Decision making on manure use and fallowing as soil fertility maintenance techniques in the Northern Highlands of Ethiopia: *The case of Ankober District*[1,2]

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Abstract

Degradation of the highly scarce agricultural resource, land, has been one of the notorious problems in Ethiopia. One form of degradation of land resource is soil nutrient depletion. Manure application as a source of major plant nutrients contributes to managing land resources towards sustainability through the improvement of physico-chemical properties of the soil. Fallowing too, allows for natural regeneration of the soil. However, decisions on how to manage the land are ultimately made by farmers and their decision-making process is influenced by several factors. This paper attempts to examine the effects of some important farm, family and institutional variables on manure use and fallowing in the Northern Highlands of Ethiopia using a logit model. Data from 111 randomly selected farm families was collected in a formal survey conducted in the Ankober district of the North Shoa Zone in 1999.

The study results show that ownership type, field distance, slope of plots and labour availability are the most important factors determining manure use. Fallowing is affected by land holding, engagement in off-farm activities, livestock ownership and use of commercial fertilizers. Therefore, it is suggested that introduction of labour saving technologies that reduce the drudgery associated with manure application can promote manure use. Ensuring more security of land ownership also encourages manure use as manure takes a long time to decompose. In mixed farming systems improving the livestock component will increase the probability of fallowing. Availability of off-farm activities as a source of other income would also give farmers the possibility to practice fallowing.

Key words: Land degradation, Manure, Fallow, Decision making, Ethiopia.

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Introduction

Degradation of the highly scarce agricultural resource, land, has been one of the notorious problems in Ethiopia. In the highlands of Ethiopia, land degradation in the form of soil erosion and soil mining is a bottleneck to maintaining or enhancing agricultural yield. The scale and cost of nutrient loss has been estimated at some 0.5 million tons of crops, or the equivalent of 934 million Birr in 1994 (over 150 million US$) (Sutcliffe, 1993).

Manure application as a source of major plant nutrients contributes to managing land resources towards sustainability through the improvement of physico-chemical properties of the soil. Fallowing[3] too, allows for natural regeneration of the soil.

However, decisions on how to manage the land are ultimately made by farmers and their decision-making process is influenced by several factors. In a country where the agricultural sector is highly dominated by family farms understanding the complex system in which farmers live and make decisions is crucial to drawing policy implications. Land degradation in Ethiopia, like in other developing countries, is the result of the economic activities of people in their attempt to satisfy their basic needs.

Therefore, knowledge of the factors influencing farmers' decisions on land management practices is essential. This includes both internal and external elements of the farming systems that are highly interlinked (Doppler, 1991). According to Doppler (1993) a farm family is seen as the core of a system in which people make decisions based on their perception of the physical, economic and cultural conditions.

Previous studies dealt almost exclusively with adoption of newly introduced technologies in land management whereas this study focuses on indigenous soil fertility management practices. This paper attempts to examine the effects of some important farm, family and institutional variables on manure use and fallowing in the Ankober district in the Northern Highlands of Ethiopia.

Methodology

Data from 111 randomly selected farm families was obtained from a formal survey conducted in the Ankober district in 1999. A logit model was used to test the significance of impacts of several determinants of manure application and fallow as land management strategies.

Farming systems in the study area

The study area is a mixed farming zone in which crop and livestock activities are interdependent and complementary to each other. Crop production is exclusively rain fed with two cropping seasons per year. As in many other parts of the country, agricultural land is a scarce resource in the study area. The average land holding per family is about 0.97 ha (Table 1), and the average number of fields owned 3 ranges from one to eight. Cultivable land per person is about 0.18 ha. Most of the land owned[4] by the families is used mainly for cultivation.

About 18 % of the sample farmers in the study area do not own all the land they cultivate. The most common way of getting access to a piece of land that is not owned is share cropping. In this arrangement, a landowner who cannot cultivate his/her land for various reasons leases it

[3] Fallowing is the practice of allowing cropland to remain idle during all or part of the growing season when a crop normally would be grown. Objectives often are to control weeds, accumulate soil water, and/or accumulate plant nutrients (Unger and Howell, 1999).

[4] Land in Ethiopia is collective property of the people and owners of farmland have the right to use or transfer it to descendants and they have no right to legally sell it. It does not have any legal asset value.

to another person. The leaseholder (usually a farmer in the same community) cultivates it and the owner and the leaseholder share the produce equally after deducting an amount of grain equivalent to the amount of seed the leaseholder has sown.

Table 1:Average size of land ownership, 1998/99

Parameters	Mean values (ha)	Standard deviation
Land size	0.97 (n=111)	0.50
Cultivable land size	0.82 (n=110)	0.44
Private grazing land	0.24 (n=67)	0.16
Cultivable land per person	0.18 (n=110)	0.11

The landowner determines the length of the period for which the land is used by the leaseholder. It normally lasts from one to several years depending on the satisfaction of the landowner. The leaseholder has to cease cultivation any moment the landowner tells him to do so.

Traditional soil fertility maintenance techniques

Farmers have indigenous soil fertility maintenance techniques such as manure application, crop rotation, fallowing and soil burning (although soil burning improves soil fertility in the short term and exacerbates run-off and erosion in the long term (FAO, 1998)). In the study area manure application is the most commonly used method (Figure 1). Manure is applied mainly for barley, faba bean, wheat, teff, sorghum and maize. But farmers did not apply manure to all of the fields they cultivate because of various reasons. Among the total of 233 plots cultivated by the surveyed farmers manure was not applied on 103 of them (44%).

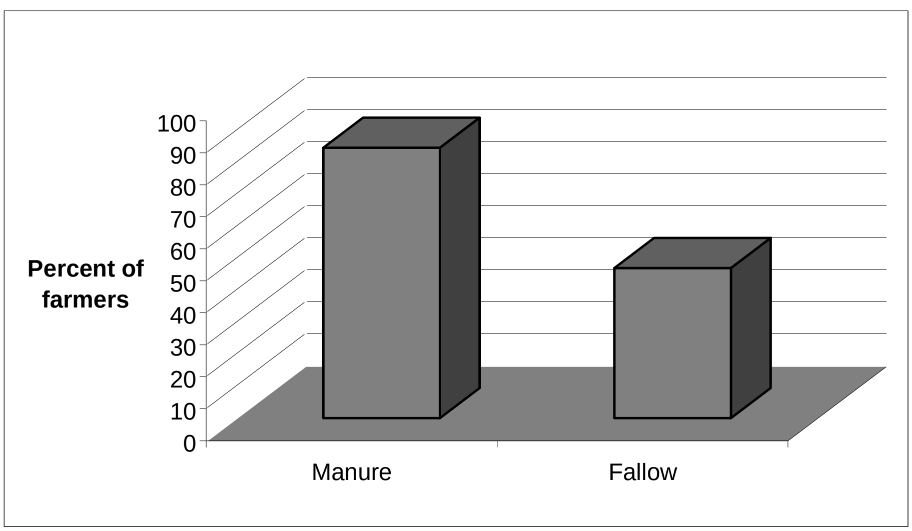

Figure 1: Percent of farmers using traditional soil fertility maintenance techniques, 1998/99

Cattle dung is used not only as a fertilizer but also as a source of energy for cooking. But in the Ankober district dried cattle dung is not a major source of cooking energy. The survey result shows that about 69% of the families use only wood and about 22% reported that they use cattle dung as the second source of cooking energy next to wood. The result of a contingency analysis (contingency coefficient = 0.154, significance = 0.103) to evaluate the significance and strength of relationship between manure application and use of dung as fuel shows that the two variables are independent (Table 2) indicating that cattle dung burning is not competing with its alternative use as fertilizer.

Table 2: Cross tabulation of manure application and use of cattle dung as fuel

Use dung as fuel	Apply manure		Row total
	Yes	No	
No	15 (17%)	71 (83%)	86
Yes	1 (4%)	23 (96%)	24
Column total	16	94	110

Contingency Coefficient = 0.154 Sig.: 0.103

In spite of the very small size of cultivable land per family, fallowing is practiced by about 40% of the sample farmers (Figure 1). But the length of fallow period is rather short. In most cases it is as short as half a year[5].

Comparative descriptive analysis of resource ownership and economic performance of families with different fertility management techniques

Comparative analysis of resource ownership between groups of farmers who apply manure to their farm and who do not, and between groups of families who practice fallow and who do not sheds light on the idea behind the decision making process. It is also worthwhile to look at the resulting differences in their economic performances in terms of farm income and household food self-sufficiency[6]. The comparative analysis was done for the above-mentioned groups of farmers concerning land holding, labour availability, livestock ownership, farm income and household food self-sufficiency.

The average land holding for those who apply manure was about 1.01 ha and 0.78 ha for those who do not (Table 3). The assumption of significant differences in land holding between the two groups holds to a probability of 95%. Families that apply manure have more labour capacity than those who do not. Likewise, they earn higher income from their farms. However, there are no significant differences in land holding, labour capacity and farm income between those who practice fallow and who do not.

[5] The study area has two cropping seasons per year and fallowing for half a year means that the land is left uncultivated during one of the two cropping seasons.

[6] Food self-sufficiency was calculated for each of the families as the difference between family food requirement and food availability either from own production or market.

Table 3: Comparative analysis of resource ownership and farm income, 1998/99

Parameters	Apply manure (Mean values)		Probability of significant differences[1]	Practice fallow (Mean values)		Probability of significant differences[2]
	Yes (n=94)	No (n=16)		Yes (n=57)	No (n=51)	
Land (ha)	1.01	0.78	97.7%	0.96	0.92	2.2%
Labour (ME)	2.81	1.84	100%	2.62	2.71	53.9%
Farm income (Birr/year)	1968	811	96.8%	1772	1849	44.7%

1 Probability of significant differences between those who apply manure and those who do not according to Mann-Whitney Test[7]

2 Probability of significant differences between those who practice fallow and those who do not according to Mann-Whitney Test

With regard to livestock ownership there is a highly significant difference between those who apply manure and those who do not and also between those who practice fallow and those who do not (Table 5). Families that apply manure have more livestock. Similarly, families that practice fallow, have more livestock than those who do not.

Table 4: Comparison of mean livestock ownership

Parameters	Apply manure		Probability of significant differences[1]	Practice fallow		Probability of significant differences[2]
	Yes (n=94)	No (n=16)		Yes (n=57)	No (n=51)	
Livestock (TLU)	4.89	2.40	99.9%	5.37	3.69	99.8%

1 T-test assuming equal variances

2 T-test not assuming equal variances

Although those who apply manure have higher farm income, a contingency analysis shows (Table 5) that there is no relationship between household food security and use of manure (contingency coefficient = 0.04 and significance = 0.678). In spite of the higher farm income earned by those who use manure (Table 3), the two groups of families did not differ in food self-sufficiency. This is because household food security depends on family income, which is comprised not only of farm income but also of off-farm income.

Similarly there was no relationship (Table 6) between household food security and fallow (contingency coefficient =0.133 and significance = 0.163). Families, which practice fallow and which do not practice fallow did not differ in of household food security.

Table 5: Cross tabulation of manure application and household food supply

Household food supply	Apply manure		Row total
	Yes	No	
Families with no food deficit	51 (85%)	9 (15%)	60
Families with food deficit	43 (88%)	6 (12%)	49
Column total	94	15	109

Contingency Coefficient = 0.04 Sig.: 0.678

7 Land holding, labour and farm income of families were not normally distributed. Thus, a non-parametric test (Mann-Whitney test) was used to test if there are significant differences between groups with respect to these variables.

Table 6: Cross tabulation of fallow and household food supply

Household food supply	Practice fallow		Row total
	Yes	No	
Families with no food deficit	31 (53%)	27 (47%)	58
Families with food deficit	20 (40%)	30 (60%)	50
Column total	51	57	108

Contingency Coefficient =0.133 Sig.: 0.163

Econometric analysis

The variables and hypotheses

Farmers make decision on whether to apply manure or not based on several factors. One of these factors is type of ownership of land. In the study area farmers cultivate both own land and rented-in land. Therefore it is important to analyse at plot level in order to assess the impact of ownership types (own and share cropped/rented-in) on land management strategies such as manure application. However, farmers do not normally fallow share cropped or rented-in land. Hence, the analysis of factors determining fallow was done at the family level.

Farm specific variables can be determinant to application of manure on the specific field under consideration. Owing to the absence of private ownership of land in Ethiopia, it is impossible to assess the impact of land ownership with full property rights on land management. However, it was attempted in this study to capture the effect of security of land ownership on traditional soil fertility maintenance techniques by comparing management of land that is rented-in or share cropped and own land (usually provided by Peasant Associations (PAs) or parents).

In addition to the frequent land redistribution during the Marxist regime (1974-1991), land has been redistributed in The Amhara National Regional State where the study area is located several times and lastly in 1997. However, reallocation of land has never been implemented in Ankober district because of farmers' resistance except in 1974, right after the Rural Lands Proclamation. Hence, farmers in the study area have more security for the land they obtained from the only land distribution that took place in 1974 or from parents.

In this respect, it was hypothesised that farmers apply manure on fields that they own and not to rented in lands. Manure takes years to decompose and its full economic benefit is realized relatively in the long run. But farmers do not know how long they are allowed to cultivate the rented or share cropped area.

Distance of fields from homesteads can have a negative relationship to manure application because of the bulkiness of dung. Field distance was measured in minutes of walking. It was also hypothesised that slopping lands have lower probability of getting manure because manure applied on slopping land can be easily washed away by run-off.

Another variable that can determine manure use is labour availability since manure application is a labour intensive activity. Labour availability was measured by agricultural family labour in Man Equivalents. Engagement in off-farm activities can also reduce the amount of labour that could be used in manure application. Hence, manure application and off-farm activities can have a negative relationship. In addition, plots owned by families with female household heads can have lower probability of getting manure because of less labour available.

The availability of manure is a prerequisite for manure application. Hence, livestock size owned by owner of a field expressed as Tropical Livestock Unit (TLU) was expected to have a positive relationship with the probability that the field would get manure.

In case of fallowing, land scarcity can be important in deciding whether to fallow or not. In this analysis land scarcity is measured by the ratio of land size owned by a family to the number of family members. It was hypothesised that the smaller the land holding per family member, the lower the probability of practicing fallowing. As another source of food and income, livestock ownership (in Tropical Livestock Unit) can encourage fallowing. Engagement in off-farm activities can have a positive relationship to fallowing because families with off-farm activities have an additional source of income and can afford fallowing. The last hypothesis in the fallow model is that use of commercial fertilizer is an alternative to fallow and as a result the two variables can have a negative relationship.

The Dummy coding for land ownership was: 1 = owned, 0 = not owned, for the slope of a plot: 1 = flat, 0 = slopping, for the engagement in off-farm activities: 1 = yes, 0 = no, the sex of the household head: 1 = male, 0 = female and for the use of commercial fertilizer: 1 = yes, 0 = no.

The model

The factors hypothesised to influence the decision of farmers to apply manure or not on a given plot of land and decision to fallow were analysed using a logit model. The model has the following functional form (Maddala, 1992):

$$\log \frac{p_i}{1-p_i} = \beta_0 + \sum_{j=1}^{k} \beta_j x_{ij}$$

Where,

$\log \frac{p_i}{1-p_i}$ = log-odds ratio

β_0 = Constant term

β_j = Coefficients

x = Independent variables

The dependent variable (log-odds ratio) in the manure model is the natural logarithm of the ratio of the probability that the farmer applies manure to field *i* (p_i) to the probability that the farmer will not ($1-p_i$). The dependent variable (log-odds ratio) in the fallow model is the natural logarithm of the ratio of the probability that the farmer practices fallowing (p_i) to the probability that he/she does not ($1-p_i$). The log-odds ratio is a linear function of the explanatory variables. The models have been estimated using SPSS.

Empirical result

In the models, for both manure and fallow analysis, the overall goodness-of-fit measured by significance of Chi-square statistic is very high (Table 7 and 8). The percent of correct prediction is fair (70.7% for manure model and 74.3% for fallow). The Hosmer and Lemeshow tests in both cases show that the model adequately fits the data (the null hypothesis could not be rejected).

In the manure model, all independent variables except involvement in off-farm activities and sex of household head, have the expected direction of relationship with the odds ratio. The findings supported the hypothesis that field ownership type (significant at 5% level), field distance (significant at 1% level), slope (significant at 5% level), and agricultural labour availability (significant at 5% level) are determinants of manure use. On the other hand, involvement in off-farm activities, gender of household head and livestock ownership did not significantly affect manure use.

In Table 7 and 8, the Exp(B) shows the predicted change in odds for a unit increase in the predictor. Holding other variables constant, the odds of using manure are more than four times higher for owned fields than for non-owned fields. The results also show that as distance of a field from homesteads increases, the odds that the field gets manure decreases.

The odds of using manure are higher by about 14% for flat plots than for slopping plots showing that flat plots have a higher probability of getting manure as compared to slopping plots. In addition, the odds-ratio of using manure increases, as labour availability increases. A unit increase in Man Equivalents of agricultural family labour leads to about 23% increase from the previous state in the odds that the farmer uses manure, given all the other independent variables are held constant.

Table 7: Factors determining manure application

Variables in the Equation	B	SE	Wald	Sig	Exp(B)
Field ownership type	1.475	0.613	5.784	0.016	4.372
Field distance	-0.035	0.011	9.912	0.002	0.966
Slope	0.132	0.066	3.996	0.046	1.141
Agricultural labor in ME	0.206	0.093	4.913	0.027	1.228
Off-farm	0.368	0.343	1.151	0.283	1.445
Sex of household head	-0.945	0.681	1.925	0.165	0.389
TLU	0.071	0.054	1.732	0.188	1.073
Constant	-1.056	1.054	1.004	0.316	0.346

Omnibus Test of Model Coefficients: $\chi^2 = 33.56$ df = 7 Sig = 0.000

Percentage of correct prediction = 70.7%

Hosmer and Lemeshow Test: $\chi^2 = 10.72$ df = 8 Sig. = 0.218

All of the variables in the fallow model (Table 8) are significant and have the expected direction of relationship with odds of practicing fallowing. Fallowing was determined by land scarcity variable, measured by land size per family member (at 5% level of significance), involvement in off-farm activities at 5% level of significance, livestock ownership (TLU) and commercial fertilizer use at 1% level of significance.

Holding other independent variables constant, the odds of fallowing considerably increase with a unit increase in land holding per family member. The odds of fallowing were more than three times higher for those who were involved in off-farm activities than for those who were not. A unit increase in livestock in TLU leads to a 35% increase in the odds ratio of fallowing from the previous state. The odds of fallowing were about 10% lower for those who use commercial fertilizer than for those who do not.

Table 8: Factors determining fallowing

Variables in the Equation	B	S.E.	Wald	Sig.	Exp(B)
Land (ha)/family member	4.928	2.258	4.766	0.029	138.149
Off-farm	1.201	0.497	5.844	0.016	3.324
TLU	0.301	0.095	9.956	0.002	1.351
Commercial fertilizer	-2.313	0.572	16.359	0.000	0.099
Constant	-2.355	0.729	10.443	0.001	0.095

Omnibus Tests of Model Coefficients: $\chi^2 = 37.434$ df = 4 Sig.= 0.000

Percentage of correct prediction = 74.3%

Hosmer and Lemeshow Test: $\chi^2 = 7.351$ df = 8 Sig.= 0.499

Conclusions and policy implications

Reversing the present trend of land degradation is crucial to sustaining and improving the living standard of farm families. The traditional soil fertility maintenance techniques, manure application and fallow can contribute towards this end by supplying nutrients, organic matters and allowing for regeneration of the land. Farm families' decision on implementation of these practices depends on several factors. Any attempt geared towards promotion of these practices needs to take these factors into consideration.

Introduction of labour saving technologies that reduce the drudgery associated with manure application can promote manure use. The study also revealed that ensuring more security of land ownership encourages manure use as manure takes a long time to decompose. In addition, slopping plots have more probability of being degraded than flat plots, as farmers tend not to apply manure on them. This leads to the conclusion that construction of physical soil conservation measures that will develop into bench terraces (change the slope) might reinforce the use of manure on such plots.

In mixed farming systems, improving the livestock component would increase the probability of fallowing since fallowed land can be used as grazing area. Families who own livestock can benefit more from fallowing as a source of feed. Moreover, livestock provides an additional source of food and income to the family as a result of which farm families can afford to leave parts of their land fallow. Availability of off-farm activities as a source of other income would also give farmers the possibility of practicing fallowing.

Use of commercial fertilizers is negatively related to fallowing. A comparison of the costs and benefits associated with commercial fertilizer use and fallowing is an issue that should be addressed by further research.

References

Kidanu. A. and Alemu. T. 1994. *Rapid population growth and access to farm land: Coping strategies in two peasant associations in North Shoa*. In: *Land tenure and land policy in Ethiopia after the Derg*. Proceeding of the second workshop of Land Tenure Project. Desalegn Rahmato (ed). Working Papers on Ethiopia Development No. 8, October 1994. The University of Tronheim Center for Environment and Development.

Doppler. W. 1991. *Landwirtshcaftliche Betriebsysteme in den Tropen Und Subtropen*. Ulmer.

Doppler. W. 1993. *Definitions and Concepts of Farming Systems*. NATURA/NECTAR project. University of Hohenheim. In: Doppler. W. (ed.) Rural and Farming Systems Analyses: Environmental Perspectives pp. 349 (1999).

FAO. 1998. *Soil Fertility Initiative*. Concept Paper. Addis Ababa.

Maddala. G. S. 1992. *Introduction to Econometrics*. Second Edition. Prentice-Hall. Inc.

A Simon & Schuster Company-Engelwood Cliffs. New Jersy. 07632.

Greene. W. H. 2000. *Econometric Analysis*. Fourth edition.Prentice-Hall. Inc. Upper Saddle River. New Jersy 07458.

Storck. H.. Emana. E.. Adnew. B.. Borowiecki. A. & W/Hawariat. S. 1991. *Farming Systems and Farm Management Practices of smallholders in the Hararghe Highlands*. A Baseline Survey. In: Doppler. W. (ed.) Farming Systems and Resource Economics in the Tropics. Vol. 11. Wissenschaftsverlag Vauk. Kiel.

Sutcliffe. J. P. 1993. *Economic Assessment of Land Degradation in the Ethiopian Highlands*. A case study. National Conservation Strategy Secretariat. Cited by: FAO, 1998. Ethiopia Soil Fertility Initiative Concept Paper.

Unger. P.W.. and Howell. T. A. 1999. *Agricultural water conservation- A Global Perspective*. In: *Journal of Crop Production* (Food Products Press. An imprint of The Haworth Press. Inc.) Vol. 2 No. 2(#4). pp. 1-36.