SOIL CONSERVATION PRACTICES AND NON-AGRICULTURAL LAND USE IN THE SOUTH WESTERN HIGHLANDS OF UGANDA

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A Contribution to the Strategic Criteria for Rural Investments in Productivity (SCRIP) Program of the USAID Uganda Mission

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Strategic Criteria for Rural Investments in Productivity (SCRIP) is a USAID-funded program in Uganda implemented by the International Food Policy Research Institute (IFPRI) in collaboration with Makerere University Faculty of Agriculture and Institute for Environment and Natural Resources. The key objective is to provide spatially-explicit strategic assessments of sustainable rural livelihood and land use options for Uganda, taking account of geographical and household factors such as asset endowments, human capacity, institutions, infrastructure, technology, markets & trade, and natural resources (ecosystem goods and services). It is the hope that this information will help improve the quality of policies and investment programs for the sustainable development of rural areas in Uganda. SCRIP builds in part on the IFPRI project *Policies for Improved Land Management in Uganda (1999-2002).* SCRIP started in March 2001 and is scheduled to run until 2006.

The origin of SCRIP lies in a challenge that the USAID Uganda Mission set itself in designing a new strategic objective (SO) targeted at increasing rural incomes. The *Expanded Sustainable Economic Opportunities for Rural Sector Growth* strategic objective will be implemented over the period 2002-2007. This new SO is a combination of previously separate strategies and country programs on enhancing agricultural productivity, market and trade development, and improved environmental management.

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INTRODUCTION

This study is motivated by the problem of natural resource degradation that results from agricultural activities, over-harvesting of forest products and other human activities. ECOTRUST (2001) estimates that Uganda loses up to 12% of her natural resources worth over $500 million per year due to natural resource degradation.[1] Since the lost natural resources are for both present and future generations, the country has accumulated an environmental debt of about $3.8 billion over the past three years only (ECOTRUST, 2001). Consequently, forest cover and biodiversity are decreasing due to pressure exerted by the increasing demand for forest products and agricultural expansion. As is the case for forest degradation, the rate of degradation of the land resource is also high. Agricultural production is the most important human activity that contributes to land degradation in Sub-Saharan Africa (SSA) (Lal, 1994, Cleaver and Donovan, 1995). It is for this reason that many studies have directed attention to the causes and remedies of land degradation resulting from agricultural production.

This study examines the soil conservation practices and factors that determine their adoption. The study also analyzes the non-farm activities and factors that condition participation in non-farm activities among household members. Non-farm activities are important determinants of soil conservation since they influence land use in many respects. For instance, Abdulai and Delgado (1999) observe that farmers in SSA have responded to declining per capita farm size and environmental stress by switching to non-farm activities. This implies non-farm activities may contribute to reduction of land degradation resulting from increasing population. Income from non-farm activities may also be used to purchase fertilizer and other external inputs used for improving soil fertility. A study by Haggblade, et al. (1989) notes that rural non-farm activities in SSA account for 10-30% of full time employment and 25-40% of income.

This study focuses on the Southwestern highlands of Uganda (SWH) region, which is among the richest ecological regions in terms of biodiversity and endemism and is therefore a significant

[1] This appears to be a gross loss of natural resources, i.e. it does not net out the annual regeneration of renewable resources such as forests, animals, etc. If this rate were net of regeneration, the natural resources in Uganda would be wiped after only 10 years or less.

attraction to tourists. The SWH region includes parts of the districts of Bundibugyo, Bushenyi, Kabale, Kabarole, Kasese, Kisoro, Ntungamo, and Rukungiri. The major concerns in the region are threat to the biodiversity and land degradation, especially with the current emphasis on commercialization of agriculture (Clausen, 2001). Pender, et al., (2001a) who observed that in Uganda, population, market access and land tenure are important determinants affecting land use and tree resource management, echo these fears. They note that areas closer to markets and hence with higher population density are converted to agricultural production.

The SWH region is characterized by high population density areas and hilly and mountainous areas that accelerate soil erosion. Most areas in the SWH rise above 1500 meters above sea level (m.a.s.l.). The high Rwenzori Mountains, which rise to the highest point in Uganda, 5110 ma.s.l., and the Virunga volcanic mountains characterize the topography of the region (Clausen, 2001). The major crops grown in the region are Irish and sweet potatoes, maize, beans, bananas and cassava in some areas of the region. The farmers also grow vegetables for commercial purposes.

The remainder of this study is divided into three major parts. The first part reviews the factors that affect land degradation in the SWH region. The description of these causes will reveal the complexity of the land degradation problem in the region. The second part describes the methodology used in collecting and analyzing the data used in the study. The third part is divided into two sections. One section discusses the adoption of soil conservation practices and the second section reports the determinants of participation of household members in non-farm activities. The last part concludes the study and discusses implications of the findings.

Factors that affect land degradation in the SWH region

Zake et. al., (1997) observe that the major types of soil degradation in Uganda are soil erosion, soil fertility mining[2], compaction, water logging and surface crusting. Soil erosion and nutrient depletion are the only serious land degradation problems evident in the southwestern regions

[2] Soil fertility mining is the practice of growing crops with insufficient replacement of nutrients taken up by the crops.

(Ibid.). The factors that influence land degradation may be divided into two major categories: proximate causes, which cause land degradation directly, and underlying causes, which affect land degradation indirectly. The discussion below reviews the major proximate and underlying causes of land degradation and shows their relevance to the SWH region.

Proximate causes of land degradation

These include physical features and human activities that induce land degradation. Examples of physical features that cause land degradation are climate, topography and soil type. Soil fertility mining, forest clearing, overgrazing, and unsustainable farming practices are examples of human activities that induce land degradation. The SWH districts are among the most affected by soil erosion in Uganda, mainly due to their hilly topography. The soils of the SWH are oxisols, utisols and inceptisols. Both oxisols, the dominant soil type, and utisols fix phosphorus, reducing its availability. They are also the very old and heavily weathered, hence less fertile. By contrast, inceptisols are young volcanic soils and hence relatively fertile. Hence the inceptisols are intensively cultivated without adequate application of fertilizer (Clausen, 2001). Climate may contribute to land degradation via rainfall and windstorms. For instance, even though the soils in the southwestern highlands (over 1500 metres) are stable, the high intensity of rainfall contributes to soil erosion (Tukahirwa, 1996 and Bagoora, 1990).

Deforestation and bushfires both lead to loss of vegetation cover, which in turn leads to soil erosion, and reduce soil organic matter (SOM).[3] Given that soil fertility in Uganda occurs mainly in the topsoil, it heavily depends on the SOM (NARO and FAO, 1999). Hence depletion of SOM significantly contributes to decline in soil fertility. It estimated that of the 20% of the 4,391 km^2 fully stocked forests in the western region of Uganda have been degraded due to deforestation (NEMA, 1999).

Soil fertility mining is a major problem in Uganda as only 2% of farmers apply inorganic fertilizer. The gross average rate of fertilizer application in Uganda is about 1 kg of nutrients/ha,

[3] SOM is most crucial for productivity of most old tropical soils, which dominate most farming systems in Uganda. SOM improves the storage and availability of cations (ammonium nitrate, potassium and calcium) because it has high cation exchange capacity (CEC). For this reasons in areas that receive little or no fertilizer, soil fertility is strongly correlated to amount of SOM. However, recent research findings show that the relationship between SOM and soil fertility has weakened due to continuous cultivation and leaching (Ssali, 2001).

which is among the lowest in the world (NARO and FAO, 1999). Consequently, it is estimated that nutrients in Uganda are depleted at an annual average rate of 38 kg of Nitrogen, 17 kg of Phosphorus and 32 kg of Potassium per hectare (IFDC, 1999).

Underlying causes of land degradation

These include population pressure, poverty, land tenure insecurity, policies and institutions, poor infrastructure and services, and farmers' lack of knowledge about soil conservation methods (Sserunkuuma, et al., 2001). The underlying causes of land degradation are of major interest to policy makers and development planners since understanding them would help them to design policies that would influence farmers and other land users to adopt practices that conserve the land.

Population pressure leads to land fragmentation, which decreases the per capita farm size. The average per capita area of cropland in Uganda has decreased from 0.44 ha in 1983 to 0.34 ha in 1993. There are large differences of the per capita cropland decline with the largest reductions occurring in the SWH and central regions (NEMA, 1996). Zake, et. al., (1997) also notes that land fragmentation is most serious in the SWH region.

Grisley and Mwesigwa (1994) note that the decrease of per capita farm size in the SWH region reduces the fallowing period.[4] Zake et al., (1997) note that the effect of short fallow leads to soil erosion and nutrient depletion because the majority of farmers in Uganda do not use fertilizer or soil conservation measures. In southwestern Uganda fallowing is seasonal and is carried out to stabilize cultivated soils and to maintain their fertility (Grisley and Mwesigwa 1994).[5] Grisley and Mwesigwa (1994) observed that homestead plots were not fallowed probably because of their proximity, and hence accessibility, and maintenance of fertility by household refuse.

Policies and institutions influence land management through land tenure system; market and price incentive policies; credit availability; suitability, availability and accessibility of production

[4] Fallowing contributes to productivity through a build up of soil nutrients and improved structure, reduction in erosion and control of noxious weeds and crop pests.

[5] However studies in east Uganda show that fallowed fields that are heavily grazed may degrade more than cropped farms (Ssali, 2001).

and market information and technology; etc. These factors interrelate in a complex manner that is in many cases difficult to analyze. Many researchers have observed that land tenure insecurity contributes to land degradation (Eicher and Baker, 1982; NEMA, 1999; NARO and FAO, 1999). The predominant land tenure in the SWH region is customary. Farmers holding land under customary tenure are likely to comply with bylaws and restrictions on soil conservation (Nkonya, et al., 2001). This is because the customary land tenure is likely to be stable and secure since land is passed from one generation to another in a smooth and stable manner. However, Place, et. al., (2001) note that customary land tenure systems in Uganda are weak in collective management of common resources. The customary land tenure systems are also associated with conversion of land from woodland to crop production (Place and Otsuka, 2000).

The impact of price and marketing policies on land management has also been studied by many researchers (Schuh, 1987; LaFrance, 1992; Lipton, 1987; Clark, 1992). Unfortunately, there is no consensus on the impact of price and marketing policies on soil conservation decisions. Schuh (1987) argues that price disincentives such as export taxes, high marketing costs, etc, influence farmers to undervalue their land resource, hence degrade it much faster. Clarke, (1992) indirectly supports Schuh's observations by noting that output price increase is likely to prompt farmers to attempt to increase the productivity of land by adopting soil conservation practices. However, Barbier, (1990) and Lipton, (1987) observed that high crop prices resulting from price support programs and other factors are likely to increase soil erosion since farmers may be motivated to expand their acreage into fragile lands and hence trigger erosion or plant high value crops using practices that accelerate erosion.

Institutions impact land management practices via the services they provide and policies that they design, implement and/or enforce. For instance, many studies have shown that local institutions are important for enacting and enforcing by-laws and regulations for soil conservation methods. This is because effectiveness of many soil conservation methods calls for collective adoption. This implies that implementation of soil conservation practices requires strong local institutions. However these institutions face challenges related to their legitimacy, i.e. real authority to decide on the soil and water conservation (SWC); and lack of political will

of the central government to devolve powers to communities and grassroots organizations (Kajembe, et al., 2000).

Poverty is another underlying cause of land degradation. Poor farmers often survive by harvesting natural resources such as forest products, soil fertility mining, etc. The resulting over-harvesting leads to exhaustion of open access resources such as ungazetted forests (NEMA, 1999). Additionally, poor farmers may discount future consumption heavily due to their limited resources. The implication of this behavior is twofold: One, poor farmers may not adopt soil fertility improvement technologies, which have limited short-term benefits (Kajembe, et al., 2000). This implies SWC technologies and environmental conservation technologies should show demonstrable/verifiable benefit in a reasonable short time in order to be accepted to poor farmers (Kajembe, et at, 2000). The second implication of farmers' high discount rate for future consumption is their undervaluing of future intrinsic value of natural resources for future generations such as biodiversity. This implies that, issues like preservation of habitat and biodiversity may not be important to poor communities. Hence poor communities may not conserve or sustainably manage habitat and biodiversity resources, without adequate compensation from government or conservation organizations.

Poverty in the SWH is a problem as it is estimated that 28% of the population in the region lives below the poverty line; i.e., live on less than one US dollar a day. The national average of population living under the poverty line is 35% (Appleton, 2001). The impact of poverty on land and environmental degradation in the SWH may be more pronounced in the region than other parts of Uganda because the SWH land is fragile due to its topography and the fact that farmers in the region live in and around a region rich in biodiversity. Additionally, some welfare indicators imply that the SWH region is among the poorest regions in the country. For instance Pender, et al., (2001a) observed that communities in the SWH region reported the highest percent (95%) of households with food insecurity. The comparable percent of households with food insecurity in Uganda is 61%. The communities in the SWH region also have the lowest percent of secondary school attendance.

METHODOLOGY

Data

The data used in this research were obtained from a household and plot surveys that were implemented by the International Food Policy Research Institute (IFPRI) in December 2000 to June 2001. A total of 451 households were randomly selected from the central, eastern, northern and western regions of Uganda. From each sampled household, a plot survey was conducted to determine the farm management practices of each plot.

The households were sampled from 100 communities, which were selected using a stratified random sample of communities representing different development pathways (livelihood strategies). Other seven communities were purposively selected from Kabale and Iganga districts where the African Highland Initiative (AHI) and the International Center for Tropical Agriculture (CIAT) are conducting research.

This study will focus on the households that were sampled in the SWH region from where a total of 45 households were selected. Results from the SWH region are compared with corresponding results from the rest of Uganda (ROU). The major soil conservation technologies analyzed in this study are agroforestry, soil and water conservation (SWC), and organic and inorganic fertilizer. It is sometimes hard to explicitly distinguish the four technologies as they closely interrelate. This is especially true for SWC and agroforestry, hence the need to clearly define the two technologies. Rocheleau et. al., (1988) defines agroforestry as any practice that associates crops and livestock with trees and shrubs in an economic or ecological manner. Young (1997) partitions agroforestry into five major components: trees, agricultural crops, pastures, livestock and soils.

Soil and water conservation is defined as conservation of soil using earth structures or vegetative cover or barriers to control runoff or break the force of downhill flow of water. In dry lands, the structures and plants are also used to conserve moisture and water for use by plant, animal and people (Young, 1997). The definitions clearly show that agroforestry may be used to achieve

SWC objectives. Hence in terms of control of soil erosion, agroforestry is a component of SWC. However, the role of agroforestry as a means of restoring soil fertility and as a source of feeds, fuelwood and other uses, is clearly distinguishable from SWC. To enrich the analysis of the two technologies, SWC and agroforestry are analyzed separately in this study.

The summary statistics of the technologies analyzed are presented in Table 1 through 3. The factors that affect adoption of improved land management technologies and those that influence participation of household members in non-farm activities are presented in Table 4. The major primary and secondary activities of household members are summarized in Table 5 and 6. These include non-farm activities, which are trading of farm and non-farm products, carpentry, making crafts, masonry, tailoring, photography, barber shop, shoe repair, bicycle and farm implement repairs/maintenance.

Data analysis

Analysis of data is done using two stages, univariate and multivariate analysis. The univariate analysis reports simple descriptive statistics of key factors that may influence adoption of soil conservation methods and participation of household members in non-farm activities. The multivariate analysis simultaneously examines the impact of many variables on probability to adopt soil conservation methods or to participate in non-farm activities using econometric models. The econometric model used in this study is probit.

The major factors that determine adoption of improved soil fertility management technologies are strongly related to or are the same as socio-economic characteristics that cause land degradation.[6] It is also likely that even the physical causes of land degradation may influence farmers to adopt soil conservation technologies. For instance, rolling topography may influence farmers to adopt bench terraces, a technology that may not be necessary in the lowland plains. However, this study will focus on the socio-economic factors that influence adoption of improved land management technologies. These factors are interesting to policy makers and development planners as they may be changed in a manner that influence farmers' decisions to adopt improved land management technologies.

The socio-economic factors that determine adoption of soil conservation technologies may be divided into three major categories: those affecting feasibility, profitability and acceptability of the technology (Swinkels and Franzel, 1997). Feasibility refers to farmers' financial resources, knowledge and experience to buy and manage the technology. Feasibility would also include institutional support like extension services, credit and marketing services. Profitability refers to returns, as perceived by the farmer, of the new technology when compared with the technology that the farmer uses and other alternative new technologies. Profitability of a technology is influenced by the opportunity cost of labor, land and other factors of production, and the output. Acceptability concerns the suitability of the technology, its riskiness, cultural acceptance and compatibility with other farm enterprises.

Data for the following variables were collected and are included in this analysis: market access, land tenure, access to credit, wealth indicators, presence of programs and organizations, number of extension visits, participation in non-farm activities, family size, age and education of household head.

[6] This is easy to note since adoption of improved land management technologies would reverse the effects of causes of land degradation. For instance, insecure land tenure system may lead to land degradation while secure land system may influence farmers to adopt technologies that conserve the soil.

Probit models estimated in this research are specified as follows:

(1) Probability to adopt soil conservation = $f(\mathbf{BX} + e_i)$

Where **B** is a vector of coefficients associated with a vector of factors (**X**) that explain the change in probability to adopt, as listed above. F is assumed to be a normal distribution function

Participation in non-farm activities may be influenced by market accessibility, availability of credit, presence of service institutions, labor constraints, age and education of household head, and availability of capital (Delgado and Siamwalla, 1999). A probit model was also used to determine the influence of factors on probability of family members to participate in non-farm activities.

The same explanatory variables, as those identified by Delgado and Siamwalla (1999), are used to explain the variation of probability to participate in non-farm activities.

RESULTS

This section reports the adoption of soil conservation practices and participation of household members in non-farm activities in the SWH region and compares them with the corresponding results from the ROU.

Adoption of soil conservation practices

Table 1 reports the proportion of respondents who used different methods of fertility management technologies. About 46% of respondents in the SWH region and 56% in the ROU reported to use at least one of the three major soil conservation technologies, namely agroforestry, SWC and use of organic or inorganic fertilizers. Agroforestry practices are used by over 40% of the respondents. The technology appears to be the most common fertility management technology in the ROU. The proportion of households using SWC technologies in the SWH region is slightly higher than the case for the ROU. The proportion of respondents who

practiced agroforestry in the SWH region is significantly lower than that of the ROU. Table 2 shows the details of the agroforestry technologies being used. The proportion of households in the SWH region who use improved fallow, alley cropping with trees and shrubs, and those who plant non-leguminous trees or grass strips is significantly less than the comparable proportion for the ROU. These findings support Pender et al., (2001a) who reported that the rate of tree planting in the SWH region is less than the case for other regions of the country.

Mulching is reported to be the most common SWC practice in the SWH region and the ROU.[7] All other SWC technologies are practiced by less than 12% of the households in the ROU implying the need to increase efforts on promoting use of SWC technologies. It is interesting to note that the proportion of respondents in the SWH region who reported to use deep and minimum tillage, grass strips, bench terraces and drainage investment were significantly higher than the case for the ROU. Even though this is good news given the hilly terrain in the SWH that forces farmers to use SWC, the proportion of households using SWC technologies in the SWH is low. This is especially true for the bench terraces, which are very important in the hilly areas of SWH and eastern highlands.

Table 1 also reports use of inorganic and organic fertilizer. No household in the SWH region reported to have used inorganic fertilizer while only 11% of ROU respondents used inorganic fertilizer. Although there are likely some households that use inorganic fertilizer in the SWH region, our results imply that the proportion using inorganic fertilizer is significantly lower than the case of ROU. This may be due to the geographical location of the region, which is far away from the suppliers of fertilizer. This leads to high transportation costs hence high retail fertilizer prices in the SWH region. Our results support other studies (NARO and FAO, 1999; IFDC 2000; Zake et al, 1997; Pender, et. al., 2001a), which report low levels of use of inorganic fertilizer among smallholder farmers in Uganda. However, our study shows much higher percentage (10.7%) of households using inorganic fertilizer in other parts of Uganda. This may imply that use of inorganic fertilizer has increased. Pender, et. al., 2001a also observed that fertilizer use in Uganda has increased. The increase in inorganic fertilizer use may be due to

[7] Even though mulching is used primarily for moisture conservation, it retards erosion.

liberalized input market, which may have led to a dramatic increase in the number of input traders (Nkonya and Kato, 2001).

Use of organic fertilizer in the SWH region is significantly higher than the case for ROU. Use of organic fertilizer in the region is probably used to substitute for the expensive inorganic fertilizer.

Table 4 reports socio-economic factors that may affect the adoption of soil conservation practices and participation in the non-farm activities in the SWH region and the ROU. Over 50% of respondents reported to have received credit in 2000. There is no significant difference between the proportion of farmers who received credit in the SWH region and in the ROU. The high proportion of respondents receiving credit may be related to the success of microfinance institutions (MFI) in Uganda. It is estimated that there are about 500 MFIs in Uganda with 550,000 active customers who save about $370 million. The numbers of MFIs in Uganda is believed to be among the highest in Africa (Duursman, 2001).

About 61% of households in the SWH reported to have received agricultural extension training as compared to only 44% for the ROU. The proportion of households reporting to have received agricultural training in the SWH region is significantly higher than the case for the ROU. This is probably due to the active participation of programs and organizations in the SWH (Pender et al. 2001a)[8]. However, the proportion of households in the SWH region reporting presence of /or membership to agricultural-related organizations is not significantly different from that of the ROU. Comparison of the average distance to all weather roads, years of formal education of household head and family size show no significant difference between the SWH region and ROU. This indicates that these factors might not account for the difference in the adoption of soil fertility management between the SWH region and ROU.

[8] Programs and organizations are institutions that affect the farmer livelihoods. The programs are government-related institutions that promote some development efforts and or enforce policies and laws. Organizations are non-governmental and community based organizations (Jagger, 2001). Most programs and organizations in SWH deal with social issues rather agriculture and environment (Jagger, 2001). However, the non-agricultural related programs and organizations may indirectly influence availability of agricultural training through lobbying or exerting pressure on government and institutions to offer better extension services.

The percent of households with non-farm activities are about 44% in the SWH region and 43% in the ROU. However, only 7% in the SWH region and 8% in the ROU reported non-farm activities as their primary activity (Table 5). This implies that most of the non-farm activities reported were part-time.

Table 7 and 8 summarize the probit model results showing the important factors that affect adoption of improved soil fertility management technologies. The factors that significantly influence adoption of improved soil fertility management technologies in the SWH region are family size, education and age of household head, land tenure, presence of program and organizations, and non-farm activities (Table 7). An increase in family size and education of household head are likely to reduce the probability to adopt SWC and agroforestry technologies. These results are puzzling since it was expected that larger families would have enough labor for investing in the labor-intensive SWC technologies. The reason for this observation is likely to be land fragmentation, which is more serious with larger families. Land fragmentation makes adoption of some SWC technologies difficult or too costly (Zake, et al., 1997; NEMA, 1999). For example, land shortage may limit farmers' ability to adopt SWC technologies that compete for land with crop production. Such SWC technologies are grass strips, trash lines, live fences, soil bunds drainage structures, etc.

The negative impact of education of household head on probability to adopt SWC and agroforestry technologies was also unexpected. Since educated farmers were expected to have a good knowledge of the importance of SWC and agroforestry technologies and hence the need to adopt the technologies. The reason for these results is the cost of farmers' labor, which is likely to increase with years of formal education. This would make the labor intensive SWC and agroforestry technologies too expensive to implement.

In both SWH and Uganda as a whole, age of household head is observed to exert a positive influence on the probability to adopt agroforestry technologies. Older farmers are therefore likely to adopt agroforestry practices than younger farmers. The likely explanation for this is the opportunity cost of labor. Younger farmers are likely to be more educated and with more non-

farm activities (Abdulai and Delgado, 1999), implying that the opportunity cost of the labor is higher.

Land tenure may be an important factor for adoption of agroforestry technologies in the SWH region (Place and Otsuka, 2000). In order to evaluate the impact of different tenure systems on probability to adopt soil conservation technologies, the most common land tenure system (customary) is compared with the other systems. It appears adoption of SWC, agroforestry, organic or inorganic fertilizer is not significantly affected by land tenure in all of Uganda (Table 7), but agroforestry is less common on freehold than customary land in the SWH. A change from the customary land tenure to the freehold tenure system would significantly reduce the probability to adopt agroforestry technologies in the SWH region. Nkonya, et. al., (2001) observed similar results with regard to compliance with bylaws and restrictions on soil conservation. They found that communities owning land under customary land tenure are more likely to comply with by-law and restrictions related to soil conservation than those owning land under freehold. The by-laws and restrictions include requirements such as planting trees after cutting one, restrictions on slashing and burning and other SWC and agroforestry requirements. Customary landholders have a special attachment to land since land is bequeathed to their children. Customary laws also place some restrictions on landholders. These restrictions are aimed at ensuring that land productivity is preserved for future generations. Therefore farmers are likely to adopt agroforestry technologies in order to conserve the farms for current and future family generations. The freehold tenure system requires the land title to be enforced and supported by an adequate legal system. The two aspects are not yet well developed in Uganda, even after the 1998 land Act that revised the old land policy (Gashumba, 2001).

The presence of programs and organizations related to agriculture and the environment increases the probability to use organic manure in the SWH region and adoption of SWC technologies and use of inorganic fertilizers in the Uganda. These results were expected as such programs and organizations are likely to promote use of organic fertilizers and other soil fertility management technologies. NGOs and CBOs have been quite successful in offering small loans to farmers, a key determinant of adoption of soil fertility management technologies (Swinkels and Franzel,

1997). Programs and organizations are also likely to increase farmers' knowledge on improved land management technologies and raise their awareness about the impact of land degradation.

Farmers often engage in non-farm activities with an objective of spreading their production and price risks, smoothing consumption and liquidity and adjusting their output mix (Delgado and Siamwalla, 1999). Since non-farm activities are important sources of income, they are likely to increase the feasibility of adopting soil fertility management technologies that require financial outlays. Our results show that participation of SWH household members in non-farm activities is likely to increase the probability to adopt agroforestry practices in Uganda as a whole and in the SWH region. Agroforestry practices such as improved fallow, alley cropping, planting tree on crop plots etc. require trade-offs between crops and tree/fallow. Such trade-offs may require alternative sources of livehoods such as non-farm activities.

Other factors that were important in determining the factors for adoption of soil fertility management technologies in Uganda as a whole but not in the SWH region are distance to all-weather roads, access to credit, wealth indicators and number of visits of extension agents. Both distance to all weather road and access to credit increase the probability to adopt agroforestry technologies in Uganda. The distance to all weather road is an indicator of market access. The further away from all-weather road, the less the accessibility to markets. Results reported in Table 7 suggest that households in low market access areas are more likely to adopt agroforestry practices than those in high market access areas. This is in agreement with findings by Pender et al. (2001a) who observed that areas with high market access reported more severe forest degradation, than low market access areas, i.e. areas further away from all-weather roads.

Access to credit may help to reduce poverty and hence land degradation. This is because poor farmers may degrade land for short-term gains (NEMA 2000). Table 7 shows that access to credit increases the probability to adopt agroforestry technologies in Uganda. The results are consistent with the findings of Pender et. al., (2001b) who observed that access to credit increased the probability to plant trees and live fences in the Ethiopian Highlands. Wealth, as indicated by houses with metal roofs or cement/burnt brick walls, has a positive impact on probability to adopt improved land management technologies. Wealth is observed to increase the

probability to adopt SWC technologies in Uganda, probably due to its role in increasing the possibility of hiring labor to implement SWC practices. Wealthy farmers may also have more land than poor farmers, hence would afford to adopt technologies that compete for land space with crops. As expected, wealth is also predicted to increase the probability to adopt inorganic fertilizer in Uganda.

As expected the number of visits by extension agents positively affects the probability to use SWC technologies in Uganda. Visits of extension agents to households is likely to increase their awareness about the effects of land degradation and the knowledge about the SWC technologies and their benefits. It is interesting to note that extension has no significant impact on adoption of fertilizer and other technologies. This suggests that extension may not be directing sufficient efforts on these technologies.

Non-farm activities in the SWH region

Farmers were asked to report the primary and secondary activities that each household member pursues. Table 5 summarizes the main primary activities undertaken by members of the sample households. The most common primary activity by household members is schooling probably because more than 50% of household members were below 18 years old. The second most common primary activity is crop production followed by non-agricultural trade. Non-agricultural trade includes retail sale of industrial products in village shops.
It is surprising to note that livestock production is the fourth most common primary activity in Uganda. Livestock production is the most important activity in the east and north east parts of Uganda. The activity is also important in the cattle corridor, which includes drier areas from the north east of Uganda to the southwestern region. It is possible that respondents who tether their animals or those who raise chicken and pigs using the free-range system did not report these activities since very little labor is required for raising livestock using such feeding systems.

The major non-farm activities reported were marketing agricultural and non-agricultural products. The non-farm activities observed in Uganda are small village shops, itinerant trading of agricultural and industrial products, and cottage industries, which include crafts making,

tailoring, construction, bicycle and farm machinery/implement repair, barber shop, photography, and shoe repairs. Other important non-farm activities reported were non-farm and farm wage-employment. This includes casual laborers, community level officials, civil servants, and skilled and semi-skilled non-civil servants.

Table 5 shows that about 7% of respondents in the SWH region reported to have non-farm activities as their primary activity as compared to 6% in the ROU. This shows the limited options for non-agricultural activities in Uganda. The respondents who reported non-farm activities as their second most important activities were about 6% in the SWH region and 8% in the ROU.

The cottage industries have great potential of modernizing peasant agriculture if supported and facilitated. This is because most farmers in Uganda still use rudimentary farm implements, which may be greatly improved if local small-scale industries were involved in producing, repairing or servicing implements such as ox-plows, ox-carts, wheelbarrows, water pumps, sewing machine, crop processing machines, etc.

Table 9 reports the results of the probit model that estimates the influence of factors that affect participation of household members in non-farm activities in Uganda. Due to a small sample from the SWH region the probit model was not statistically significant, hence not reported. However, the factors affecting participation in the whole country are likely to have similar impact on households in the SWH region.

Family size appears to be the most important determinant of probability to engage in non-farm activities. This is a reflection of labor constraints that may prevent household members from participating in non-farm activities. Since non-farm activity is not a primary activity for 92% of household members, the limited family labor is probably allocated to agricultural production, which is a primary activity to the majority of the adult household members. This leaves little time for non-farm activities. This also may imply that family labor in Uganda is more efficiently used in agricultural production than non-farm activities. Hence smaller families with more

severe labor shortage are not likely to engage in non-farm activities than larger families, as our results suggest.

Presence of programs and organizations dealing with agricultural production or environmental conservation significantly (at P=0.10) reduces the probability to engage in non-farm activities. Given that there is competition among several activities for family labor, the emphasis and support of the agricultural and/or environmental-related programs and organizations may increase the households' comparative advantage in agricultural production. This is likely to reduce the probability to engage in non-farm activities, as these results show.

CONCLUSIONS AND IMPLICATIONS OF THE FINDINGS

This study shows that only about 44% of sampled household used at least one of the three fertility management technologies, i.e. agroforestry, soil and water conservation (SWC), and application of fertilizers. This research shows that about 11% of the respondents in Uganda used inorganic fertilizer. This rate is considerably higher than that reported in other studies, i.e. 2%. It appears that use of inorganic fertilizer among farmers has increased due to the improved input markets and extension efforts by government programs and organizations. This is an encouraging sign, which shows that the input market reforms and extension efforts are having an impact. Since accessibility to inorganic fertilizers remains low due to high prices and other marketing problems, the levels applied are still low. This points to the need of encouraging farmers to use a combination of complementary soil conservation technologies.

Agroforestry is the most common fertility improvement technology used by the respondents. Hence agroforestry appears to be more feasible and compatible with the existing farming system than the other technologies considered. This suggests the need to increase efforts in promoting use of improved agroforestry practices that have been developed by researchers but have not yet reached farmers. The results also suggest the need to continue investment in agroforestry research in order to continue generating new technologies. However, there are very few well-established private traders or organizations that market agroforestry technologies such as seeds and planting materials of trees and shrubs. This may contribute to the low uptake of agroforestry

technologies. There is a need to have concerted efforts to commercialize agroforestry research products since most government programs and NGOs have directed their efforts towards generation and dissemination of agroforestry technologies only.

A significantly higher proportion of farmers used bench terraces, grass strips, deep and minimum tillage and invested in drainage in the southwestern highlands (SWH) region than the rest of Uganda (ROU). These observations were expected due to the steep terrain in the SWH region that calls for soil conservation. However, there is reason to worry about the 68% of households that do not use any form of SWC practices in the SWH region where lands are fragile. There is therefore a need to increase extension efforts of improved land management technologies since the soils in the SWH are fragile, hence easily degraded. There is reason for concern even among farmers who reported to have adopted bench terraces and other conservation structures, since such structures are poorly maintained and hence their effectiveness is low. In some cases, farmers have opened up the bench terraces to utilize the nutrients accumulated over time.

Land tenure, labor constraints, age and education of household head and non-farm activities appear to be important factors that influence adoption of agroforestry practices in the SWH region. The customary land tenure system, which is the most common in the SWH region, is associated with higher adoption of agroforestry practices than the freehold system. The reason for low adoption of agroforestry practices associated with farmers holding land under free hold system is likely to be related to tenure insecurity due to weak land law enforcement institutions. Therefore the government needs to strengthen the land tribunals at community and district level in order to ensure security and stability of land tenure systems.

Family size is found to reduce the probability to adopt SWC and agroforestry technologies in the SWH region. The reason for this observation is likely to be related to land scarcity, which is more severe with larger families. Land shortage for the large families may not permit adoption of SWC and agroforestry technologies that compete for land with crops. Promotion of participation in non-farm activities may take some rural labor force out of agriculture, permitting adoption of soil conservation methods that compete for land with crops.

In both the SWH region and ROU, farmers with more years of education are likely to have lower probability of adopting SWC and agroforestry technologies than less educated farmers. This was not expected as educated farmers are likely to be better informed about the improved soil conservation technologies and the adverse effects of land degradation. The likely explanation for these results may be related to higher cost of labor for more educated farmers, which reduces the probability to adopt labor-intensive soil conservation methods. The policy implications for these findings are that, farmers need to be given incentives for adopting labor-intensive technologies via tax breaks, and non-monetary compensation such as recognition. Taxing people who harvest products from common resources like forests, wetlands, water, grazing lands, etc, may finance the loss of revenue due to the tax breaks given to adopters of labor-intensive soil conservation technologies. There is also a need to use moral suasion by educating farmers about the short-term and long-term effects of land degradation.

Older farmers are more likely to adopt agroforestry technologies than younger farmers in the SWH region, and elsewhere in Uganda. This may be related to differences in endowment of land between old and young farmers. Older farmers are likely to have larger farms than younger ones because older farmers acquired their land when population pressure was lower. This would allow older farmers to adopt agroforestry technologies that compete for land with crops. It is also likely that the cost of labor for younger farmers is higher than older farmers since younger farmers are likely to be better educated and to have non-farm opportunities to pursue. This makes them less likely to adopt labor-intensive agroforestry technologies.

Agricultural and environmental related programs and organizations are predicted to increase the probability of using organic fertilizers in the SWH region and of adopting SWC technologies in Uganda as a whole. This was expected as such programs and organizations are likely to promote sustainable agricultural production practices. This points to the importance of institutional support in increasing the feasibility of adopting soil conservation methods. The institutions provide technical information, credit and other crucial support that is necessary for adopting new technologies. For instance, numbers of visits of extension agents and access to credit are likely to increase the probability to adopt SWC in Uganda.

There are many programs and organizations in Uganda that are related to agriculture and the environment. However, in the SWH region, many programs and organizations are related to mutual support. This implies that there is a need to deliberately promote presence of agricultural and environmental-related programs and organizations in the SWH region, as these may be very effective in increasing adoption of soil conservation methods. However, the role of government in regulating activities of programs and organizations is quite crucial as some of their activities may be counter-productive. For instance some NGOs have been reported to discourage farmers from using inorganic fertilizer for fear of "destroying" the soil (Bashaasha, 2001).

Non-farm activities are predicted to increase adoption of agroforestry in the SWH region. Non-farm activities are expected to increase income, spread production and price risks, and more importantly, they have the potential of reducing the pressure on land resulting from increase in population. All these factors may favor adoption of agroforestry practices that compete for land with crops or practices that involve considerable amount of financial outlay. However, less than 10% of members of the sampled households in both the SWH region and ROU reported to have non-farm activities as their major primary or secondary activity. This implies there are few non-farm opportunities with comparative advantage over agriculture. There is a need to increase the competitiveness of non-farm activities in order to increase their profitability and acceptability among farmers. This is likely to relieve pressure on land, which is too high in the SWH region. Increased participation of household members in non-farm activities would result in a win-win scenario where both environmental degradation and poverty are reduced.

The factors that significantly influence participation of household members in non-farm activities in Uganda are family size and presence of agricultural related programs and organizations. An increase in family size is predicted to increase participation of household members in non-farm activities. This implies that the labor constraint, which is more severe with smaller families, leads to less participation in non-farm activities. The results suggest that in rural Uganda, agriculture has a comparative advantage over non-farm activities. This is probably caused by the lack of market for non-farm products and/or the poor quality of the products that are made using minimum or no skills.

The presence of programs and organizations promoting agriculture and the environment appears to decrease the probability to engage in non-farm activities. This is expected as such programs and organizations are likely to increase the competitiveness of agricultural products over non-farm products. This points to the need to create and support programs and organizations that train farmers to produce higher quality non-farm products and facilitate them to engage in non-farm activities. Such efforts would increase the competitiveness of non-farm products and hence attract more farmers to engage in non-farm activities. Such programs and organizations may be related to training farmers in agricultural processing, bookkeeping and accounting for their small businesses, and supporting vocational training institutions in the villages. They could attract young high school dropouts to train in masonry, carpentry, farm tools and machinery repairs, and other skills. The non-farm products produced by skilled and semi-skilled producers would become more competitive and hence result in higher participation even among smaller families who are predicted to participate less in non-farm activities due to labor constraints.

The general conclusion of this study is that measures that need to be taken to increase adoption of soil conservation technologies call for a multi-sectoral approach since land degradation is a complex phenomenon. Both markets for inputs and outputs need to be improved to lower the transaction costs and hence the input prices. This would allow farmers to earn remunerative returns to their labor invested in soil conservation and other technologies. This means transportation and information infrastructure need further improvement. Efforts to increase farmers' vocational education would increase the competitiveness of non-farm products, which in turn would increase their participation in non-farm activities, reducing the population pressure on land. However, non-farm activities require rural electrification and other sources of energy.

Further research need to be undertaken to understand the impact and cost-benefits of soil conservation technologies in the SWH region. It is also important to do bioeconomic modeling to understand the sustainability of the different soil conservation technologies in the SWH and other regions of Uganda.

Table 1: Comparison of Adoption of Fertility Management technologies between the SWH region and rest of Uganda (ROU)

SWC Technology	SWH (N=41)	ROU (N=384)	P**
	Proportion Adopted		
Agroforestry*	0.268	0.435	0.04
SWC*	0.390	0.307	0.28
Inorganic fertilizer	0.00	0.107	0.03
Organic fertilizer	0.415	0.276	0.06
Uses none	0.54	0.44	-1.28

* See details on Table 2 for agroforestry and Table 3 for SWC

** P-value of χ^2 comparing proportions of adoption in the SWH and ROU

Table 2: Agroforestry Technologies adopted in Uganda

Technology	SWH (N=41)	ROU(N=384)	P*
	Proportion adopted		
Improved fallow	0.000	0.0015	0.00
Alley cropping	0.000	0.0015	0.00
Leguminous trees	0.072	0.0161	0.01
Non-leguminous trees	0.000	0.0440	0.00
Woodlot	0.000	0.0073	0.00
Grass strips	0.000	0.0059	0.00
Other	0.062	0.0117	0.01

- P values of Paired T-test. This is a statistical test that is comparing the proportion of respondents who used SWC technologies in the SWH and ROU.

Table 3: SWC technology adoption in the SWH region and rest of Uganda (ROU)

SWC Technology	SWH (N=41)	ROU (N=384)	Paired T-test*
No SWC	0.68	0.73	0.63
Mulching	0.32	0.27	-0.71
Contour plow	0.07	0.04	-0.96
Min. tillage	0.24	0.02	-11.07
Deep tillage	0.24	0.02	-8.80
Grass strip	0.22	0.09	-2.80
Trash line	0.00	0.06	1.50
Bench terrace	0.05	0.00	-5.41
Trench	0.12	0.11	-0.14
Live fence	0.02	0.04	0.59
Stone wall	0.02	0.02	-0.43
Irrigation	0.05	0.02	-1.02
Drainage investment	0.24	0.04	-6.41
Infiltration ditches	0.00	0.02	0.89
Soil bunds	0.00	0.02	0.83

* Statistical test comparing the proportion in the SWH and ROU.

Table 4: Factors that affect adoption of soil conservation practices or participation in non-farm activities

Service/Activity	SWH (N=41)	ROU (N= 384)	P- Value*
	Proportion		
Received credit	0.61	0.52	0.27
Received agricultural training	0.61	0.44	0.04
Agric. programs & organization	0.15	0.20	0.39
Has non-farm activities	0.44	0.43	0.88
	Mean*		
Distance to all weather road (km)	2.23 (0.4)	5.0 (0.7)	0.19
Education of hhd head***	4. 83 (0.6)	5. 3 (0.2)	0.49
Family size (#)	13.60 (1.0)	14.57 (0.6)	0.56

* P-value of χ^2 comparing proportions in the SWH and ROU
** Figures in brackets are standard deviations of the mean
** Hhd = household

Table 5: Main Primary Activities done by members of sampled household

Primary Activity	Proportion reporting on: SWH (N=41)	ROU (N=384)	Paired T-test*
Crop production	0.35	0.40	2.07
Student	0.52	0.51	-0.51
Livestock production	0.03	0.02	-1.19
Other agricultural activities**	0.01	0.01	0.32
Non-farm activities (all)	0.07	0.08	
Non –ag. Trade	0.01	0.02	3.05
Farm wage employment	0.00	0.02	-1.73
Cottage industries***	0.01	0.01	-0.64
Other activities	0.05	0.03	-1.67

* Statistical test comparing the proportion in the SWH and ROU.
** Includes: Fishing, agricultural output processing, local beer brewing and ag. Input/output trade.
*** Includes: Carpentry, crafts, masonry, tailoring, photography, barber shop, shoe repair, bicycle and farm implement repairs/maintenance.

Table 6: Main secondary activities of household members in the SWH region and ROU

Secondary activity	Population reporting in: SWH (N=41)	ROU (N=384)	Paired T-test*
House chores	0.54	0.59	1.93
Crop production	0.18	0.18	-0.63
Livestock production	0.16	0.05	-5.44
Other ag. related activities	0.03	0.09	6.18
Non ag. Trade	0.02	0.03	1.73
Cottage industries**	0.05	0.02	-2.23
Other activities	0.01	0.01	1.27

* Statistical test comparing the proportion in the SWH and ROU.
** Includes: Carpentry, crafts, masonry, tailoring, photography, barber shop, shoe repair, bicycle and farm implement repairs/maintenance.

Table 7: Determinant of adoption of soil fertility management technologies in Uganda

Factor*	SWC		Inorganic fertilizer		Agroforestry		Organic fertilizer	
	Impact	P	Impact	P	Impact	P	Impact	P
Distance to all weather road	-	NS	+	NS	+	**	+	**
Land tenure**: Freehold	-	NS	-	NS	-	NS	-	NS
Leasehold	+	*			-	NS	-	NS
Mailo	-	NS	-	NS	-	NS	-	NS
Access to credit	+	NS	-	NS	+	***	+	NS
Wealth	+	*	+	***	-	NS	-	NS
Programs/organizations	+	**	-	NS	-	Ns	+	**
Visits of extension agent	+	***	+	NS	+	NS	+	NS
Non-farm income	+	NS	+	NS	-	NS	+	NS
Family size	-	NS	-	*	+	NS	+	NS
Age of hhd head	+	NS	+	NS	+	**	+	NS
Education of hhd head	-	NS	+	NS	-	*	+	NS

* Details of full probit model results may be obtained from author upon request.

** The most common land tenure category (customary) was assigned a value of zero and one to the other three tenure categories. This means the impact reported is that of changing from the customary to another land tenure.

Notes: (i) Hhd = household

(ii) P shows the significance of the impact of the associated factor. *, **, and *** mean the impact is significant at 10%, 5% and 1% level respectively. NS means the impact is not significant, at least at 10% level.

(iii) + means the impact of the associated factor is positive, and – means the associated factor is negative

Table 8: Determinants of adoption of soil fertility management technologies in the SWH region

Factor	SWC		Agroforestry		Organic fertilizer	
	Impact	P	Impact	P	Impact	P
Land tenure: Freehold	-	NS	-	**	-	NS
Programs/organizations	-	NS	+	NS	+	**
Non-farm activities	-	NS	+	*	-	NS
Family size	-	***	-	*	-	NS
Age of household head	+	NS	+	***	+	NS
Education of hhd head	-	***	-	*	-	NS

Notes: (i) Hhd = household

(ii) P shows the significance of the impact of the associated factor. *, **, and *** mean the impact is significant at 10%, 5% and 1% level respectively. NS means the impact is not significant, at least at 10% level.

(iii) + means the impact of the associated factor is positive, and – means the associated factor is negative

(iv) Only variables significant in at least one econometric model are reported in this table

Table 9: Determinants of participants in non-farm activities for household members in Uganda

Factor	Impact	Significance of impact
Distance (km) to all weather road	+	NS
Received credit (yes/no)	+	NS
Wealth	-	NS
Ag. program/organization	-	*
Number of extension visits in 2000	+	NS
Family size (# of household members)	+	***
Age of household head	+	NS
Education of household head	-	NS

Notes: (i) Only variables that are significant (at p=0.1) in at least one of the three models are reported.

(ii) Hhd = household

(iii) P shows the significance of the impact of the associated factor. *, **, and *** mean the impact is significant at 10%, 5% and 1% level respectively. NS means the impact is not significant, at least at 10% level.

(iv) + means the impact of the associated factor is positive, and – means the associated factor is negative

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