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Site Specific Soil Conservation Strategies Around Mt. Elgon National Park, Eastern Uganda

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Abstract: This study investigates the site specific soil conservation strategies adopted by farmers to control land degradation around Mt. Elgon National Park, Uganda. Primary data were obtained through household survey conducted in Mutushet and Kortek parishes, Kapchorwa district between June to December, 2003. The differences between adopters and non-adopters of soil conservation practices in terms of contact with extension workers, tribe, size of productive family labour, membership to farmer organization, education level and participation in communal soil management activities and frequency of natural hazards on private agricultural lands were examined. Farmers have increasingly adopted different structural measures like terraced farming, construction of waterways, check dams, retention walls and gull control. Similarly, they have also adopted different biological measures including alley cropping, bamboo plantation in gullies, mulching and applied organic and inorganic fertilizers to control soil degradation. However, farmers have not been able to control soil degradation to a great extent due to relatively weak technological backup by concerned agencies. It was concluded that severity of soil degradation is higher in the parishes with traditional farming methods because farmers are not provided with the necessary technical advisory services.

Key words: Highland, farmers, soil fertility, soil erosion, family labour, soil conservation

INTRODUCTION

The highlands occupy around 25% of Uganda's total land area and contain 40% of the country's population. Population densities are, in general, high in these areas and most land, including marginal lands, are under cultivation. There is as yet little evidence that the increases in population densities have led to sufficient adoption of soil conservation strategies to offset worsening erosion and nutrient depletion (Bagoora, 1988).

Typically, mountain ecosystems in Uganda comprise four types of agricultural lands according to location and dominant cropping system (Nakileza and Nsubuga, 1999). Valley floors are cultivated with horticultural crops in the rainy season followed by beans and maize. Hill-slope, with inward facing terraces are primarily utilized for mixed crop combinations in the rainy season followed by fallowing in the dry season specifically in lands with adequate soil moisture. Upland-crop terraces, with outward facing terraces, are cultivated with maize, millet and sweet potatoes and; homesteads, are most intensively utilized for kitchen crops like maize and beans. Because of variations in location, physical and chemical properties and conservation strategies, the status of these different types of land and associated causes of degradation are not same. This was often overlooked by past researches (Nakileza and Nsubuga, 1999). As a small step towards bridging this research gap, this study makes an attempt to analyze the soil conservation strategies adopted by farmers and factors influencing the adoption of different soil conservation strategies around Mt. Elgon, Uganda.

Despite agriculture being the major sources of highland people's livelihood in Mbale region, little attention has been paid to their conservation and development (Nakileza and Nusbuga, 1999). Most studies on natural resources in the mountain ecosystems of Uganda have focused on conservation of mountain environmental resources. Even the few studies carried out on farmlands have based on results of simulated soil erosion models that indicate lands undergoing severe erosion (Nakileza and Nsubuga, 1999). Because of variations in human, bio-physical factors and conservation strategies, the status of these different types of land and associated causes of degradation are

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not same. This was overlooked by past researches. This study therefore, examined factors influencing the adoption of different soil conservation strategies around Mt. Elgon National Park, eastern Uganda.

MATERIALS AND METHODS

Study area: The study was conducted around Mt. Elgon National Park. Mt. Elgon National Park (MENP) (1°25'N and 34°30'E) is situated approximately 100 km Northeast of Lake Victoria on the Kenya-Uganda border. According to Scott, Mt. Elgon is one of the oldest volcanoes in East Africa. It rises to a height of about 4.320 m above sea level. The region receives an approximately bimodal pattern of rainfall, with the wettest months occurring from April to October. The mean annual rainfall ranges from 1500 mm on the eastern and northern slopes to 2000 mm in the south and the west. On lower slopes, the mean maximum temperatures decrease from 25°C-28°C and mean minimum temperatures are 15° C-16°C.

The study area, comprised of villages where National Agricultural Advisory Services (NAADs) programme has been implemented hereto referred to as NPV has as compared to villages still using traditional farming methods hereto referred to as TFV. The NPV received external financial and technical support from the central government under the Plan for Modernization of Agriculture (PMA) whereas farmers in the TFV are managing their farmlands using only the local knowledge and resources at their disposal without external technical and financial support. On average, a farm household in NPV owns 0.65 hectare of farmland, fragmented into several parcels, whereas in TFV, the average landholding size is 0.75 hectare per household. Farmlands in both parishes are found on valley floors, hill-slopes and ridges, with several cropping systems.

Data collection: This study was based on information obtained through a questionnaire survey, field observation and group discussions. The household survey was conducted during the months of June to December, 2003. Primary data were obtained through householdsurvey conducted in Mutushet and Kortek Parishes, Kapchorwa District. Mutushet was among the NAADS pilot villages while Kortek did not participate in the NAADS programme and still applied traditional farming methods. Based on the sampling method devised by Arkin and Colton (1963) a sample size for each parish was calculated proportionally corresponding to the total number of households in the selected parish. On average, 26 households were surveyed from each chosen local council in NPV and 24 households in TFV. A systematic random sampling method was adopted to select households for the questionnaire survey.

Data analysis: The degree of adoption of soil conservation strategies was rated based on percentage of farmers adopting particular soil conservation practice. If the percentage of farmers adopting particular soil conservation practice was higher than 80%, it was rated as high, 40-80 % as medium, 20-40% low and, below 20% as poor. Adoption of soil conservation strategies, however, varied from one farm household to another, depending on their socio-economic condition, bio-physical characteristics of lands and institutional support services provided. Therefore, stepwise regression analysis was applied to find out the factors influencing the adoption of soil conservation strategies.

Primary data collected through household survey were analyzed using statistical programming for social scientist sciences (SPSS ver. 11.0) and simple descriptive statistics such as frequencies, means and cross tabulations were performed to establish the socio-economic profile of the area under study.

The model was constructed using the stepwise probability criteria of F to enter <= 0.050 and probability of F to remove >= 0.100. To determine the overall degree of adoption of soil conservation strategies, firstly, 8 common soil conservation strategies of farmers were selected (Table 1). A score of 1.0 was assigned to the practice adopted by farmers and 0.0 to the practice not adopted. Then, all scores were aggregated and divided by 8 to obtain a composite index of adoption of soil conservation strategies. This index has been considered as dependent variable.

Initially 28 variables including, extension service (X_1), ethnic group of farmer (X_2), farm-based labor force (X_3), village land pressure (X_4), farmer field school training (X_5), landownership (X_6), education status of the household head (X_7), Origin of the farmer (X_8), participation of household head in joint soil conservationactivities (X_9), landslide density in farmland (X_{10}), family labor force (X_{11}), labor input per hectare of land (X_{12}), livestock ownership (X_{13}), fuel wood production (X_{14}), tree crop yield (X_{15}), tree cropping intensity (X_{16}), farm income (X_{17}), off-farm income (X_{18}), distance to arable land from farmhouse (X_{19}), soil erosion index (X_{20}), ecologically ruined land (X_{21}), micro-credit (X_{22}), farmer organization (X_{23}), out-migration of labor (X_{24}), land holding size (X_{25}), land tenure rights (X_{26}), tree tenure rights (X_{27}) and, land use value index (X_{28}) were considered as independent variables influencing the adoption of soil conservation strategies.

RESULTS AND DISCUSSION

Structural measures: Terraced farming was an important structural soil conservation practice adopted by farmers

Table 1: Farmers' adoption of different site specific soil conservation strategies

Soil conservation strategies		NAADS villages (NPV) (n = 26) Rating	Traditional karming villages (TFV) (n = 24) Rating
Structural	Terraced farming	High	High
	Waterways	High	High
	Gully control	Low	Poor
	Retention walls	Low	Poor
	Check dams	Poor	Poor
Biological	Alley cropping	Low	Poor
	Bamboo plantation along escarpments	High	High
	Vegetative measures	High	Medium
	Mulching	Medium	Low
Application of fertilizers	Farmyard manure	High	High
	Compost	Poor	Low
	Green manure	Low	Poor
	Legume cultivation	Low	Low
	Chemical fertilizer	High	Medium

to control soil erosion. Regardless of land type, most terraces in both parishes were constructed several years ago. Some of them were, however, constructed in response to ever-increasing food demand for a steadily growing household size. Farmers have reduced terrace risers to increase the area under crop production (Paudel, 2002).

Uncontrolled surface runoff moving down slope damages terrace risers and removes fertile soils from the farmlands, eventually aggravating crop yield and increasing the cost of terrace maintenance. To cope with this natural hazard, farmers in both parish have constructed waterways. The proportion of farmers constructing waterways is found equal and adoption rate is found high in both parishes (Table 1).

According to farmers, gullies were extensively formed during the 1960s and 1970s when forests on hill slopes were cleared for the expansion of farm and grazing lands. Following their formation, gullies expanded both vertically and laterally, eventually engulfing adjacent farmlands. To control this problem, farmers in NPV participated in the gully control program under the technical and financial support provided by the project.

Adoption rate of gully control is found low in NPV and poor in TFV. Farmers in NPV could not control large gullies due to lack of technical and financial resources. They, however, had controlled the expansion of small gullies using resources at their disposal.

Farmers were seriously concerned about the management of their landholdings, as any negligence would make them vulnerable to food shortage (Carswell, 2002). On average, a farm household in both parishes spent 13 workdays per hectare of land on maintenance and repairing farmlands affected by landslides. A landslide, depending on its size, may affect single or several farmers. Therefore, concerned farmers jointly construct reinforcement walls to protect terrace risers from collapsing. At the outset of the project, contraction of retention walls is relatively high in NPV compared with TFV. Therefore, adoption of this practice was found low in NPV and poor in TFV.

To protect their farmlands from landslides and flood related damages, farmers have made substantial amounts of labor investment in the construction of check dams. Check dams construction is found poor in both parishes, however the intensity of check dams was observed relatively high in NPV.

Biological measures: Confronted with miniaturizing landholdings and dwindling forest fodder and fuel-wood supply caused by deforestation and restriction on free access to forest, farmers in both parishes have increasingly practiced alley cropping to fulfill subsistence requirements. Planting fodder trees including palatable species like *Artocarpus lakoocha*, *Ficus auriculata*, *F. lacor*, *F. nemoralis* and shrubs on edge of terrace risers began in the early 1970s. In NPV, some exotic species, including *Leucaneia leucocephala* have been promoted, while in TFV mostly indigenous species are found. Overall adoption of alley cropping is low in NPV and poor in TFV. Establishing bamboo species in deep gullies and along stream banks has been a traditional practice adopted to control soil erosion, river bank cutting and gully expansion (Buyinza and Nabalegwa, 2007). Bamboo species propagate rapidly and have fibrous root systems with excellent soil binding capacity. There is no variation in the adoption of this practice in both parishes.

Use of organic and inorganic fertilizers: Farmers depend on different site specific organic and inorganic fertilizers to improve soil fertility. The proportion of farmers using Farmyard Manure (FYM) to fertilize the land was high in both parishes (Table 1). Farmers began to apply compost to maintain soil fertility in their farmland as the production

Table 2: Summary of the regression model

Independent variables	Model	R	R^2	Adjusted R^2	SE estimate
(X_1) Contact with extension staff	1	0.364[a]	0.169	0.166	0.1401
(X_2) Farmers' tribe	2	0.492[b]	0.231	0.225	0.1250
(X_3) Agricultural family labour force	3	0.499[c]	0.258	0.250	0.1330
(X_5) Training in soil conservation	5	0.549[e]	0.305	0.292	0.1294
(X_7) Education level of household head	7	0.579[g]	0.337	0.330	0.1270
(X_8) Landholding with *lateritic* soils	8	0.582[h]	0.352	0.333	0.1259
(X_9) Participation in communal soil conservation activities	9	0.612[I]	0.362	0.341	0.1252
(X_{10}) Landslide density in farmland	10	0.624[j]	0.374	0.350	0.1243

of FYM declined gradually over the time. However, compost application is poor in NPV and low in TFV. Confronted with declining FYM supply, a considerable proportion of farmers in NPV started applying chemical fertilizers provided cost-free by the NAADS programme since the late 1990s. Farmers in TFV are just starting to use chemical fertilizers in the early 2000s, as they could not receive any external assistance.

Overall application of chemical fertilizer was high in NPV and medium in TFV. Farmers also apply green manure species, namely *Calliandra calothyrsus*, *Leucaneia leucocephala* and *Tephorosia Candida*, to fertilize the farmland in both parishes. According to farmers, these plant species have more than double NPK content as compared to FYM. Some of these species are helpful for controlling weeds and pests. Normally green manure is applied to vegetable seedbeds (Carswell, 2002). However, application of green manure was low in the NPV and poor in TFV (Table 1). The need for increasing cropping intensity coupled with maintaining land fertility has increasingly attracted farmers in both parishes to legume cultivation, which was not a usual practice until recently.

While increased application of FYM and compost seems to be a suitable solution for replenishing soil nutrient, it is not an easy option for farmers. Increasing the supply of these fertilizers requires increasing livestock herd size and collection of more leaf litter. Both of these are not preferred choices of farmers, as they would put additional burden on already over stressed household labor force. A pragmatic approach would be to enhance the quality of available FYM through composting and promotion of legume cultivation. Farmers should also be made aware as to how the way that they keep and apply FYM lead to loss of valuable soil nutrients and as to how composting of FYM can help to improve fertility of their farmlands. In the long-term, a land use strategy that would promote agricultural enterprises, including livestock raising, requiring relatively small quantities of fertilizers and contributing to control accelerated soil erosion needs to be implemented.

Factors influencing the adoption of soil conservation strategies: Regression analysis revealed 15 independent variables with high degree of correlation with each other (r>0.5) and low degree of correlation with the dependent variable. All those variables with high collinearity (r>0.5) were dropped from the regression model. Finally, 10 independent variables with high degree of correlation with the dependent variable and low degree of correlation with each other were included in the model (Table 2). These 8 variables represent one way or another other variables dropped from the model. For example, X_1 included in the model, is associated with X_{22}, as normally, the farmers provided with extension services receive formal credit for investment in agricultural activities, including land management. The second variable X_3 is associated with X_{12} and X_{24} dropped from the model. Farmers with relatively small number of household members available for agriculture cannot provide much labor required for land management. Particularly in the study area, this happens due to out-migration of economically active males. Several variables, including X_{13}, X_{14}, X_{15}, X_{16}, X_{17}, X_{18}, X_{20}, X_{21} dropped from the regression model are directly or indirectly linked to three variables, namely, X_4, X_6 and X_{10} retained in the model.

Independent variables, which had strong correlation with the adoption of soil conservation technologies (Y), were entered step by step in the regression model. All variables included in the model have significantly influenced the adoption of soil conservation strategies. Both multiple R and R^2 values have increased with the addition of independent variables (Table 2) and they have reasonable explanatory power in the models. The final model, with ten independent variables, has moderate level of explanatory power, as the adjusted R^2 demonstrates 35% variation in the adoption of soil conservation strategies. However, the model is statistically significant with minimum error of the estimate and it can partly explain the adoption of soil conservation strategies in complex biophysical and socioeconomic situation in the hills.

The economic impact of the erosion and land degradation have not been estimated, but model results based on measurements and farmer perceptions of productivity decline by Nabalegwa *et al*. (2007) indicated that the relationship of soil loss and yield decline for lateritic has a negative exponential form, though results

Table 3: Farmlands seriously affected by soil erosion (Nakileza and Nsubuga, 1999)

	NPV			TFV		
Land type	Surveyed area (hectare)	Farmlands seriously affected	% of total farmlands seriously affected	Surveyed area (hectare)	Lands seriously affected	% of total farmlands seriously affected
Valley- land	10.6	0.8	8.0	28.2	2.8	10.0
Hill-slope land	66.0	10.6	16.0	47.5	7.6	16.0
Upland-crop terraces	8.3	3.3	40.0	17.3	8.3	48.0
Homesteads	15.7	3.1	20.0	15.0	4.1	27.0
Total	100.6	18.0	18.0	108.0	22.8	21.0

varied by soils and management types. On ferralsols and acrisols, cultivation without soil and water conservation can lead to critical losses of production even on moderate slopes after one to four years. The model results also indicated that good soil cover was the most important factor reducing yield loss. Farmers traditionally have used trash lines and these are indeed beneficial. However, when labor costs are taken into account it becomes uneconomical to cultivate a field after 4-5 years of cropping with trash lines and 3-4 years without trash lines. Their study concludes that the traditionally used techniques are very important, but have inherent weaknesses and limitations that will become increasingly apparent (Ellis-Jones and Tengberg, 2000).

Extension service and training on land management, which appeared important factors influencing the adoption of soil conservation strategies. There were limited such support services in NPV provided by the watershed management project during 1975-1995 (Nakileza and Nsubuga, 1999). Despite continuous efforts farmers could not be able to avert the land degradation effectively, owing to lack of awareness of alternative production potentials and unavailability of efficient support services and facilities, including extension services. Analysis of the status of land indicates that the farmland in both areas are undergoing to degradation.

Soil erosion: The area undergoing severe soil erosion is assessed from farmers' experience. According to four fifths of surveyed farmers, soil erosion is a common phenomenon in both parishes. Upland-crop terraces and homesteads are mainly affected by serious erosion. Nearly half of the upland-crop terraces in TFV and two-fifths in NPV are undergoing severe soil erosion (Table 3). Though based on farmers' assessment, this finding is consistence with field experiments carried out elsewhere in the mountains of Uganda (Buyinza and Nabalegwa, 2007). Even the hill-slope lands are not spared of erosion, although not as seriously as upland-crop terraces. Overall, the proportion of area affected by severe soil erosion is slightly lower in NPV.

Upland-crop terraces are undergoing severe soil erosion due to their outward facing slope. Farmers in NPV were provided financial assistance to hire labor required for conversion of outward facing terraces into inward facing terraces in order to control soil erosion. Besides, a large number of waterways, check dams and gully control measures were constructed under the technical and financial assistance provided by the project. This is why considerably low percentage of upland-crop terraces in TFV is undergoing severe erosion. In TFV, where such support was not provided, the proportion of upland-crop terraces undergoing severe erosion is considerably higher (Table 3).

On-going farming practices are also responsible for aggravating soil erosion. Farmers believe that exposure of land to the sun, rain and air for a long period helps to improve soil fertility. Therefore, they plough lands immediately after the harvest of crops and leave them exposed without any vegetative cover for a period of up to several weeks, depending on cropping intensity.

Even hill-slope lands are not free from erosion. Normally valley lands are puddled for transplantation of horticultural crops. In events of heavy rainfall immediately after the horticultural crop transplantation, terraces are flooded and the loose soil is easily washed away. Particularly terraces not protected by waterways are severely affected. A normal, low intensity rainfall does not cause such problem.

Livestock grazing also accelerates soil erosion particularly on hill-slope lands, which are opened for grazing immediately after the harvest of horticultural crops in November and remain so until the next crop cultivation. Regular trampling of lands by a large number of livestock leads to disintegration of soil particles and compaction of soil structure (Nabalegwa *et al*., 2007). The disintegrated soil particles are easily washed way by rainwater. Upland-crop terraces and homesteads, cultivated with two to three crops per year, are not much affected by livestock grazing, as these lands are intensively utilized for crop cultivation.

Farmlands in both NPV and TFV are undergoing degradation, though its causes, area coverage and severity vary depending on the type of land and conservation strategies. Among different types of farmlands, nearly half of the upland-crop terraces in both parishes are undergoing most serious degradation caused by the combined effects of severe soil erosion and landslide.

While severe soil erosion and landslide have affected mainly upland-crop terraces, soil nutrient depletion has been a problem on virtually all types of lands in both watersheds, if a very small percentage of land under homesteads is discounted. The problem is relatively less severe in NPV because of soil conservation measures promoted by the project. Possessing only small landholdings, most farmers in the study area have been vulnerable to subsistence food supply due to steadily decreasing soil fertility caused by the combined effects of soil erosion, landslide and soil nutrient depletion.

CONCLUSION

This study has shown that farmers in both parishes are seriously concerned about the dwindling status of their soil fertility and Any negligence in soil conservation would make them vulnerable to food security under the situation of shrinking landholding size and undergoing process of land degradation due to interactive natural and cultural factors. Farmers in both parishes, therefore, have increasingly adopted different soil conservation strategies to maintain the fertility of land. Increasingly they have adopted different structural and biological soil conservation strategies developed by their forefathers and consolidated by line agencies and NGOs and used different organic and inorganic fertilizers to maintain soil fertility. Adoption of gulley control measures, construction of retention walls, alley cropping, use of vegetative measures for landslide control, mulching, use of green manure and chemical fertilizer are found high in NPV compared with TFV due to the financial and technical support to project farmers whereas use of compost is relatively high in NPV because farmers were not supported with subsidized chemical fertilizers.

Degree of adoption of soil conservation strategies varies from one farmer to another, depending on several ecological, social and institutional factors. Specific factors significantly influencing adoption of soil conservation strategies are extension service, farmers' tribe affiliation, agricultural labor force size, landholdings, farmers' training, schooling period of farm household head, participation in joint soil conservation activities and landslide density in farmlands.

As suggested by Nakileza and Nsubuga (1999) in principle, there is prospect for promotion of application of several types of biological fertilizers, including legume, green manure and compost, for improving land productivity. Because of very heavy workload on household labor force, farmers are unlikely to adopt land conservation measures intensively, which require high labor input. Therefore, discussion should be held with them about problems and prospects of promotion of different types of biological fertilizers.

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