiable from the point of view of further resource (mainly financial and labor) requirements for the application of these two inputs. Whereas prices of chemical fertilizers are very high in the study area, manure requires a relatively more labor for its application. Hence, the negative coefficients reveal the fact that if farmers can afford to buy fertilizers, then the probability to use the labor-intensive manure decreases. On the contrary, if households are endowed with sufficient labor to apply manure, then the probability to opt for expensive fertilizers decreases. It is an indication where the two inputs are considered substitutes to one another. Generally, the result reveals that using more of one input renders less of the other and vice versa. It is in fact against some research reports that indicate a positive reciprocal relationship between these two inputs (WAITHAKA et al., 2007).

Other than reciprocally affecting one another, manure and fertilizer uses are also affected by other factors in similar or in different directions. The result reveals that the likelihood of applying both fertilizer and manure increases with an increase in parcel size, as also indicated in CLAY et al. (1998). The possible justification is that larger parcel sizes encourage investment and intensification by improving economies of scale through minimizing costs related to application of these inputs.

Moreover, the likelihood of using manure decreases with an increase in steepness of the slope and an increase in fertility. This indicates that farmers tend to use manure on flat lands as compared to steep lands because of severe runoff in the latter case (CLAY et al., 1998), and on less fertile lands as compared to plots with good fertility level. Not surprisingly, it decreases with an increase in farm distance as also revealed in the findings of CLAY et al. (1998), NKONYA et al. (2005) and BIRUNGI (2007). This is because of the labor requirement of transporting it from homestead to distant farms. It can also be because distant farms are relatively fertile as they are brought into production more recently as compared to the nearby farms. Because of the same reason of labor requirement, as the total land holding increases the likelihood of using manure decreases, a result which has also been reported by other studies (SSERUNKUUMA, 2005; WILLIAMS, 1999; CLAY et al., 1998). This is also supported by the positive and significant effect of adult equivalents which is an indication of labor endowments of the farm households. Manure application is also considered as a job that can be done by female labor in the area as male members work on other major activities. Due to this reason, the proportion of female members is found to have a positive and significant effect on the likelihood of using manure.

Table 2. Parameter estimates of a two-stage probit model for determinants of manure and fertilizer applications

Variables	Manure application		Fertilizer use	
	Coeff.	Robust S.E	Coeff.	Robust S.E
Predicted: Fertilizer	-0.149*	0.091	–	–
Predicted: Manure	–	–	-0.151*	0.091
Parcel size	1.510***	0.333	1.350***	0.345
Slope (cf. flat)				
Gentle	-0.338**	0.169	-0.094	0.194
Steep	-0.369*	0.207	-0.135	0.227
Very steep	-0.355	0.341	-0.078	0.161
Fertility level (cf. poor)				
Good	-0.113	0.157	-0.077	0.175
Medium	-0.498***	0.182	-0.057	0.214
Farm distance	-0.040*	0.021	0.002	0.050
Terracing	0.375**	0.176	-0.040	0.185
Land holding	-0.567***	0.152	-0.267	0.225
Livestock holding (TLU)	0.001	0.036	0.092**	0.040
Farm equipments	-0.001	0.001	0.010	0.009
Land fragmentation (SI index)	-0.179	0.499	-0.047	0.534
Proportion of t'chat	-0.155	0.266	0.813***	0.357
Extension	-0.054	0.216	0.635*	0.363
Credit	-0.092	0.146	0.340*	0.184
Organization member	-0.160	0.156	0.125**	0.059
Training	0.035	0.158	0.020	0.197
Land ownership	0.310	0.230	0.047	0.258
Age	0.124*	0.070	-0.002	0.010
Gender	-0.120	0.240	0.153	0.321
Level of educ. (cf. no formal educ.)				
Primary	0.015	0.165	0.033	0.196
Secondary	0.127	0.219	-0.145	0.300
Adult equivalent	0.115*	0.066	–	–
Proportion of female	0.475*	0.286	–	–
Market distance	–	–	0.002	0.018
Off-/non-farm activities	–	–	-0.034	0.207
District (cf. Metta)				
Goro-Gutu	-0.025	0.164	-1.061***	0.208
Tullo	-0.228	0.188	-2.230***	0.292
Constant	0.020	0.645	-0.902	0.773
Log likelihood (Wald Chi2)	-273.749 (93.91***)		-182.199 (128.71***)	

Notes: ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.
Source: model estimation output

Availability of terraces also affects the likelihood of using manure positively and significantly, a situation indicating the influence of prior land investments on current land management practices. This finding indicates the possible complementary effect of long-term land investments and annual soil fertility maintenance techniques through the use of inorganic fertilizer. The result also shows as age of the household head, an indicator of farm experience, increases the use of manure increases. Positive effect of farm experience on use of manure is in line with the result reported by MKHABELA and MATERECHERA (2003).

On the contrary, many variables which are not significant in affecting the likelihood of using manure are significant in determining the likelihood of using chemical fertilizers. These variables are probably associated with the ability of affording and the technical knowhow required for applying chemical fertilizers. Accordingly, farmers who own more number of livestock (as also supported by MARENYA and BARRETT, 2007; and PENDER and GEBREMEDHIN, 2008), large proportion of t'chat, and who borrowed credit are more likely to adopt fertilizer. Especially, livestock holding and amount of t'chat are considered in the area as indicators of income level and hence wealth status of the households. These give farmers financial ability to buy fertilizers as it is reported to be a very expensive input in the area. Moreover, as most farmers cannot afford to purchase fertilizers on a cash basis, access to credit may be helping households to smooth their cash requirements in buying this input. This result is consistent with the finding reported in PENDER and GEBREMEDHIN (2008). Unexpectedly, however, livestock ownership is not significant in affecting the probability of using manure unlike the case in other studies (SOMDA et al., 2002; SSERUNKUUMA, 2005), though livestock are major sources of manure. This probably indicates that availability of manure is less important in determining its application, as compared to factors related to labor endowments (like adult equivalent and proportion of female), plot characteristics (like parcel size, slope, distance), and others.

Not surprisingly, farmers who have access to agricultural extension and who are members of organizations are more likely to use fertilizer on their farms, a result consistent with many other studies (JANSEN et al., 2006; NKONYA et al., 2008; BIRUNGI, 2007). These are important channels through which agricultural education and information reach farm households in the area. The result also shows that farmers in Goro-Gutu and Tullo districts are less likely to use chemical fertilizers as compared to those in Metta district. Unexpectedly, however, there is no sufficient statistical evidence for level of education in affecting manure application and fertilizer use in this study. The effect of education on using fertilizer and manure inputs is not clearly observed probably because of the generally low level of education in the area.

5 Conclusions and Policy Implications

In an effort to assess factors affecting adoption of fertilizer and manure application and how these are interrelated, this study employed a two-stage probit model and highlighted large number of statistically significant variables. The complexity of these factors calls for careful decisions for enhancing adoption and use levels of fertilizer and manure applications, and thereby increasing or maintaining fertility status of the soil.

The results of this study showed that the decisions to use fertilizer and manure are negatively related to one another. Fertilizer is expensive in prices and inadequate in supply but less demanding of labor in its application. Manure in most of the cases is freely available but labor intensive in transportation and application. As a result, the choice between the two is mostly based on labor endowments and income levels of the farmers. But there are farmers traditionally using different levels of both inputs in combination, as facing shortages of both labor and money may happen at the same time. However, optimum combinations of these inputs are not yet known. Therefore, it is necessary to revisit the traditional combinations of these inputs used in crop production and to look for a judicious blend of chemical fertilizer and organic manure.

In addition, short-term interventions like manure applications are found to augment the long-term structural interventions like terraces in preventing the problem of soil degradation and its consequences. It is, therefore, necessary to strengthen, expand and support both long-term conservation programs and short-term land management strategies.

The study also revealed that parcel size has a positive effect on both land management practices indicating the need to have large-sized parcels and to minimize fragmentations. It is, therefore, necessary to implement programs of consolidation that create viable-sized farms, enlarge the current fragmented holdings, and reduce production costs. Land consolidation and enlargement of parcels can be achieved through several ways. These include, land reform programs that allow land markets (buying, selling, renting); legalization of voluntary exchange of farm lands among farmers; and creations of agricultural production groups (group farming) where farmers finance production costs together and divide the production and income among themselves according to the size of parcels (advanced form of cooperation).

Furthermore, access to credit is found to be significant in positively affecting the probability of using fertilizer. The implication is that credit is very helpful in relieving capital constraints faced by farmers for using fertilizer and other purchased inputs. This calls for an institutional support for resource poor farmers in terms of creating access to rural credit, among others.

The overall results imply that major changes related to land management interventions will require attention to all of the interrelated significant factors so as to contribute to the policy prescriptions required for minimizing the consequences of degradation problems; no single factor can be used single-handedly as a major policy instrument.

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