DETERMINANTS OF LAND USE IN THE DENSELY POPULATED KIGEZI HIGHLANDS OF SOUTHWESTERN UGANDA

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Abstract

We characterize land use at the household level and identify two types of long-term uncultivated lands – those that are intentional fallows and those that are neglected or abandoned. We then use a multinominal logit model to examine the determinants of plot abandonment and long fallows in order to propose policy interventions that lead to optimal and sustainable management of land use systems in Kigezi highlands. Household factors such as age, and formal education positively influenced farmers' decision to abandon plots. Plot variables such as slope and distance between the homestead and the plot had the expected positive signs while soil fertility had a significant negative sign. From the analysis different typologies of uncultivated lands were defined depending on their inherent characteristics and distance to the homestead. Farmers then provided technological and policy options as to how these types of plots could be made more productive.

1. Introduction

The development of the agricultural sector in Kigezi highlands in South Western (SW) Uganda has involved progressively more intensive use of land resources for cropping and grazing leading to unsustainable adaptation and changes in land use. Restoration of soil productivity had relied on natural fallow practices and subsequent natural resource regeneration. However, existence of large proportions of uncultivated land in such densely populated area is evidence that some of this may be unintentional fallows (AFRENA 1999). This observation appears contrary to the expectation of increased annual cultivation in land scarce areas as postulated by the theory of induced innovation (Boserup 1965).

Some authors have suggested that the increased area under long fallows could be a farmer's management strategy to improve natural resource management and fertility regeneration (Lindblade, 1998). Others have argued that disuse is because plots are very heterogeneous with some plots being very unproductive in terms of crop yields despite effort to increase production. Furthermore, poor land markets could be inhibiting farmers from acquiring land that they would put into use and disposing of land that they have abandoned. In order to understand the impact of human activity on the highland ecosystem and identify interventions to address the issue, it is important to identify and estimate the factors that influence farmers' decisions to put land to particular usage. Therefore, the main objective of this study is to determine the present status and causes of land abandonment, and propose policy options for sustainable management.

The Kigezi highlands are a region of high agricultural potential but with a high population density (about 300 per km^2) and population growth of about 2.2% per annum. The highlands lie in SW Uganda at an altitude of 1500-2700 meters above sea level. The rainfall pattern is bimodal and ranges from 1000 to 1500 mm per annum. The temperatures are moderate with mean minimum of 13^0 C and mean maximum of 23^o C. Soils are generally volcanic and are inherently fertile (Djimbe and Hoekstra 1987).

2. Previous work on farmers land use decisions

In this research, the practice of leaving land to rest for longer periods than the farmer would have desired (*unintentional fallow)* locally known as "*Eibija*" is what is referred to as abandonment of land. This is opposed to *intentional fallow* that is commonly practiced and known to farmers locally known as "*Hinga raza.*" Land abandonment has been observed in several other countries including Botswana, and Japan (Mmopelwa 1998, Arntzen 1984, Kashiwagi 1998,).

Mmopelwa (1998) examined the proportion and factors causing unintentional fallowing in Botswana. The study revealed that 20% of farmers unintentionally fallowed 1% intentionally fallowed and 79% did not fallow at all. The factors attributed to unintentional fallows were lack of draught power (86%), labor (82%) and rainfall variability (100%). Two aspects of fallowing were noted. One aspect was intentional fallowing, whereby farmers purposefully left land uncultivated for it to regain soil fertility and the other was unintentional fallowing whereby farmers involuntarily left land uncultivated due to biophysical, social and economic factors.

Grisley and Mwesigwa (1995) investigated the socio economic factors that influence seasonal fallowing in Kigezi highlands. The study revealed that 76% of farmers reported some cropland in grass fallow. Households reported an average of 26% of cropland under fallow and intercropping and farmsize were highly associated with the land fallowing decision. A study by Barbier (1998) used a bio-economic model to investigate the theory of induced innovation and land degradation in the intensively cultivated areas of West Africa. The results showed that farmers prefer extensification to intensification even if land is marginal and produces lower yields over time soil organic matter and soil nutrients become scarce and the cost of land degradation increases.

The changes in land use system in Kigezi highlands between 1945 and 1996 were investigated by Lindblade *et al* (1998) using transects conducted in 1945 as baseline. They observed significant increase in area under fallow since 1945. For example, 19% of plots were left to fallow in 1945 as compared to 32% in 1996. The duration of the fields rested had extended significantly with 95% left to fallow for more than half a year in 1996 compared to only 5% in 1945. Finding more fallow to day compared to 1945 is perplexing given that both local people and various researchers report consistently that land fallow periods have decreased or are non-existent for some farmers.

3. Analytical framework

The five land use options analyzed include continuous cropping, short fallow, long fallow, woodlots and abandonment. At an individual farm level, decisions to use a given plot of land for annual production or to put it under any other land use options is assumed to depend on the net present value of the option available to the farmer. For example, the practice of continuous cultivation with intermittent short duration fallows would only continue if normal returns on fixed capital would be obtained after all farm running costs have been paid. However, if land resources become depleted, potential future profits will be reduced until ultimately the plot is fallowed or put to some other land use option that would be less profitable in comparison to cropping. Because the use of fertilizer is very low in Uganda as a whole, Kigezi no exception, the possibility that land become degraded with continuous use is real.

We assume that plot characteristics that affect the net returns will affect land use decisions. For example, plots of inherently poor soil fertility would be less likely to be put to into cultivation compared to other plots. The distance to the plot will also generate differences in labour costs and risks (e.g. of crop theft) and affect land use decisions. Household factors such as access to resource (e.g. labour, land) will also affect the net returns from the portfolio of plots and affect general land use decision-making at the farm level. Farms are characterized by extreme land fragmentation, with households owning 6 -10 plots widely scattered on the landscape. Thus, the possibility that a household will face widely varying net returns to an identical investment on their different plots is high.

4. The econometric model of land use decisions

We estimate an econometric model of land use decisions using a snapshot or cross sectional data. The dependent variable (land use options) has five response levels representing the current land use option of a given plot. These are continuous cropping, abandonment, woodlot, long fallow and short fallow. The covariates include age of the household head, farm size, plot distance from homestead, household size, education level of the household head, gender of household head, polygamous or not, plot location, soil fertility status, presence of stones, plot size and slope.

The logistic model is generally specified as follows;

$$Y_i^* = \beta' X_i + \varepsilon_i \qquad (1)$$

Where, Y_i^* is the underlying latent variable that indexes the land use option on a given plot. X_i is a (kx1) vector of explanatory variables, β is a (kx1) vector of the parameters to be estimated, and ε_i is the stochastic error term.

A general expression (Greene 2003) for the conditional probability for the five land use options (categories) is:

$$P(Y = j)\Big| X = \frac{e^{g_j(X)}}{\sum_{k=0}^{4} e^{g_k(X)}} \qquad (2)$$

Where j is the category of land use. From this specification, the probabilities for each of the observed responses are easily derived.

5 The empirical model

The model used to estimate the influence of plot and household characteristics on land use choices is specified as follows:

$$A= \beta_0 + \beta_1 \text{ FARMSIZE} + \beta_2 \text{ HHSIZE} + \beta_3 \text{ AGEHH} + \beta_4 \text{ HHPMALE} + \beta_5 \text{ HHFEMALE} + \beta_6 \text{ EDUCPRIM} + \beta_7 \text{ EDUCPOST} + \beta_8 \text{ FERTMOD} + \beta_9 \text{ FERTGOOD} + \beta_{10} \text{ TOPMID} + \beta_{11} \text{ TOPTOP} + \beta_{12} \text{ STONFEW} + \beta_{13} \text{ STONMANY} + \beta_{14} \text{ SLOPMOD} + \beta_{15} \text{ SLOPSTP} + \beta_{16} \text{ PLOTSIZE} + \beta_{17} \text{ PLODIS} + e$$

Where;

A = Land use options (cropped plots, short fallow, long fallow, abandonment and woodlots)

FARMSIZE	The total land holdings measured in hectares
HHSIZE	Number of household members measured in number of persons
AGEHH	Age of the farmer measured in years
HHFEMALE	Households headed by female (base case is monogamous households headed by males)
HHPMALE	Polygamous households measured as number of women living with the head.
EDUCPRIM	Household heads with education level of primary (base case is no formal education)
EDUCPOST	Household heads with education levels of post-primary or more
FERTGOOD	Terrace plots with good soil fertility
FERTMOD	Terrace plots with moderate soil fertility (base case is plots with poor soil fertility)
TOPMID	Terrace or plot is located in the mid slopes
TOPTOP	Terrace plots located on landscape (base case is valley bottoms)
STONFEW	Plot has few stones (base case is plots with no stones)
STONMANY	Plot or terraces has many stones
SLOPMOD	Plot or terrace is on moderate slope (base case is flat plots)
SLOPSTP	Plot or terrace is on steep slope
PLOTSIZE	The plot size in hectares
PLODIS	The distance of the plot from the home measured in Km

5.1 Selected variables for the model

The age of the household head is one of the exogenous household variables included in the model because it may affect the probability of plot abandonment. Land markets exist, but are imperfect so older farmers may have had more opportunity to dispose of unwanted plots or have accumulated more wealth so as to avoid abandonment. On the other hand, they may have acquired many plots and found that they cannot adjust their land holdings as quickly as other factors like labor or capital have changed.

Household size, sex of household head, polygamous households, and education of household head are also included. Household size is hypothesized to have a negative relationship with abandonment. Educated farmers (especially those with post-primary education) are expected to have acquired knowledge in relation to improved methods of land management. They have the ability to acquire loans to improve the land but they are also capable of diverting the resources to non-agricultural activities perceived to offer higher returns. This therefore may lead to less investment in soil improvement and increased land abandonment. Therefore, a priori the hypothesized sign is unclear.

The plot related variables included in the model among others were TOPTOP (plot on a hilltop) and TOPMID (plot on a midslope) with plots in the valley bottom acting as a base. Although both represented the topographic location of the plot, they are entered as separate variables because they are expected to influence abandonment of plots differently. It is expected that plots located on the hilltop are more likely to be abandoned compared to plots in the valley bottom because of poor accessibility. The plots in the mid slope are more likely to be either short fallowed or long fallowed because they are closer to the homes. The variables FERTMOD (moderate soil fertility) and FERTGOOD (good soil fertility) are entered separately as dummy variables and plots with poor soil fertility acted as the base case. It is hypothesized that soil fertility is negatively related to abandonment. Therefore, soil fertility variables are both expected to have negative signs.

5.2 Data and Sources

Kabale district with a land area of about 1850 km^2 has three counties and 19 sub counties. In each county, 2 sub counties were selected randomly. To estimate the model data were collected from a total of 6 sub counties in Kabale district. Selection of sub-counties and parishes was undertaken using multistage simple random sampling. Twenty farmers were chosen from each parish while a total of 60 farmers were selected from each sub county. Interviews were carried out in 18 parishes and data were collected from about 360 households through use of a structured questionnaire and plot visits. The unit of analysis was a farmer's plot, but data were also collected on the farming household. Given that each household has about 8 plots, the survey covered over 2,530 plots.

6 Results:

6.1 The extent of abandonment and land use options

The current use of plots by farmers reveals that about 59.6% of the plots are cultivated with crops. The short fallow and long fallow comprise of 8.1% and 13.7% respectively. The woodlots and abandoned plots by farmers are about 10.1% and 8.1% of the total plots visited. Farmers' reported that poor yields are the main reason for both long fallow and abandonment of fields. The survey reveals that of about one-quarter of plots either long fallowed or abandoned, 61% was due to soil fertility problems. Livestock grazing (10%), location of fields (11%), labor shortage by households (9%) and old age (2.3%) are also important factors for non-cultivation. The results (Table 1) reveal that the average distance of plots from the homestead and roads is about 1.15 km and 1.5 km respectively ranging from 0 to 20 km. Hilly terrain makes it difficult to reach the plots that look to be near homes. The average number of plots per household head is 8 plots and ranges from 1 to 20 although scattered over the landscape. This scattering of land though sometimes used as a risk management strategy may partly lead to sub optimal usage of the plots.

Table 1: Variations in factors that influence farmers' land use decisions.

Factors	N	Minimum	Maximum	Mean	± S.E
Distance of plot from home	2530	0.00	20.00	01.15	0.03
Total number of plots	2530	1.00	20.00	07.80	0.08
Farm size	2530	0.07	46.00	10.97	0.25
Age of household head	0360	18.0	82.00	45.12	0.27
Household size	0360	1.00	23.00	07.73	0.00
Size of plot	2530	0.03	25.00	01.26	0.04

Note: Distance was measured in km, farm size and area in acres.

The mean household farm size is about 4 hectares (ha). This appears to be on the high side compared with existing data, which reports the average land holding of about 1 ha. Examination of data and the land use system revealed that an average land holding of 1 ha per farmer in the Kabale district could be an underestimate. This is based on land area divided by farm households, which does not cater for the land farmers own on the hillsides. Furthermore, unless one visits the plots, farmers tend to report fewer plots that they use gainfully rather than plots lying idle. The mean for household size is about 7 members per household with only 4 active members (55%) who are above 14 years. The rest are either elderly (0.5) or still young (3) members.

Econometric results

A single multinomial logit model was run, but because there are five outcomes, the estimates of the determinants of farmers' decisions for each category are in Tables 2 and 3. The coefficients can be interpreted as the change in the log odds associated with a unit change in the respective independent variable. Results of four land uses (short fallow, long fallow, woodlot and abandonment) models are presented below; as follows;.

Short fallow model

The household level variables that are significant for short fallow were FARMSIZE and EDUCPOST. Other significant plot variables included, SLOPMID, FERTMOD, FERTGOOD, PLOTSIZE and PLOTDIS. The short fallow model results show that the odds ratio values for a given plot to be under short fallow are significant for EDUCPOST and FARMSIZE at a 1 % level. For example, the odds ratio values obtained for EDUCPOST is 2.26. This implies that as the variable changes from no formal education to EDUCPOST, the odds ratio for the plot to change from cultivated plot to be under short fallow increases more than 2 times compared to that of no formal education, the value of other independent variables held constant.

Table 2: Estimated coefficients and odds ratio for factors influencing farmers' decisions to either use land for short fallow or long fallow.

	Short fallow		Long fallow	
Factor	Coefficient estimate	Odds ratio	Coefficient estimate	Odds ratio
Intercept	-1.799		-0.767	
AGEHH	0.003	1.002	0.013	1.013**
HHSIZE	0.003	1.003	-0.059	1.060
FARMSIZE	0.026	1.026***	0.005	1.006
EDUCPRIM	0.118	1.125	0.217	1.240
EDUCPOST	0.816	2.260***	-0.013	1.014
HHFEMALE	0.105	1.110	0.488	1.630**
HHPMALE	0.026	1.027	0.445	1.550**
TOPTOP	0.299	1.348	0.279	1.321
TOPMID	-0.723	2.060***	-0.526	1.692***
FERTMOD	-0.486	1.625**	-1.657	5.243***
FERTGOOD	-0.877	2.403***	-2.276	9.738***
STONFEW	-0.230	1.258	-0.172	1.188
STONMANY	-0.359	1.431	0.031	1.031
PLOTSIZE	-0.133	1.142**	-0.017	1.017
SLOPMOD	0.086	1.090	0.225	1.250
SLOPSTP	0.297	1.346	0.294	1.341***
PLOTDIS	0.126	1.134***	0.195	1.215

*, **, *** denotes statistical significance at the 10%, 5% and 1% level respectively

Plot variables such as TOPMID, PLOTDIST, and FERTGOOD significantly influence short fallowing. The results show that the odds ratio of TOPMID was 2.06 This shows that the probability of a plot being under short fallow are 2 times less likely if a plot is located in the midslopes relative to the plots in the valley bottom.

Long fallow model

Three household variables that are significant at the 5% level include the age of the household head (AGE), households headed by females (HHFEMALE) and polygamous families (HHPMALE). Relationships between long fallow and age of household head have a positive sign. This implies that long fallow plots are more likely to belong to farmers who are older compared to those who are younger. The odds ratio value obtained for the variable (HHFEMALE) is 1.6. This shows that the probability (odd values) for a given plot to change from cultivated to long fallow is relatively higher for households headed by females compared to those headed by males.

The significant differences are observed in soil fertility, location of the plot in the midslopes and plot distances at a 1% level of significance. For example, results show that the odds ratio for FERTMOD and FERTGOOD were 5.24 and 9.74 respectively and had the hypothesized negative sign. This implies that the odds ratio value of long fallowing for poor soils is 5 times higher compared to that for plots with moderate soil fertility and about 10 times greater than plots with good soil fertility.

Woodlot model

The woodlot model results (Table 3) reveal that one household variable (EDUCPOST) is important in determining the farmers' decision to establish woodlots and had the expected positive sign. Farmers with post primary education are more diversified into profitable livelihoods and could afford medium and long-term investments. The plot variables that are significant at 1 % level include, STONEMANY, FERTMOD, FERTGOOD, and SLOPESTP. The fact that variables FERTMOD and FERTGOOD, reflecting plots with either moderate or good soil fertility are strongly negative and significant implies that soil fertility is a critical determinants for farmers' decision making to use plots for woodlots. Woodlots are more likely to be planted on plots with poor soils compared to fertile soils.

Table 3: Estimated coefficients and odds ratio for factors influencing farmers' decisions to either use land for Woodlot or abandon it.

Factor	Woodlot		Abandoned plot	
	Coefficient estimate	Odds ratio	Coefficient estimate	Odds ratio
AGEHH	0.011	1.012*	0.020	1.020***
HHSIZE	0.019	1.020	0.219	1.245
FARMSIZE	0.097	1.000	-0.006	1.007
EDUCPRIM	0.414	1.513*	0.781	2.184***
EDUCPOST	0.671	1.956**	-0.058	1.060**
HHFEMALE	-0.132	1.141	0.313	1.368
HHPMALE	-0.555	1.742*	-0.398	1.489
TOPTOP	-0.118	1.125	1.073	2.924***
TOPMID	0.243	1.275	0.255	1.290
FERTMOD	-1.950	7.029***	-2.279	9.767***
FERTGOOD	-2.892	18.029***	-2.669	14.425***
STONFEW	0.184	1.202	-0.316	1.372*
STONMANY	1.216	3.373***	0.419	1.520**
PLOTSIZE	0.083	1.087*	0.070	1.073
SLOPMOD	-0.030	1.031	0.739	2.094***
SLOPSTP	0.768	2.155***	0.522	1.685**
PLOTDIS	0.094	1.099*	0.211	1.235***

*, **, *** denotes statistical significance at the 10%, 5% and 1% level respectively.

Abandoned plot model

Table 3 highlights household variables that are significant at 1% level. These are age of the household head (AGE) and primary level education (EDUCPRIM). Post primary (EDUCPOST) is significant at the 5% level. The odds ratio value obtained for EDUCPRIM is 2.18. This implies that as the variable changes from no formal education to EDUCPRIM while the value of other independent variables are constant, the (odds) relative chances of a plot being abandoned increases by about 2 times. Farmers with abandoned plots are more likely to have post primary education compared to those with cultivated plots. Farmers with post primary education may have greater financial resources with which to invest on their land, as shown in the woodlot results.

The plot level variables related to abandonment that are highly significant at 1% level include TOPTOP, FERTMOD, FERTGOOD, SLOPMOD and PLOTDIS from home. The coefficients for the variables moderate soil fertility (FERTMOD) and good soil fertility (FERTGOOD) have the hypothesized negative sign and are significant at a 1% level. The associated odds ratio imply that when the soil fertility changes from poor soils to FERTGOOD the chances (odds) of a plot being abandoned decreases by about 14 times other factors remaining constant. Furthermore, the odd ratio (probability) of a plot remaining under abandonment decreases more (10 times) as the plot changes from poor soil to moderate soil status.

7. Conclusion and policy implications

Results reveal that plot abandonment and long fallow is a common problem in the Kigezi highlands. Secondly, while plot characteristics are important in the long run, farmers' attitude, social and economic factors contribute to farmers land use decisions. In order to address the issue of abandonment or low investment depends partly on the specific characteristics of plot. Analysis showed that 26% and 40% of long fallows and abandoned plots multiple constraints to cultivation such as steep slopes and stoniness. About 30% of long fallows and 15% of abandoned plots appear to be highly cultivable. Further analysis revealed that about 65% of the cultivable plots are located within 500 m from the homestead. This will impinge upon incentives for intensification and investment in labour intensive systems. For the cultivable plots and nearby plots, there are already available technological options to increase production if resources permit. The large number of plots with physical constraints implies that on the technological side, options that require relatively less management need to be identified.

There is a group of uncultivated plots that are far from the homesteads of the current owner. As a result, policy makers and farmers need to consult and find meaningful ways to encourage free exchange of land, renting and selling of far off plots. This is feasible because there already exists an active land market. But the same land market has created the high levels of fragmentation on the landscape. The process of improving the spatial distribution of plot holdings will be slow so long as only bi-lateral transactions occur. Thus, the government could facilitate interested exchangers of land to meet and enable multiple party exchanges to take place. This study has some limitations. For example, the farm level data on which the findings and recommendations are made are mainly for one season. Data covering more years and greater geographical scope would be better suited to meeting the objectives of this study and lead to greater extrapolation because of varying social-economic and climatic conditions.

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