Poverty, property rights and land management in Uganda

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Abstract

This study investigates the impact of poverty, social capital and land tenure on the adoption of soil fertility management (SFM) and conservation technologies in Uganda. Considering four land management technologies (fallowing, terracing and inorganic and organic fertilizers), the study estimates a multinomial logit model to link farmers' characteristics to the choice of technologies. The findings show that investments in land management are driven by factors such as land tenure security, level of poverty and participation in community organizations (social capital), and, most importantly, that household level poverty reduces the probability of adoption of most of the technologies, while social capital and land tenure security increase it. The findings suggest that more efficient government efforts to reduce poverty would enhance the adoption of SFM technologies. Other policies that would enhance the adoption of sustainable land management practices are infrastructure development, tenure security through a more efficient system of land registration, and investment in and use of social capital institutions.

Keywords: poverty; social capital; property rights; soil fertility management; Uganda

Cette étude examine l'impact de la pauvreté, du capital social et du régime foncier dans l'adoption d'une gestion de la fertilité du sol (SFM, en anglais) et les technologies de conservation en Ouganda. Prenant en considération quatre technologies de la gestion foncière (jachère, étagement, engrais biologiques et inorganiques), l'étude évalue le modèle logit multinomial pour relier les caractéristiques des fermiers au choix des technologies. Les conclusions montrent que les investissements en gestion foncière sont guidés par des facteurs comme la sécurité du régime foncier, le degré de pauvreté, la participation au sein des organisations communautaires (capital social) et, d'abord et avant tout, que le degré de pauvreté des ménages réduit la probabilité de l'adoption de la plupart des technologies, alors que le capital social et la sécurité du régime foncier l'augmentent. Les conclusions suggèrent que de plus amples efforts de la part du gouvernement, efficaces et destinés à réduire la pauvreté, encourageraient l'adoption de technologies SFM. D'autres politiques sont capables d'inciter l'adoption de pratiques en matière de gestion

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foncière durable, à noter le développement de l'infrastructure, la sécurité foncière, grâce à un système plus efficace d'enregistrement des terres, et l'investissement dans et l'utilisation des institutions du capital social.

Mots-clés : *pauvreté ; capital social ; droits liés aux biens immobiliers ; gestion de la fertilité du sol ; Ouganda*

1. Introduction

Reduction of poverty has become the major challenge for the international community over the coming few years (World Bank, 2001). While poverty is a global phenomenon, it is particularly pervasive in sub-Saharan Africa where in 2005 more than 46% and 70% of the population lived on less than $1 and $2 a day, respectively (World Bank, 2005; UNDP, 2005). As in many other developing countries, poverty is one of the major challenges facing policy makers in Uganda. Although poverty (measured in head count below the poverty line) in Uganda fell from 56% in 1992 to 35% in 1999, more recent estimates indicate a national increase in poverty by four percentage points, reaching 39% in 2002 (Appleton & Sewanyana, 2003). About half of the rural households are classified as poor and poverty is more acute for crop farmers than for those practicing non-crop agriculture such as livestock and fishing (GoU, 2004). The fact that agriculture remains the key economic activity in Uganda (contributing 40% of the GDP, 85% of export earnings and 80% of employment) and the main source of livelihood for the vast majority of the population, especially in the large subsistence segment, indicates the importance of this sector's performance for food security and poverty reduction (NEMA, 2002; GoU, 2004).

Recent studies show that the major cause of low incomes in the rural areas of Uganda has been stagnating agricultural production (Deininger & Okidi, 2001). One major constraint to improved agricultural productivity in Uganda, as in many of the sub-Saharan African countries, is land degradation. There is ample evidence of widespread land degradation in Uganda (NEMA, 2002; GOU, 2004), as manifested in high rates of soil nutrient loss, soil erosion and compaction and water logging (Nkonya et al., 2004). More than 85% of water contamination and more than 15% of biodiversity and topsoil loss have been attributed to soil erosion and deforestation. The extent of land degradation, however, varies between regions. For instance, while the Arua and Kapchorwa districts experience relatively fewer soil and land degradation problems, other districts such as Kabale and Kisoro are heavily eroded (GOU, 2002). The densely populated and extensively cultivated highlands and the overstocked cattle corridors of the severely de-vegetated drylands of Uganda are identified as the most fragile ecosystems in the country (NEMA, 2002).

Exacerbated by poverty, a fast growing population, and inadequate tenure security, land degradation poses a threat to national and household food security and the overall welfare of the rural population in Uganda (Nkonya et al., 2004). Poverty acts as a constraining factor on households' ability to invest in mitigating land degradation. Poor households are unable to compete for resources, including high quality and productive land, and are hence confined to marginal land that cannot sustain their practices, which perpetuate land degradation and worsen poverty

(Kabubo-Mariara, 2003). The poor and food insecure households may contribute to land degradation because they are unable to keep land in fallow, make investments in land improvements or use costly external inputs (Reardon & Vosti, 1995). Due to credit constraints, inadequate tenure security and weak institutions, poverty can also cause farmers to take a short-term perspective, which limits incentives for long-term investments in soil conservation (Holden et al., 1998; Shiferaw & Holden, 1999).

Access to land, the key productive asset for the rural population in Uganda, is extremely limited because of the very high fertility and population growth rates, which averaged 3.5% per annum over the past decade. Moreover, high degrees of uncertainty over tenure security prevail under some of Uganda's key land tenure systems, and this reduces incentives to adopt land conservation practices and protect soil fertility by terracing, fallowing and applying manure and fertilizers. For example, the bulk of the land in Uganda is under customary systems governed by communal rules enforced by elders and clan leaders.

Land degradation and poverty are bound to continue worsening in Uganda unless sound intervention policies are put in place. Designing appropriate intervention programs requires proper understanding of the factors that determine the adoption of land conservation practices. It is of particular interest to understand the role of poverty in land degradation. Given that government resources for eradicating poverty are limited, a more rational and effective way to allocate them would be to target specific aspects of poverty that critically limit farmers' ability to invest in soil conservation and enhance agricultural productivity. In order to design appropriate interventions, it is also necessary to gain a deep understanding of the social and institutional environments in which policies to curb land degradation operate, as this will facilitate knowledge transfer, encourage cooperation, help to coordinate and monitor public service delivery, and make it easier for farmers to access credit, markets and farm equipment, all of which are important for the adoption and diffusion of agricultural technologies (Isham, 2000; Nyangena, 2005).

In Uganda, studies investigating how social structures that vary from one village to another may affect the diffusion and adoption of SFM and conservation technologies are nonexistent despite the country's wide heterogeneity of tribal affiliations and formal and informal social organizations. Very few attempts have so far been made to investigate the impact of poverty on adoption of soil conservation practices in Uganda. The only available studies (Nkonya et al., 2005) used binomial decision models, which treat adoption choices as being independent of each other and exclude useful economic information contained in the interdependence and simultaneity of adoption decisions.

Applying a multinomial logit model (MNL) to a dataset purposefully collected by the World Bank and the International Food Policy Research Institute (IFPRI), this study analyzes the way land tenure, property rights, social capital and poverty influence the adoption of SFM and conservation practices.

A short survey of relevant theoretical and empirical literature is presented in Section 2. Section 3 presents the analytical model used to estimate the determinants of SFM conservation practices in Uganda. Section 4 presents the data and discusses the choice of variables and the empirical implementation of the MNL model. The MNL results are presented in Section 5, and Section 6 concludes the paper with some policy implications.

2. The links between poverty, tenure security, social capital and land degradation

Poverty and land degradation

Many theoretical studies have conceptualized the connection between rural poverty and the environment as a 'downward spiral', where poverty coupled with population growth leads to environmental degradation and thus worsens poverty (Mink, 1993, Dasgupta, 1995; Scherr, 2000). Some of these studies argue that poor farmers are limited to labor intensive production strategies, as they are unable to use external inputs such as fertilizers to support sustainable intensification and are therefore destined to contribute to natural resource degradation. Even if it is endowed with some natural resource assets, a household may be poor if it lacks complementary assets such as human capital or physical and financial farm assets. Some attempts have been made to study the factors that reduce poverty and at the same time increase investment in land management (Reardon & Vosti, 1995; Duriappah, 1996; Barrett et al., 2005).

Land tenure security and investment in SFM and conservation

The literature also tends to suggest that incomplete property rights reinforce the poverty-environment vicious circle (Duriappah, 1996; Scherr, 1999). This line of argument proposes that insecure tenure rights to land and the imperfect functioning of land markets tend to reduce incentives for smaller rural farmers to invest in long-term conservation measures such as planting trees, and soil conservation structures.

Surprisingly, despite the well-thought-out theoretical links, the results from studies that link tenure security and investment in conservation activities are contradictory and inconclusive. For instance, some studies argue that tenure security is not important for conservation (Migot-Adholla et al., 1991; Brasselle et al., 2002), while others argue that it is (Shiferaw & Holden, 1999; Place & Otsuka, 2000; Gabremedhin & Swinton, 2003; Kabubo-Mariara, 2003). These different findings are the result of differences either in the way tenure security is measured or in the way the relationship between investments and tenure rights is empirically conceptualized (Kabubo-Mariara, 2003).

Social capital and investment in SFM and conservation

Empirical studies show that greater social capital, acquired through information sharing and collective action, results in improved adoption and diffusion of technology (Isham, 2000; Nyangena, 2005). Reid and Salmen (2000) found that while all aspects of trust were important in explaining the level and extent of technology adoption, social cohesion in the form of attending social and church meetings and cooperating in providing public goods creates the ground for external inputs such as agricultural extension to take root. Women's organizations were also found to be consistent diffusers of information and technology (Reid & Salmen, 2000).

Isham (2000) showed that in rural Tanzania tribal-based social affiliations act as a form of social capital in the adoption decision. A household in a community within which there is greater ethnic homogeneity and greater member participation in decision making is more likely to adopt.

Other factors that influence investment in SFM and conservation

Many studies have found a strong association between household assets and environmental problems (Reardon & Vosti, 1995; Swinton & Quiroz, 2003). The characteristics of the natural resource base are also important in explaining the pathway from poverty to environmental degradation. The agricultural landscape for each different agro-ecological zone is typically quite distinct, and each therefore carries its own distinct risks of resource degradation, and offers its own distinct opportunities for intensification, diversification and land improvement (Scherr, 2000). In Ethiopia, for example, Bekele and Drake (2003) found that slope of the plot has a positive correlation with all types of conservation structures.

Lack of farmer awareness has been found to be a significant constraint to positive adaptation to environmental changes and also to making appropriate investments in land for conservation, especially where degradation effects are not easily observable and where resource degradation is not a local concern but a negative externality to outsiders, such as downstream sedimentation (Scherr, 2000).

3. The analytical framework for modeling farmers' decisions to adopt SFM and conservation practices

Many previous studies have modeled the decision to adopt conservation technology as a binary choice process (Place & Otsuka, 2000; Kabubo-Mariara, 2003, 2005; Pender et al., 2004; Nkonya et al., 2005). Using such bivariate models excludes useful economic information contained in the interdependent and simultaneous adoption decisions (Dorfman, 1996; Wu & Babcock, 1998; Bekele & Drake, 2003). It is therefore important to treat adoption of soil conservation measures and adoption of soil nutrient enhancing technologies as multiple-choice decisions made simultaneously.

Multinomial probit (MNP) and multinomial logit (MNL) models provide alternative approaches to analysis of land management decisions because such decisions are usually made jointly. They can also be used to evaluate the alternative combinations of management practices, as well as individual practices (Wu & Babcock, 1998). MNP models are, however, not commonly used, since it is difficult to compute the multivariate normal probabilities for any dimensionality higher than two, i.e. more than two (bimodal) choices (Greene, 2000).

In the present study, farmers' adoption of land management practices is modeled using an MNL model. Zilberman (1985) used this model to examine choices of irrigation technologies in California and Bekele and Drake (2003) used it to examine choices of soil and water conservation practices in Ethiopia.

Households' adoption of soil conservation and nutrient enhancing technologies can be evaluated on the basis of alternative decision choices, which can easily be linked to utility. According to Greene (2000), the unordered choice model could be motivated by a random utility framework, where for the i^{th} household faced with *j* technology choices, the utility of technology choice *j* is given by

$$U_{ij} = \beta_j^{'} X_{ij} + \varepsilon_{ij} \tag{1}$$

where U_{ij} is the utility of household *i* derived from technology choice *j*, X_{ij} is a vector of factors that explain the decision made, and $\beta_j^{'}$ is a set of parameters that reflect the impact of changes in X_{ij} on U_{ij}. The disturbance terms ε_{ij} are assumed to be independently and identically distributed. If farmers choose technology *j,* then U_{ij} is the maximum among all possible utilities. This means that

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

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

$$\Pr ob(Y_i = j) = \frac{e^{\beta_j^{'} X_{ij}}}{\sum_{j=1}^{j} e^{\beta_j^{'} X_{ij}}}, j = 0, 1, 2. \tag{3}$$

Estimating equation (3) provides a set of probabilities for j+1 technology choices for a decision maker with characteristics X_{ij}. The equation can be normalized by assuming that β_0= 0, in which case the probabilities can be estimated as

$$\Pr ob(Y_i = j) = \frac{e^{\beta_j' X_{ij}}}{1 + \sum_{K=1}^{j} e^{\beta_j' Z_{ij}}} \text{ and:} \quad (4)$$

$$Pr\,ob(Y_i = 0) = \frac{1}{1 + \sum_{j=1}^{j} e^{\beta_j' X_{ij}}} \quad (5)$$

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

$$\ln\left[\frac{p_{ij}}{p_{ik}}\right] = x_i'(\beta_j - \beta_k) \quad (6)$$

In this case, the dependent variable is the log of one alternative relative to the base/reference alternative.

The coefficients in an MNL model are difficult to interpret, so the marginal effects of the explanatory variables on the choice of alternative management strategies are usually derived as (Greene, 2000)

$$m_j = \frac{\partial P_j}{\partial x_i} = P_j\left[\beta_j - \sum_{k=0}^{j} P_k \beta_k\right] = P_j\left[\beta_j - \overline{\beta}\right] \quad (7)$$

The sign of these marginal effects may not be the same as the sign of respective coefficients as they depend on the sign and magnitude of all other coefficients. The marginal probabilities measure the expected change in the probability of a particular choice being selected with respect to a unit change in an independent variable (Long, 1997; Greene, 2000). Also important to note is that in an MNL model the marginal probabilities resulting from a unit change in an independent variable must sum to zero, since the expected increases in marginal probabilities for certain options induces a decrease for the other options within a set.

4. Data and empirical methods

This study used two datasets. First, we had access to data from a survey conducted in 2002 by IFPRI in collaboration with the World Bank and the Uganda Bureau of

Statistics to provide an understanding of the links between natural resource management and poverty in Uganda. The IFPRI survey covered rural areas in eight districts in Uganda: Arua, Iganga, Kabale, Kapchorwa, Lira, Masaka, Mbarara and Soroti (Table 1). The districts were chosen to represent a wide range of social, economic, environmental and institutional circumstances. The IFPRI survey collected information on plot and household characteristics as well as these households' participation in agrarian associations.

The IFPRI data, however, did not cover key variables such as education and gender and did not collect information on household expenditure. This information was therefore obtained from a second dataset, the 2000 Uganda National Household Survey (UNHS), since the two datasets had common identifiers. The UNHS covered all districts surveyed under the IFPRI project. A sample of 9,711 households was randomly selected from 972 enumeration areas (565 rural and 407 urban) in proportion to the population density of each district. The IFPRI data on the other hand covered a subsample of 851 households from 123 enumeration areas (all rural, given the focus of their study). Many of the observations had missing values and a large number of questionnaires were left out since they had incomplete or unreliable information (a high percentage of outliers), with the result that there were only 2110 usable data units.

4.1 Choice of explanatory variables and model implementation

Controlling for the effect of poverty

This study uses the level of per capita household expenditure to construct appropriate measures of poverty. This is one of the most widely used approaches to measuring poverty (Geda et al., 2001; Mukherjee & Benson, 2003). To compute this variable the study uses data from the 2002 Uganda National Household Survey (UNHS). The per capita household expenditure is expressed in real terms, normalized using 1989 as the base year.

Using the generated per capita household expenditure, the households in the sample are classified into two categories (poor/non-poor) using the standard national poverty lines (calculated on the basis of the people's food calories requirements adjusted by a mark-up for non-food requirements). Different poverty lines are used for different regions to take into account differences in staple foods consumed, tastes and consumption preferences, and price differences (Appleton & Sewanyana, 2003).

The literature postulates that poverty and adoption of various land management technologies are reciprocally interrelated. On the one hand, poverty determines the level of adoption of particular technologies. On the other, however, the level of adoption may have implications for land productivity and consequently for poverty. Introducing poverty on the right-hand side therefore introduces an endogeneity problem. Treatment of endogeneity in non-linear models cannot be pursued using the instrumental variables approach, as commonly used in linear models. Two-stage least-squares probit and logit models have been widely used to correct for endogeneity in the literature (Lee et al., 1980; Hassan, 1996) as described in Section 4.2.

Controlling for social capital impacts

The study uses one critical component of social capital, namely participation in agrarian associations such as production, supra-community and social groups. Membership of these associations has been widely used in the literature to measure social capital (Putnam et al., 1993; Narayan & Pritchett, 1999; Grootaert, 1999; Alesina & La Ferrara, 2000; Grootaert et al., 1999). Putnam et al. (1993) argue that participation in social groups may lead to transmission of knowledge and may increase aggregate human capital and the development of trust, which improves the functioning of markets.

Since different social organizations play different roles in the lives of rural communities, it is important to establish which particular institutions may be more related to adoption of agricultural technologies and which particular technology. To achieve this objective, a dummy variable (membership in production institutions) is used in the adoption model.

Controlling for the impacts of land tenure

It is hypothesized that insecure land tenure is a disincentive for farmers to invest in land improvements and conservation and therefore decreases agricultural productivity. In this study, land tenure measured by the right to bequeath land to next generations (an indicator of long-term tenure security) is used as the control for the effect of land tenure.

Other explanatory variables

Examination of the literature on adoption of soil conservation and fertility enhancing technologies in Africa suggests that choices among the different technologies depend on household attributes (level of poverty and asset endowments, access to information, household size, age and education of household head), institutional factors (land tenure, social capital) and plot level characteristics (state of soil nutrients, slope, farm size) (Shiferaw & Holden, 1998; Pender et al., 2004; Kabubo-Mariara, 2005; Nkonya et al., 2005). The set of regressors that were chosen, their definition, measurement and expected direction of influence on adoption are given in Table 1.

Table 1: Definition of variables used in the empirical analysis and key attributes of the surveyed sample (n=2110)

Variable	Definition	Values/measure	Expected sign
Sex	Sex of household head	1=Male and 0=Female	+/-
Bequeath	Right to bequeath land to next generations	1=yes and 0=no	+
Dist Res	Distance from plot to residence	Kilometers	-
Dist MKT	Distance from plot to nearest market	Kilometers	-
Nutrient prob.	Perceived nutrient deterioration of plot	1 if observed deterioration and 0 if not	+
Non-farm inc.	Non-farm income	Uganda shillings	+
Agric extension	Access to agricultural extension information	Dummy (1=if household had access to an extension agent in 2002, 0=if not)	+
Age of hh head	Age of household head	Number of years	+/-
Educ of hh head	Education of household head	Number of years in school	+
Hh size	Size of household	Number of household members	+
Livestock	Livestock ownership in tropical livestock units (TLUs)	Average TLU for Uganda is cow =0.9, ox =1.5, calf =0.25, sheep or goat =0.2	+
Number of parc	Number of parcels a household owns	Number	+
Agro-climate	Agro-ecological zones based on rainfall patterns	Agro-ecological zones, (Dummy: bimodal rainfall =1 and unimodal rainfall=0)	+/-
Memb to pdn org	Membership of production associations	1=yes and 0=no	+

Descriptive statistics of key attributes of the study sample (sample size n=2110)

District	Population (people/km^2)	Head count (% below poverty line)	Agro-climate	Land management practices (% farmers)					Livestock assets in TLU	Non-farm income ($/annum)
				Fallow	Organic fertilizer	Inorganic fertilizer	Terracing	None (no adoption)		
Masaka	151	35.9	Bimodal	10.40	18.04	01.22	00.92	64.41	1.66	323
Iganga	288	56.2	Bimodal	12.96	12.15	01.39	00.00	66.74	1.13	259
Kapchorwa	67	13.3	Unimodal	00.00	28.85	15.72	16.98	34.32	3.28	222
Soroti	50	47.6	Unimodal	80.00	05.00	05.00	00.00	06.87	7.19	81
Arua	82	67.3	Unimodal	46.90	04.40	07.56	04.26	34.37	2.93	161
Lira	70	66.7	Unimodal	86.21	00.00	00.00	00.00	10.42	4.11	245
Kabale	250	37.6	Bimodal	35.84	07.78	02.41	19.88	30.22	1.45	186
Mbarara	88	37.9	Bimodal	12.71	24.82	01.37	09.28	49.36	5.34	318
All	92	44.7		27.9	12.61	04.14	09.50	42.64	2.53	229

4.2 Specification of the land management decisions MNL model

An MNL model for land management practices was estimated using data collected from all the eight districts. The complete choice set (response variable) for the MNL model gives 16 factorial combinations of possible outcomes (Table 2). However, it is clear from Table 1 that farmers who combine different soil conservation and fertility management practices represent a very small percentage (an average of 3.43%). This meant that modeling all possible combination outcomes results in very small sample units in many of the combination outcomes. We therefore decided to group all choices other than only fallowing (outcome 1), only using organic fertilizers (outcome 2), only using inorganic fertilizers (outcome 3), only terracing (outcome 4), or none, i.e. no adoption (outcome 16) into one other alternative choice outcome (i.e. all possible combinations of choices – outcomes 5 to 15 in Table 2). Accordingly, the set of outcomes for the response variable was limited to six land management technology choices: (i) fallowing only (ii) using only organic fertilizer (iii) using only inorganic fertilizer, (iv) only terracing (v) using a combination of SFM practices and (vi) continuous cropping without any land management (i.e. no adoption of any of the land fertility management practices – outcome 16 of Table 2, which is used as the reference choice for comparing the marginal effects of other choice outcomes). 'Terracing' here means using stones (*fanya juu)*, or bench (*fanya chini*) types of terraces. 'Organic fertilizer' means mulch, animal manure, household refuse, biomass transfer and cover crops. 'Inorganic fertilizer' means N fertilizer (urea, ammonium nitrate), P fertilizer (SSP, DAP and TSP) and composite fertilizers (NPK). These technologies were chosen because they are commonly used in Uganda as land management practices (see Table 2) or are being promoted for use through the country's extension system.

Table 2: Alternative outcomes as possible combinations of land fertility management practices defining modeled decision choices (where 1 means that the practice is adopted and 0 that it is not)

Possible outcomes	Technology bundle			
	Fallowing	Organic fertilizer	Inorganic fertilizer	Terracing
1	1	0	0	0
2	0	1	0	0
3	0	0	1	0
4	0	0	0	1
5	1	1	1	1
6	1	1	1	0
7	1	1	0	0
8	1	1	0	1
9	1	0	1	1
10	1	0	0	1
11	1	0	1	0
12	0	1	1	0
13	0	1	0	1
14	0	1	1	1
15	0	0	1	1
16	0	0	0	0

Before empirical estimation of the MNL model, the independent variables were scrutinized for possible correlations since multicollinearity is a common problem with such datasets. Distance to the nearest all-weather road and distance to the nearest seasonal road were found to be strongly correlated with distance to markets. Also, main source of income was correlated with non-farm income; and ethnic dominance and origin of farmers' association (whether local or foreign) showed a strong correlation with membership. These variables were therefore excluded from the analysis.

A two-stage econometric process was used to correct for endogeneity caused by the endogenous regressors being correlated with the error term. In the first stage, a poverty model was estimated using the probit[2] maximum likelihood procedure. In the second stage, fitted values of the endogenous variable (poverty) were computed using the first stage parameter estimates and used as regressors (instruments) in the MNL adoption model to estimate the determinants of technology adoption.

The other problem common in cross-section data analysis is heteroscedasticity. This study used White's heteroscedasticity consistent covariance matrix (HCCM) to correct for heteroscedasticity of an unknown form (White, 1980). The study specifies the Huber-White sandwich estimator to correct for heteroscedasticity. Long (1997)

[2] Logit estimation is also appropriate for analysing binary response data. There is therefore no apriori reason to prefer probit over logit estimation (Gujarati, 1995; Greene, 2000)

argues that the HCCM provides a consistent estimator of the covariance matrix of the slope coefficients in the presence of heteroscedasticity and can be used to avoid its adverse effects on hypothesis testing even when nothing is known about the form of heteroscedasticity.

MNL models are very commonly used for estimating polychotomous choice models because of their relative ease of estimation and interpretation. However, the MNL imposes a rather restrictive assumption known as the irrelevance of independent alternatives (IIA) assumption. This assumption implies that the ratio of the utility levels between two choices, say organic fertilizer and inorganic fertilizer, remains the same irrespective of the number of choices available. The Hausman test (Hausman & McFadden, 1984) was used to check whether the IIA assumption is violated. The test results show that we cannot reject the null hypothesis of independence, suggesting the use of MNL is appropriate. Stata software (StataCorp, 2005) was used to implement the econometric analysis.

5. Results of the multinomial analyses of determinants of adoption of land improvement and conservation practices

This section discusses the results of the econometric analyses of the links between poverty (measured as members of the population falling below the poverty line), property rights,[3] social capital[4] and the land management practices of farmers in Uganda. The estimated MNL coefficients showing marginal effects and P-levels are presented in Table 3.

[3] Security (insecurity) of tenure or property rights means having (not having) the right to bequeath land to the next generation.
[4] Access (no access) to social capital means being (not being) a member of a production association.

Table 3: Marginal effect for the MNL for adoption of land management technologies (sample size=2110)

Variable	Fallow		Organic fertilizer		Inorganic fertilizer		Terracing		Terracing+SFM		Non-adopters	
	ME	**P-level**	**ME**	**P-level**	**ME**	**P-level**	**ME**	**P-level**	**ME**	**P-level**	**ME**	**P-level**
Sex	0.0916***	0.0000	0.0114	0.3560	-0.0166*	0.0530	0.0232***	0.0010	0.0051	0.5930	-0.1146***	0.0000
Bequeath	0.0447**	0.0470	0.0417***	0.0010	-0.0111*	0.0590	0.0038	0.5090	0.0010	0.9310	-0.0800***	0.0030
Dist res	0.0110***	0.0040	-0.0407***	0.0000	0.0015***	0.0000	0.0011**	0.0280	0.0027***	0.0040	0.0244***	0.0020
Dist MKT	0.0094***	0.0070	0.0002	0.9350	-0.0044***	0.0000	0.0002	0.7840	0.0038***	0.0000	-0.0092**	0.0200
Nutrient prob.	0.0304	0.1060	0.0095	0.3430	-0.0046	0.2260	-0.0034	0.5270	-0.0110	0.2380	-0.0210	0.3350
Non-farm inc.	0.0588***	0.0000	-0.0088	0.1400	-0.0058**	0.0240	-0.0423***	0.0000	-0.0347**	0.0220	0.0329*	0.0660
Agric extension	0.0061	0.7840	0.0105	0.3800	0.0157**	0.0150	0.0110	0.1240	-0.0160	0.1510	-0.0274	0.2920
Age of hh head	0.0020**	0.0140	-0.0008*	0.0760	-0.0006***	0.0080	-0.0003	0.2010	0.0004	0.4740	-0.0008	0.4170
Educ of hh head	0.0004	0.9080	0.0007	0.6700	-0.0006	0.2800	-0.0014	0.1250	0.0013	0.4750	-0.0004	0.9190
Hh size	-0.0116***	0.0090	0.0072***	0.0040	0.0052***	0.0000	0.0010	0.4260	-0.0013	0.6560	-0.0006	0.9190
Poverty	0.2375***	0.0060	-0.1525***	0.0010	-0.0815***	0.0000	-0.0025	0.9030	-0.0657	0.1470	0.0646	0.5280
Livestock	-0.0007	0.7560	-0.0008	0.4910	-0.0002	0.7160	0.0007**	0.0460	-0.0007	0.3780	0.0017	0.4600
Number of parc	0.0207***	0.0000	-0.0072***	0.0010	0.0018***	0.0010	0.0034***	0.0000	0.0064***	0.0000	-0.0251***	0.0000
Agro-climate	-0.2763***	0.0000	0.0446***	0.0010	-0.0969***	0.0000	0.0245***	0.0000	-0.0078	0.6620	0.3118***	0.0000
Memb to pdn org	0.0432*	0.0560	-0.0050	0.6550	0.0089	0.1030	0.0117*	0.0860	-0.0069	0.4820	-0.0519**	0.0450

SFM = soil fertility management; non-adopters are used as the base category. *, **, and *** represent the level of significance at 10%, 5% and 1% respectively.

Most of the explanatory variables are statistically significant at 10% or less and have the expected signs except for a few surprise outcomes discussed below. Generally the results show that poverty hinders the adoption of SFM and conservation technologies. Poverty is negatively related to adoption of organic fertilizer, inorganic fertilizer, terracing and a combination of terracing and other SFM practices. The magnitudes of the estimated marginal effects of poverty indicate that, compared to other factors, poverty has a very strong influence on the adoption of these practices. Poverty is also found to positively influence the probability of non-adoption of any technology. The negative association between poverty and technology adoption suggests that poverty is a key constraint to adoption of land management technologies, which supports the findings of earlier, related studies (Li et al., 1998; Shiferaw & Holden, 1998, 1999). However, it could also be a reflection of poor targeting of technologies, since the national extension services in Uganda have been blamed for targeting the rich and neglecting the poor (Hassan & Poonyth, 2001). These findings suggest that government efforts to reduce poverty would improve adoption of conservation and SFM practices. More important is to target the needs of poor farmers when developing and disseminating SFM technologies.

The results also suggest a positive relationship between adoption of fallowing and poverty. This is a rather surprising result, because it suggests that the poor may adopt fallowing more than the rich, who are expected to have more land. However, there may be two explanations for this finding. First, sample descriptive statistics showed that there is no significant difference in farm size between the different income quintiles. In fact, the results show further that poor districts such as Lira and Soroti have on average larger farms than better-off districts, because the poor districts of the north have a low population density and hence more land is available. It is also important to note that the poor usually have limited choices, given the cost implications of the alternative of intensification through external inputs such as inorganic fertilizers.

The right to bequeath land to future generations is seen as an indicator of long-term tenure security and as a result encourages farmers to have longer planning horizons. As expected, we find that long-term tenure security positively influences adoption of fallowing, organic fertilizer application, terracing and a combination of terracing and other SFM technologies, generally reducing the probability of non-adoption. This suggests that policies that facilitate and encourage tenure security, such as easing the land registration and titling processes in order to ensure long-term tenure security, can significantly increase the probability of adoption of SFM and provide incentives for investment in conservation activities.

However, a negative relationship was found between land tenure and adoption of inorganic fertilizer. This suggests that farmers prefer to use inorganic fertilizer on less secure land to maximize short-term benefits and reserve other inputs for owned plots with long-term security. Similar results were found by Gavian and Fafchamps (1996) in Ethiopia.

Membership of production associations was found to be positively related to the likelihood of adopting fallowing, terracing and use of inorganic fertilizer and generally reduces the probability of non-adoption of all technologies. These findings suggest that investment in and promotion of social capital institutions such as production associations is important for encouraging the adoption of SFM and conservation technologies.

Two policy implications of these outcomes are clear. First, development projects should not be designed to deal with all communities uniformly, but should be adapted to different levels of existing social institutions and norms. Second, extension workers need to understand the social and institutional fabric of their areas of work. They should promote and exploit the existing social infrastructure to disseminate information about new technologies and encourage cooperative action in areas of resource pooling such as labor sharing and savings.

The results of this study show a negative relationship between membership of production associations (savings and credit associations, rotating credit schemes, farmers' groups and women's groups) and the adoption of organic fertilizer. Of these categories, membership in the first two (savings and credit) constitutes 60% of the total membership. Availability of credit through these organizations to support SFM alternatives to the labor intensive organic fertilizer could therefore be the reason. In the districts of Arua and Kapchorwa, where inorganic fertilizer is mostly used, production associations such as farmers' groups are directly involved in procuring inorganic fertilizer and distributing it to the members, which promotes the use of purchased inputs and hence there is less need for organic sources.

The results show that, although farmers' access to information is positively related to most of the practices, agricultural extension does not significantly affect the adoption of most of the technologies other than the use of inorganic fertilizer. Prior adoption studies in Uganda (Nkonya et al., 2005) have come up with similar findings. There may be two reasons for this weak relationship between extension and adoption decisions. First, the extension system in Uganda has been packaged to promote the use of inorganic fertilizer, in an effort to intensify agricultural production, and, second, the extension services are inadequate and sometimes completely lacking. For instance, only 28% of the sampled households had had a single visit by an extension agent over a period of one year. The policy implication of this outcome is that there is a need to revitalize the extension services and ensure that they support the use of traditional SFM and conservation technologies that are more readily available to the farmers.

The positive and significant relationship between household size and adoption of organic fertilizer and terracing suggests that households that are endowed with family labor tend to use labor intensive management practices. The negative relationship between household size and fallowing could be attributed to the fact that larger households tend to have smaller farms and hence cannot afford to fallow but must use other SFM practices. Farmer's age was significantly and positively related to adoption of fallowing, but negatively related to adoption of inorganic fertilizer. One possible explanation for this outcome could be that older farmers are more risk averse and therefore resistant to changing to newer technologies since they are more used to traditional management systems.

Education was negatively related to adoption of terracing and inorganic fertilizer, contrary to expectations that better educated household are more likely to adopt land management practices. A possible explanation for this outcome is that education improves access to alternative livelihood strategies such as non-farm activities, which may increase the labor opportunity cost and compete with agricultural production (Nkonya et al., 2004).

In fact, non-farm income was found to be positively related to adoption of fallowing but negatively related to adoption of inorganic fertilizer, terracing, a combination of terracing and other SFM technologies, and organic fertilizer. This is another surprising result, since non-farm income is expected to provide the much-needed cash to buy external inputs, but consistent with the results of earlier analyses (Nkonya et al., 2005). There are two possible explanations for this outcome. First, agriculture is generally not profitable in Uganda (Nkonya, 2002) and this discourages investment in SFM and conservation. Second, since non-farm activities are generally more profitable and are full-time activities and sometimes located away from the farm, they take away the much needed farm labor. Non-farm activities eventually become the key source of family livelihood. As Haggblade et al. (1989) argue, initially farmers integrate non-farm activities with farming activities on a seasonal or part-time basis. Returns from non-farm activities are invested in farming activities but eventually, because of increases in demand for non-farm goods, those involved in non-farm activities break away from farming to become involved in non-farm activities on a full-time basis.

Agro-climatic zones stand out as an important factor that could explain differential use of SFM and conservation technologies in the study areas. For instance, the likelihood of using fallowing and inorganic fertilizer in the bimodal agro-climatic zones is 27.63 and 9.69%, respectively – lower than in unimodal agro-climatic zones. As noted earlier, most districts in the unimodal zones are sparsely populated, so fallowing is more likely here than in the densely populated districts in the bimodal zones. The likelihood of using inorganic fertilizer is also higher in the unimodal agro-climatic zones because of the organized input supply for maize and barley farmers in the Kapchorwa district and tobacco farmers in the Arua district, and the better extension services in the Soroti district.

In general, having more plots reduces the probability of non-adoption. Having more plots is an indicator of a larger farm size, which allows the farmer to practice terracing and fallowing quite easily. A major problem in the densely populated highland districts is that terraces are occupying a large amount of productive space and so they are being destroyed. However, the results also show a negative relationship between number of plots and organic fertilizer use. This is again as expected, since the use of bulky manure on many plots involves high transport and distribution costs.

Overall, longer distances from homesteads to plots increase the probability of non-adoption, since using organic fertilizer is a labor intensive activity – the greater the distance, the greater the labor needs and associated costs of transport and distribution. Farmers therefore choose to use less costly technologies such as fallowing and inorganic fertilizer in far-off plots and more labor intensive organic fertilizer in plots close to their homesteads.

As expected, distance to markets was found to reduce the probability of adopting inorganic fertilizer but to increase the probability of using fallow and a combination of terracing and other SFM technologies. Far-off markets imply high costs of transactions for both inputs and outputs. The high costs, coupled with the level of poverty, therefore reduce the probability of using marketed inputs such as inorganic fertilizer while increasing the use of traditional technologies such as fallowing. These findings suggest that road infrastructure development would increase adoption of marketed inputs.

Ownership of livestock has a limited impact on most land management technologies and is only positively and significantly related to adoption of terracing. Surprisingly, we do not find that livestock ownership has a positive and significant impact on adoption of organic fertilizer. The explanation for this may be that in areas where households keep cattle, which produce a significant amount of manure, the farmers are nomads for whom livestock is the main source of income or are not seriously involved in crop agriculture except for small subsistence gardens, and in areas where households keep sheep and goats and other small animals, the farmers may be involved in crop agriculture but their animals produce only small amounts of manure.

6. Conclusions and policy implications

This paper analyzes the impact of poverty, social capital and land tenure on the adoption of SFM and conservation activities. To capture the interdependence and joint nature of adoption decisions, we performed an MNL analysis that generated findings that suggest the following,

1) Poverty increases the probability of non-adoption of technologies in general and particularly reduces the probability of adopting organic and inorganic fertilizers and terracing, mainly because the poor have limited access to cash and markets and lower land and livestock assets. This finding suggests that government programs to reduce poverty would go a long way to promote the use of SFM and conservation practices.

2) Land tenure security is positively correlated with the adoption of fallowing and organic fertilizer use but generally reduces the probability of non-adoption of land management technologies. However, it was not found to significantly influence the adoption of inorganic fertilizer and terracing. These results also suggest that programs that enhance tenure security, such as land registration, would encourage the adoption of most land management practices.

3) We also find that participation in social institutions generally tends to increase the probability of adopting some land management practices. This finding is especially important in Uganda, where social capital issues are not well researched or incorporated into government policy. Investment in social capital is therefore of paramount importance for the adoption of land management technologies. The policy implication here is that extension workers should understand the social and institutional fabric of the places where they work, and they need to articulate the relevance of promoted technologies to the local social context so that the villagers become more receptive to new agricultural techniques and methods. For policy purposes,

therefore, development projects should not be designed so that they deal with all communities uniformly, but be adapted to take advantage of existing social institutions and norms.

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